The role of organophosphate exposure in the aetiology of depression and suicidality amongst farm workers on wine and table grape farms in the Worcester area of the Western Cape Province, South Africa

by

Student: Viveca Joy Major
Student number: HNDVIV002

SUBMITTED TO THE UNIVERSITY OF CAPE TOWN
In dissertation fulfillment of the requirements for the degree
M Sc (Med) in Public Health

Faculty of Health Sciences
UNIVERSITY OF CAPE TOWN

Date of Submission: February 2010

Supervisor: Professor Leslie London
Department of Public Health and Primary Health Care
University of Cape Town

DECLARATION

I, Viveca Joy Major, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise), and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

I empower the university to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

Signature: ………………………………………………………

Date: ………………………………………………..

ACKNOWLEDGEMENTS

First and foremost I wish to express my thankfulness to God for His Divine guidance, grace and blessings without which the fulfillment of this task would not have been possible.

I wish to acknowledge and thank the following individuals and organizations / institutions for the role they played in making this study possible:

- My supervisor, Professor Leslie London, for his continuous support, encouragement, scientific advice and ‘never giving up on me’ throughout this process.
- The Research Committee of Peninsula Technikon (now CPUT, Bellville Campus), SANPAD and the National Research Fund (NRF) for their financial support for the project.
- The Mauerberger Foundation for awarding the Solm Yach Fellowship to me for two consecutive years.
- Shafiek Hassan, Head of Department of Health Sciences (Nursing Division), Peninsula Technikon (now CPUT, Bellville Campus), for his encouragement, support and assistance with the organization of the field work and data collection.
- The farmers and farm workers in the Boland region who participated in the study.
- All the interviewers for all their hard work during the data collection phase of the study, including Sister Cynthia Johnson, who measured the erythrocyte cholinesterase levels of the farm workers, using the Test-mate ChE Cholinesterase Test System (Model 400) field kit.
- My children, Kim, Vaughn and Ashne who assisted with various aspects of the study

- A special word of thanks to Roslyn Baatjies and Tim Meijster who spent many hours assisting me with the data analysis.
- Colleagues and friends, Zelda Holtman, Aqiel Dalvie, Mohamed Jeebhay, Algernon Africa and Andrea Rother at the Occupational and Environmental Health Research Unit, University of Cape Town, for their continuous encouragement and support throughout the years of this study.
- Colleagues and friends, Kay Moodley, Joy Francis and Shanaaz Mia at the Western Cape College of Nursing (WCCN), for their understanding, encouragement and support in the last two years of this study.
- Senior librarians at the WCCN, Nazma Vajat and Mark Frier for their patience and timely accessing of most of the neuropsychiatric articles used in the study
- My late father, and mother, sister and brothers for their ongoing support and encouragement.
- My husband, Arthur, who helped to sustain my energy levels, by keeping me well-fed with his home-cooked meals and endless mugs of tea and coffee, while I sat glued to the computer for hours and hours.

Great appreciation goes to all the collaborators from Peninsula Technikon, Mr. Shafiek Hassan; University of Cape Town, Professor Leslie London and Professor Alan Flisher (Department of Psychiatry) and Utrecht University, Professor Hans Kromhout, for their support and scientific input into the study.

ABSTRACT

Despite the obligatory requirements of the Occupational Health and Safety Act (Act 85 of 1993, Section 8(1)) that ‘every employer shall provide and maintain a working environment that is safe and without risk to the health of its employees’, farm workers in South Africa are exposed to numerous occupational health and safety hazards on a nearly daily basis. One of the many occupational hazards confronting farm workers is their exposure to pesticides, particularly organophosphates, which are potent neurotoxic chemicals used for pest control. Exposure to organophosphate pesticides (OP’s) is the cause of a significant number of acute and chronic poisonings amongst rural farm workers and residents in South Africa. While it is evident that the workers involved with the mixing and application of these agrichemical substances are at the greatest risk of exposure, others who are involved with general farm work are similarly at risk of exposure from spray drift and residue on crops, trees and leaves.

An important association with the use of and exposure to pesticides is that of suicide in that OP’s are agents that are frequently used to commit suicide. However, being neurotoxins, it is known that OP’s have psychoactive effects and it is thought that long-term exposure to OP’s may be implicated in causing depression. Hence, exposure to OP’s has been postulated to result in suicidality amongst exposed farm workers perhaps through the pathway of depression, impulsivity, aggression or some combination of these factors. There are very few studies exploring this hypothesis to date.

South Africa is the largest market for pesticide use in Sub-Saharan Africa and the grape farming sector is an intensive user of pesticides, particularly OP pesticides. This, study sets out to investigate the neuropsychiatric effects of long-term exposure to OP’s in wine and table grape farm workers in South Africa

Objectives

1. To assess the levels of recent and long-term occupational exposure to organophosphate pesticides (OP's), and describe the red blood cell acetylcholinesterase levels (RBC - AChE) in wine and table grape farm workers participating in the study
2. To determine the current levels of depression, aggression, impulsivity and suicidality of farm workers participating in the research study
3. To describe the levels of environmental exposure to OP's, and its relationship to depression, aggression, impulsivity and suicidality in farm workers participating in the study
4. To investigate the relationship between specific farming occupations, OP exposure and current levels of depression, aggression, impulsivity and suicidality in farm workers participating in the study
5. To describe the following factors and assess their role as potential confounders for the relationship of pesticide exposure to depression, aggression, impulsivity and suicidality
   - age
   - gender
   - alcohol consumption (CAGE score ≥ 2)
   - current / past psychiatric illness
   - socio economic status

Methods

A cross-sectional analytical study was conducted on 817 workers employed on 9 wine grape and 48 table grape farms in the Worcester area of the Western Cape Province of South Africa. Occupational exposure was assessed by characterizing current and cumulative exposure to pesticides, and a history of past pesticide poisoning. Environmental exposure was assessed by the reporting of spray drift and pesticide smell in farm workers' homes. Depression and suicidal symptoms were assessed using six recognized instruments: 28 – item General Health Questionnaire

(GHQ) and the GHQ Depression Subscale; Beck Depression Inventory (BDI), Brief Symptom Inventory (BSI) Global Severity Index and BSI Depression Symptom Dimension; Refined 12-Item Four-Factor Measurement Model of Aggression, Barratt Impulsiveness Scale (BIS – 11), and Scale for Suicidal Ideation. Potential confounders for pesticide exposure and depression included general medical and psychiatric history, alcohol consumption, demography, use of protective clothing and current socio economic status. The data was analyzed using the Statistical Package for Social Studies (SPSS) Version 15.0.

Results

179 wine- and 638 table grape farm workers participated in the study. The mean age of the workers was 35 (SD 10) years. The gender distribution of the study population was 486 (59%) males and 331 (41%) females. The average years worked in agriculture was 14 (SD 10) years. The workers regarded as being at greatest risk of OP exposure were the 480 (59%) workers involved in one or more category of spraying, i.e. tractor spraying and / or lead spraying and / or hand spraying and / or backpack spraying. The remaining 337 (41%) study participants were predominantly female workers (70% females; 30% males) who executed general vineyard maintenance tasks

In this study, no evidence was found for a positive association between long-term (cumulative) and recent years of working in agriculture and any of the neuropsychiatric outcomes. On bivariate comparison, it was found that farm workers with cumulative years (≥ 13 years) of working as a head sprayer were more likely to have increased BSI Depression scores (Spearman r = 0.17, p = 0.05). However, in the multivariate model controlling for all identified confounders, this association fell away.

An important finding was that 110 farm workers (13%; 73 males; 37 females) reported a history of previous pesticide poisoning, and when controlling for all potential covariates, previous pesticide poisoning was significantly associated with psychiatric morbidity as measured by the GHQ (OR: 2.17; CI: 1.26 – 3.72) and depression as measured by the GHQ depression subscale (OR:1.62; CI: 1.00 – 2.63).

Environmental exposure was reported by 459 (56%) workers who observed spray drift reaching their homes and 516 (63%) reported a pesticide smell in their homes on pesticide spraying days. Moreover, 65% of the study population reported that they had lived next to vineyards during their years of residence on a farm. In the multivariate model controlling for all potential covariates, it was found that workers who reported smelling pesticides in their homes, were more depressed (OR: 1.66; 95% CI: 1.11 – 2.47) as measured by the GHQ Depression Subscale, and more aggressive (OR: 1.41; 95% CI: 1.00 – 2.00) on the 12-item Aggression Questionnaire.

Other significant findings were the positive associations between

(1) current / past psychiatric illness and

  (a) psychiatric morbidity (OR 4.83) as measured by the GHQ

  (b) physical, physiological and psychological distress (general distress (OR 3.55) as measured by the BSI GSI

  (c) depression as measured by the GHQ Depression Subscale (OR: 2.90), BDI-IA (OR: 6.02) and BSI Depression Symptom Dimension (2.36)

(2) low socio economic status and all the neuropsychiatric outcomes except suicidal ideation

(3) aggression and a high CAGE score (OR of the order of 1.2 to 1.3).

Limitations of the study

- The cross-sectional design of the study lends itself to the ‘healthy worker effect’ selection bias, where the ‘exposed’ workers selected for the study were healthier and protected because of the skilled tasks they performed, while the ‘unexposed’ workers selected, were possibly the problematic workers and those not employed in high risk / more skilled jobs. This type of bias may have led to an underestimation of the prevalence of neuropsychiatric outcomes for the ‘exposed’ workers studied and account if not completely, then at least partly, for the contrary findings for the ‘unexposed’ workers.

- An inability to calculate a JEM cumulative exposure metric, which may have improved the exposure metrics, because interviewers under-estimated exposure by missing specific exposure tasks which were crucial to determining cumulative pesticide exposure.
- Unavailability of farm records on spraying schedules, which would have provided vital information on the types of pesticides being sprayed as workers were often unable to remember the generic or trade names of pesticides. Hence, it can be assumed that the exposure findings in this study were not for organophosphates only, but for a mixture of pesticides.
- A lack of Information regarding time periods for re-entry into the vineyards after spraying, pesticide residue levels on vines after spraying and the extent of residue degradation. These factors may have assisted in pesticide exposure characterisation for general vineyard workers. and provided an explanation for the counter-intuitive outcomes for this group of farm workers.
- The timing of the study allowed for mainly farm workers with permanent employment status to be included in the study population, and excluded many seasonal workers who may have been involved in tasks with high pesticide exposure.
- The neuropsychiatric outcome instruments used in this study were able to measure the outcomes or covariates intended, since they produced associations with risk variables already established in the literature and consistent with expected patterns for age, gender and alcohol abuse. Therefore th main weakness of the study was the exposure estimation and not the validity of the instruments

Conclusion

The results do not show evidence that cumulative pesticide exposure experienced by farm workers on wine and table grape farms increases risk for adverse neuropsychiatric outcomes. However, environmental exposure may be associated with depression-related symptoms, or conversely depressed and/or aggressive workers may be more aware of environmental pesticide exposure. The likelihood of the development of psychiatric disorders and depression amongst grape farm workers is modestly increased by a history of past pesticide poisoning. Additionally, the findings suggest that poor socio economic conditions and a history of a current / past psychiatric illness are significant predictors of depression.

Recommendations

It is recommended that

- Future studies in the grape farming sector be designed as cohort studies, which may provide better answers to the outcomes of pesticide exposure for this community of farm workers
- Further exploratory or descriptive studies be conducted on the wine grape farming sector to establish the true nature / magnitude of pesticide exposure in this area of farming
- With future exposure studies, data on table and wine grape farms should be collected over time to track any trends.
- Methods of exposure assessment that have better reliability and validity be developed to maximize the quality of data collected as sole reliance on job history recall and measurement of frequency and intensity of pesticide spraying as a measure of cumulative exposure, may not be suitable for this group of workers
- More attention be given to the characterization of pesticide exposure in general farm workers with particular reference to pesticide residues on vines and post-spraying re-entry time into vineyards

- More precise measurements of psychiatric illness other than ‘nerves’ be developed
- Environmental exposure and biomarkers for exposure be factored into existing or revised Job Exposure Matrices to provide better estimates of exposure
- The findings of this study should be made available to the National Departments of Agriculture, Labour, Health, Environmental Affairs and Tourism, and the Department of Rural Development and Land Reform (former Department of Land Affairs) who is responsible for the national Comprehensive Rural Development Programme (CRDP).

TABLE OF CONTENTS

CHAPTER 4 RESULTS 147

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

1.1 Introduction

Farm workers in South Africa are not only confronted with a diversity of social, economic and labour-related challenges, they are also exposed to numerous occupational health and safety hazards on a nearly daily basis (du Toit, 1992; London et al, 1998a & 1998b; World Socialist Web Site (WSWS), 2003; Andersson, 2003; South African Human Rights Commission, 2007; Kruger et al, 2006; Atkinson, 2007). This is a situation that continues to exist despite the obligatory requirements of the Occupational Health and Safety Act (Act 85 of 1993, Section 8(1) that „every employer shall provide and maintain a working environment that is safe and without risk to the health of its employees', and the Constitution of South Africa (Act 108 of 1996, Chapter 2 „*Bill of Rights*') that everyone has „the right to an environment that is not harmful to their health or well-being' and „the right to the enjoyment of the highest attainable standard of physical and mental health'.

1.1.1 Pesticides as an occupational hazard

One of the many occupational hazards compounding the difficulties confronting farm workers is their exposure to pesticides, particularly organophosphates (OP's), which are potent neurotoxic chemicals used for pest control. Pests are unwanted living organisms that cause damage to crops, humans or other animals. Examples of pests in the agricultural setting include weeds, fungi, worms, mites and insects like mealybugs, snails and ants (U.S. Environmental Protection Agency, 2003).

South Africa is the largest market for pesticide use in Sub-Saharan Africa (Mishara, 2005; Dinham cited in Dalvie et al, 2009), wherein agriculture is the largest sector consuming pesticides (Dalvie et al, 2009). An audit comparing the mass of pesticides sold in the agricultural sector for 1994 and 1999, found that in 1999 an increase of over 50% in mass of pesticides had been sold in the pome fruit, potato and stone fruit sectors, while the grape fruit sector accounted for the most pesticides sold by mass in 1994 (39%) and 1999 (47%) (Dalvie et al, 2009).

Organophosphates (OP's), also known as organophosphorous compounds, are a group of pesticides with similar chemical properties (they are all derived from phosphoric acid) used for the eradication of pests in the agricultural, non-agricultural, including domestic sectors (Moschandreas et al, 2001). OP's are nerve poisons, which kill pests by disrupting their nervous systems. The same neurotoxic effects that they exert on pests, they are capable of exerting on humans (Costa et al, 2008). Most OP pesticides are insecticides, although there are also a number of related herbicide and fungicide compounds (*Organophosphate insecticides* 1996, pp.20-21).

OP exposure has been postulated as one of the most dire occupational-related risks experienced by the farming workforce making it a major public health problem globally. This exposure is the cause of a significant number of acute and chronic poisonings amongst rural farm residents in South Africa (Innes et al, 1990; Barlin- Brink, 1991; London, 1992; London et al, 1994; Dalvie et al, 1999; Bailie and London, 1998; Dalvie et al, March 2009; Dalvie et al, May 2009) and in other African countries (Bwititi et al, 1987; Ohaya-Mitoko, 1997; Hanshi, 2001).

While workers involved in the handling (application and mixing) of pesticides are at greatest risk of exposure (London, 1994; Dalvie et al, 1999; Meijster et al, n.d.; El Batawi M, 2004; Costa et al, 2008), there is evidence that they and all farm residents are also potentially at risk of spray drift (London and Myers, 1993; London and Rother, 1998; Smetherham, 2007; Dalvie et al, 2009), contact with post-spraying agrichemical residues on crops and trees (Coronado et al, 2004) and / or pesticide residues brought home on work clothes (overalls), shoes and other means (Hammond, 1999; Curl et al, 2002; Coronado et al 2004; London, 2006; Sherwood et al, 2007). Farm workers' exposure to agrichemicals is further compounded by pesticide contamination of water used for domestic and recreational purposes (London et al, 2000; Schulz et al, 2001; Kamel & Hoppin, 2004; Schulz et al 2007), and the presence of pesticide residue in fruit, vegetables and certain foods (THE Supplement, 1998; Poster: Pesticides in Your Food, 2004; Dalvie & London, under review). It is the combined effect of all these exposures that make farm workers more vulnerable to pesticide poisoning in the workplace.

1.1.2 Pesticides and suicide

Intentional and unintentional pesticide exposure has become associated with suicide worldwide. In its 2009 World Suicide Prevention Day statement, the World Health Organization (WHO) identified suicide as a leading cause of death for people worldwide and estimated that by the year 2020 „suicide will represent 2.4% of the global burden of disease' (WHO, 2009). In 2006, the WHO and the International Association for Suicide Prevention (IASP) identified that deliberate pesticide ingestion resulting in acute pesticide poisoning and more than 250 000 deaths annually, had become one of the leading methods of suicide globally (Eddlestone & Phillips, 2004; WHO, 2006; Bertolote et al, 2006; Konradsen, 2007; Gunnell et al, 2007). This statement updates a previous widely-cited WHO estimate of 2 million cases of intentional pesticide poisoning occurring annually, with 220 000 deaths (completed suicide) (cited by Gunnell & Eddlestone, 2003). The WHO (2004) reported that pesticide poisoning was the method of suicide for: 71% of Sri Lanka's suicides during 1980 - 1989; 62% of suicides in China for 1998 - 2000 and 30% of suicides in India in 1999. Gunnell and Eddlestone (2003) estimated that there were about 300 000 pesticide suicides annually in South East Asia and Western Pacific Regions. In their review of fatal pesticide self-poisonings, Gunnell et al (2007) confirm the above picture, estimating that 258,234 fatal suicides occurred annually worldwide, which accounted for 30% of global suicide deaths.

In Africa, a retrospective audit of completed suicides in Malawi (2000-2003) found that of the 84 reported suicide cases, 66 (79%) used an agricultural pesticide as the main method of suicide (Dzamalala et al, 2006). Similarly, it was found in Benin City, Nigeria, that during January 1996 and December 1997, 1.8% (n = 13 / 726) of medico-legal autopsies were suicide cases, and ingestion of „Otapiapia' (a locally concocted insecticide used to kill mosquitoes and cockroaches) was the commonest mode of suicide (Akhiwu et al, 2000). Additionally, research conducted by Pesticide Action Network (PAN) Africa and Beninois Organisation for the Promotion of Organic Culture (OBEPAB) (1999 - 2001) reported 703 documented incidents of pesticide poisoning, of which 16% of 619 cases in Benin resulted in death as did 23% of the 84 cases in Senegal

(PAN UK, n.d.). OBEPAB reported a frequency estimate of 21.3 serious pesticide poisonings per 100 000 population for 2000-2001 in Benin and a fatality incidence of 0.8 to 1.9 deaths per 100 000 persons per year. It was also found in this study that the insecticide endosulfan was responsible for 88% of fatalities. Because of its easy availability, suicide by pesticide ingestion has become a serious concern for cotton farming communities in Senegal, where PAN Africa documented 16 cases of suicide by deliberate pesticide ingestion in 11 villages during 2002-2006 (PAN UK, n.d.). A study in the coffee growing areas of Tanzania found that for the period 1980 - 1990 an average of 62 individuals with pesticide poisoning were admitted annually to the local hospitals and most of these cases were due to attempted suicide (Work and Health in Southern Africa – WAHSA, 2008). In South Africa, London et al (1994) reported that 35% of notified cases of pesticide poisoning in the Western Cape Province of South Africa were due to self inflicted injury. Moreover the South African Department of Health (DOH) (2005), reported that for the period 2001 to 2005, 72 deaths from pesticide poisoning had been notified to the DOH. The South African DOH (2008) further reported that 12, 364 cases of pesticide poisoning had occurred for the period 2000 to 2008, but no data on deaths ensuing from the pesticide poisonings for this period were reported. For this period (2000-2008), the Limpopo province accounted for 83% (n = 10273) of pesticide poisoning, followed by the Free State province (n = 509) and the Western Cape (n = 498), both of whom accounted for 4% of the burden of poisoning (DOH, 2008). Due to under-reporting and under-notification, there is however, a paucity of data on pesticide-related morbidity and mortality in South Africa (London & Rother, 1998; London and Bailie 1998; DOH, 2005; Mishara, 2005).

Therefore, taking cognizance of the available literature, it is clear that suicide due to deliberate or accidental pesticide ingestion has increasingly become a major public health problem globally, particularly in developing countries. Yet despite this association between pesticides, poisoning and suicide, highly toxic and dangerous agrichemicals are still being exported to certain developing countries from exporting countries where these same chemicals had been banned, or whose use had been severely restricted (PAN, 1999; FFTC, 1999; López-Valcárcel, 2001; Schafer, 2006).

In addition to the use of pesticides as an agent of self-injury, the international literature (Crombie, 1991; Parrón et al, 1996) suggests that OP pesticides may also be implicated as a cause of suicide amongst exposed farm workers based on evidence from clinical (Bradwell, 1994; Davies, 1995) and epidemiological (Stallones & Beseler, 2002; London et al, 2005; Beseler et al, 2006; Beseler et al, 2008) studies, in that acute or chronic exposure to OP's may be associated with affective disorders, particularly depression.

In contrast to the situation for acute OP poisoning, the literature on the relationship between chronic OP exposure (absent of an acute episode) and affective disorders like depression is sparse; what evidence exists is further outlined in more detail in Chapter 2.

Previous reviews (Kamel and Hoppin, 2004; London et al, 2005) have pointed out that, other than for symptom outcomes, evidence for health and neurological effects associated with long-term, non-acute, low dose organophosphate exposure was equivocal. Further, the literature that suggested a possible relationship between OP exposure and depression did so indirectly. London et al (2005) hypothesised a relationship between OP exposure and suicide based on the argument that there is a relationship between affective disorders (mainly depression) and suicide, and hence, the hypothesis that cumulative OP exposure could possibly lead to depression and then to suicide with impulsivity perhaps playing a mediating role (London et al, 2005). However, relatively few epidemiological studies have explored this hypothesis in any detail in recent years (Beseler et al, 2006; Lee et al, 2007; Beseler et al; 2008) and further analytical epidemiological studies on this topic are still warranted.

An ecological study conducted in the State of Rio Grande do Sul, Brazil (Faria et al, 2006) found no association with increased suicide rates and farming activities particularly pesticide poisoning, but there were correlations between suicide and social and economic factors. The study findings suggested that uncertain or poor socioeconomic conditions may be associated with improper pesticide handling and „inadequate pesticide use may be a mediator between low socioeconomic status and suicides' (Faria et al, 2006).

1.2 Importance of the study

Agriculture is one of the primary pillars of the Western Cape Province's economy and accounts for 5.2 % of the province's regional Gross Domestic Product (GDP) of R185,4 billion in 2004 (Wesgro, 2008).

The province contributes about 14% to the country's GDP and generates approximately 23% of the total value of the entire agricultural sector in South Africa (Wesgro, 2008). The Western Cape Province's economy is estimated to be larger than many other national economies in Africa and has outperformed the national economy of South Africa by a margin of at least 0.5% a year, over the period 1999 – 2006 (Wesgro, 2008).

The Western Cape Province produces between 55% and 60% of South Africa's agricultural exports of which deciduous fruits and viticulture are two of the main contributors. In fact about 73% of the total deciduous fruit crop was produced in the Western Cape in 2005/06, and grapes totalled 25% of the crop (South African Government Information, p.10). The Hex River Valley is one of the largest producers of export table grapes in Africa. Agriculture therefore forms a significant part of Western Cape Provincial economy and exhibits considerable potential for job creation.

However, when considering the benefits of agriculture to the economy of the country, cognizance must be taken of the impact of labour practices and working conditions on the heath of the workforce in this sector, as well.

Nationally and internationally, agricultural workers constitute three-quarters of the world's working population, yet they are often deprived of essential basic occupational services available to other worker communities. They are further compromised by being inadequately represented in government infrastructures and neglected in occupational health and safety legislation (El Batawi, 2003). These conditions persist despite agriculture work being regarded as a more hazardous occupation than mining/quarrying and construction in the United States in 1990 (USA National Safety Council cited by El Batawi, 2003).

The situation for farm workers in South Africa is very similar. Most farm workers live and work in remote rural areas of South Africa, where their isolation and poverty has caused them to become invisible and sometimes forgotten to society as a class of people. Farm workers' social isolation is compounded by their powerlessness over their occupational and residential circumstances and their vulnerability to the farm owner / manager on whom they are dependent for most aspects of their livelihood. Moreover, farm workers in South Africa are usually the last social constituency to be reached by government agencies (Atkinson, 2007). Farm workers in South Africa have a history of repression and exploitation, which is currently still evidenced by the inequality of power between the employer (farm owner / manager) and worker and their extremely impoverished living conditions. Additionally, the psychological impact of their past (and in some cases, current) situation has resulted in farm workers' inability to assert themselves in the workplace (du Toit, 1992; Husy & Samson, 2001), resulting in them being voiceless regarding their working conditions.

In addition to the plethora of historical, social and economic attritions confronting farm workers, they are also exposed to unsafe and unfair working conditions and labour practices (London et al, 1998a & 1998b; Kruger et al, 2006; South African Human Rights Commission, 2007). Hence it is not unusual for farm workers in South Africa to work hours in excess of 8 to 9 hours per day; be engaged in spraying, maintenance and harvesting activities simultaneously; be uninformed of the hazardous substances to which they are exposed; not be issued with PPE appropriate to the job they are doing; not be remunerated as specified by the Basic Conditions of Employment Act No. 75 of 1997, Sectoral Determination 13: Farm Worker Sector, South Africa; and to occupy farm houses that are in dire need of repair (observations as a WIETA social auditor)[1].

The grape farming Worcester area of the Western Cape was considered for this study because studies investigating the outcome of (London 1994; Dalvie et al 1999) and exposure to (Dalvie et al, 2003; van Wendel de Joode et al, 2005; Dalvie et al, 2009) long-term agrichemical use, have been conducted mainly in the fruit farming areas of the Western Cape, but less so in the grape farming area. Moreover, the 2002 census of commercial agriculture found that of the

[1] WIETA: Wine and Agricultural Ethical Trade Association

grape farming areas in the Western Cape, the Worcester area had the largest number of farming units employing the most full-time and seasonal farm workers. They also had the most planted hectares of table and wine grapevines in the Western Cape (Statistics South Africa, 2006). Additionally, the grape fruit sector accounted for the most pesticides sold by mass in 1994 (39%) and 1999 (47%) in the southern part of South Africa (Dalvie et al, 2009).

1.3 Statement of the Problem

The hazards of organophosphate pesticide exposure have been well-documented nationally and globally, yet in their work situations, farm workers in South Africa continue to be exposed daily to these agrichemicals. This is happening because despite South Africa having the necessary laws governing occupational health and safety, environmental protection and pesticide use in the country, the legislation is not being properly enforced. Also, farm workers are often ignorant of their right to a healthy and safe working environment or are powerless to assert themselves in the work situation. Moreover, the legislation regarding the registration of pesticides, toxicological classification and disposal and importation of pesticides, are outdated (Mishara, 2005; Rother et al, 2008).

Additionally, farming has been identified by the WHO as one of the occupations with high suicide rates because of workers „high rates of depression, hazardous work environments, job stress due to economic pressures and social isolation, access to large amounts of pesticides, and poor access to emergency services' (WHO 2006, p. 8). In fact, it has been predicted that by 2020 depression will be the leading cause of disability in developing countries (WHO, 2006).

It is disturbing that farm workers in South Africa (as with farm workers globally) are still highly exposed to the adverse effects of pesticides almost daily, despite the neurotoxic effects of acute OP exposure (Savage et al, 1988; Rosenstock et al 1991; Reidy et al, 1992; Kaplan et al, 1993; Yokoyama et al, 1998; Stallone & Beseler 2002) being well-documented, and the evidence of symptom outcomes for effects of long-term low-level OP exposure, in the absence of an acute poisoning episode (Gomes et al, 1998; Pilkington et al,1999; Pilkington et al, 2001; Jamal et al, 2002; Rothlein et al, 2006; Screenivasan & Stephens, 2004; Kamel et al, 2005).

Furthermore, it has been established that OP's are capable of affecting the central nervous system (CNS) (Minton & Murray, 1988; Singh & Sharma, 2000; Colosio et al, 2003) and there is evidence from studies on humans suggesting a positive association between depression, suicide and serotonin levels in the CNS (Oquendo & Mann 2000; Grohol 2005). Hence, it is reasonable to hypothesise that OP exposure may play a role in the aetiology of non cholinergic psychiatric and affective disorders (London et al, 2005). There are studies in other countries that have cited a relationship between OP exposure and depression (Ali et al, 1979; Davies, 1995; Stephens et al, 1995; Amr et al, 1997; Smits, 2000; Jamal et al, 2002; Beseler et al, 2006 & 2008), however further investigations of such an association is required, particularly in South Africa, where the association between OP exposure and neuropsychiatric outcomes have not been explored.

It is important to determine whether farm workers in South Africa may be at increased risk of depression and suicidal behaviour (WHO, 2006; WHO IASP, 2009), not only because of the myriad of social, economic and occupational atrocities that confront them regularly, or their tendency to alcohol abuse (London et al, 1998 & 2006), but also because of the agrichemicals they are exposed to in their daily occupations.

1.4 The Purpose, Aims, Hypothesis and Objectives of this study

1.4.1 Purpose of the study

The results of this study will assist in the development of an understanding of the neurotoxic effects of low-level long-term (chronic) and acute exposure to pesticides amongst farm workers in the grape farming sector. This will contribute to advancing scientific knowledge in an area where current understandings are limited.

Further, this information could be used when addressing current agricultural policy issues such as the review and initiation of new legislation, particularly concerning the registration of new pesticides, the improvement of health and safety practices on farms and occupational risk surveillance, so that the quality of life of farm workers can be enhanced. Lastly, the study findings will also provide some perspective of the neuropsychiatric status of farm workers on grape farms, and the impact of socioeconomic conditions on their mental health. This information can be made available to the provincial and regional and other relevant Departments of Health and Social Services for further action.

1.4.2 Aim of the study

The aim of this study is to ascertain the relationship between long-term exposure to organophosphate pesticides (OP'S) and psychological factors, specifically depression, that predispose to suicide, amongst farm workers in the Western Cape Province of South Africa.

1.4.3 Hypothesis

The study sought to test the hypothesis that greater long-term exposure to OP's is associated with increased risk of depression and suicidality in farm workers working on grape farms, independent of acute OP poisoning.

1.4.4 Objectives of the study

The objectives of the study were:

1. To assess the levels of recent and long-term occupational exposure to organophosphate pesticides (OP's), and describe red blood cell acetylcholinesterase levels (RBC - AChE) in wine and table grape farm workers in the study sites
2. To determine the current levels of depression, aggression, impulsivity and suicidality of farm workers in the study sites
3. To describe the levels of environmental exposure to OP's, and its relationship to depression, aggression, impulsivity and suicidality in farm workers in the study sites

4. To investigate the relationship between specific farming tasks, OP exposure and current levels of depression, aggression, impulsivity and suicidality in farm workers in the study sites
5. To describe the following factors and assess their role as potential confounders for the relationship of pesticide exposure to depression, aggression, impulsivity and suicidality
   - age
   - gender
   - alcohol consumption
   - current / past psychiatric illness
   - socio economic status

The layout of the thesis is as follows:

- Chapter 1 sets out the background to the study and the purpose, aims and objectives
- Chapter 2 reviews the literature on organophosphate action, neurotoxic and neuropsychiatric effects of pesticides, depression, suicide, neuropsychiatric instruments and potential confounders for pesticide exposure and depression, aggression, impulsivity and suicidality
- Chapter 3 sets out the methods used in the study
- Chapter 4 presents the univariate, bivariate and multivariate results of the study
- Chapter 5 discusses the results and limitations of the study, and gives a summary of the findings of the study
- Chapter 6 concludes with recommendations arising out of the study

The Harvard referencing method was used in this study

1.5 References

„Acute Pesticide Poisoning and the Need for National Surveillance Systems – The Case Example of Tanzania' 2008, *Work and Health in Southern Africa (WAHSA) Policy Briefs.*

Akhiwu, WO; Nwosu, SO; Aligbe, JU 2000, „Homicide and Suicide in Benin City, Nigeria', *Anil Aggrawal's Internet Journal of Forensic Medicine and Toxicology,* vol. 1, no. 2.

Andersson, H 2003, „Race tensions on South African farms', *BBC News,* 3 September 2003, 13:00 GMT 14:00 UK.

Atkinson, D 2007, *Going for broke: The fate of farm workers in arid South Africa,* HSRC Press, South Africa. www.hsrcpress.ac.za

Bailie, R & London, L 1998,'Enhanced surveillance for pesticide poisoning in the Western Cape – An elusive target', *S Afr. Med J,* vol. 88, pp.1105 -1109.

Barlin-Brinck, M 1991, „Pesticides in South Africa – An assessment of their use and environmental impact', *The Wildlife Society of South Africa*, Durban.

Bertolote, JM; Fleischmann, A; Eddlestone, M and Gunnell, D 2006, „Deaths from pesticide poisoning: a global response', *British Journal of Psychiatry,* vol. 189, pp. 201 – 203.

Beseler, C; Stallones, L; Hoppins, JA; Alavanja, MCR; Blair, A; Keefe, T; Kamel, F 2006, „Depression and Pesticide Exposures in Female Spouses of Licensed Pesticide Applicators in the Agricultural Health Study Cohort', *Journal of Occupational and Environmental Medicine,* vol. 48, no. 10, pp. 1005-1013.

Beseler, C; Stallones, L; Hoppins, JA; Alavanja, MCR; Blair, A; Keefe, T; Kamel, F 2008, „Depression and Pesticide Exposures among Private Pesticide Applicators Enrolled in the Agricultural Health Study', *Environmental Health Perspectives,* vol. 116, no. 12, pp. 1713 - 1719.

Bradwell, RH 1994, „Psychiatric sequelae of organophosphorous poisoning: a case study and review of the literature', *Behavioural Neurology,* vol. 7, pp. 117 - 122.

Bwititi, T; Chikuni, O; Loewenson, R; Murambiwa, W; Nhachi, C; Nyazema, N 1987, „Health Hazards in Organophosphate Use among Farm Workers in the Large-scale Farming Sector', *Central African Journal of Medicine,* vol. 33 no. 5, pp. 120 – 126.

Costa, LG; Giordano, G; Guizzetti, M; Vitalone, A 2008, „Neurotoxicity of pesticides: a brief review', *Frontiers in Bioscience,* vol. 13, pp. 1240 - 1249.

Coronado, CG; Thompson, B; Strong, L; Griffith, WC; Islas, I 2004, „Agricultural Task and Exposure to Organophosphate Pesticides Among Farmworkers', *Environmental Health Perspectives,* vol. 112 no. 2, pp. 142 - 147.

Crombie, IK 1991, „Suicide among men in the highlands of Scotland', *British Medical Journal,* vol.302, pp. 761 - 762.

Curl, CL; Fenske, RA; Kissel, JC; Shirai, JH; Moate, TF; Griffith, W; Coronado, G; Thompson, B 2002, „Evaluation of Take-Home Organophosphorous Pesticide Exposure among Agricultural Workers and Their Children', *Environmental Health Perspectives,* vol. 10, no. 2, pp. A787 - A792.

Dalvie MA, White N, Raine R, Myers JE, London L, Thompson M, Christiani DC 1999 „Long-term respiratory health effects of the herbicide, paraquat, among workers in the Western Cape', *Occup Environ Med,* vol. 56, No.6, pp. 391-396.

Dalvie, MA; Cairncross, E; Solomon A; London, L 2003, „Contamination of rural surface and ground water by endosulfan in farming areas of the Western Cape, South Africa, *Environmental Health: A Global Access Science Source 2:1* http://www.ehjournal.net/content/2/1/1

Dalvie, MA; Africa, A; London, L 2009, „Change in the quantity and acute toxicity of pesticides sold in South African crop sectors, 1994 - 1999', *Environment International,* vol. 35 no. 4, pp. 683 - 687.

Dalvie, MA; Africa, A; Adams, H; Solomons, S; London, L; Brouwer, D; Kromhout, H 2009, „Pesticide exposure and blood endosulfan levels after first season spray amongst farm workers in the Western Cape, South Africa', *Journal of Environmental Science and Health,* vol. 44 no. 3, pp. 271 - 277.

Dalvie, MA & London, L, „Risk assessment of pesticide residues in South African raw wheat', paper under review.

Davies, DR 1995, „Organophosphates, affective disorders and suicide', unpublished paper.

Department of Health (DOH) 2005, *Statistical Notes: Pesticide Poisoning 2001-2005,* Republic of South Africa.

Department of Health (DOH) 2008, *Statistical Notes: Pesticide Poisoning South Africa 2000 - 2008,* Republic of South Africa.

du Toit, 1992, „The Farm as Family: Paternalism, Management and Modernisation on Western Cape Wine and Fruit Farms', *Report on Fieldwork conducted for the Centre for Rural Legal Studies,* Stellenbosch, South Africa.

Dzamalala, C; Milner, DA; Liomba, NG 2006, „Suicide in Blantyre, Malawi (2000 - 2003)', *Journal of Clinical Forensic Medicine,* vol. 13, pp. 65 - 69.

Eddlestone, M; Phillips, MR 2004, „Self poisoning with pesticides', *British Medical Journal,* vol. 328, pp. 42 - 44.

El Batawi, MA 2003, *Health of workers in agriculture,* World Health Organization Regional Publications, Eastern Mediterranean Series 25.

Faria, NMX; Victora, CG; Meneghel, SN; de Carvalho, LA; Falk, JW 2006, „Suicide rates in the State of Rio do Sul, Brazil: association with socioeconomic, cultural, and agricultural factors', *Cadernos de Saúde Pública,* vol. 22, no.12.

Flemming, Konradsen 2007, „Acute pesticide poisoning – a global health problem', *Danish Medical Bulletin - No. 1,* vol. 54, pp.58 - 59.

Gunnell, D & Eddlestone, M 2003, „Suicide by intentional ingestion of pesticides: a continuing tragedy in developing countries', *Int J Epidemiol,* vol. 32, pp. 902 - 909.

Gunnell, D; Eddlestone, M; Phillips, MR; Konradsen, F 2007, „The global distribution of fatal pesticide self-poisoning: Systematic review', *BioMed Central Public Health,* vol. 7, no. 357. http://www.biomedcentral.com/1471-2458-7-357

Hammond, M 1999, „Organizing against Pesticide Use in Suburbia', in Miriam Wyman et al, *Sweeping the Earth,* pp. 203 - 215, Gynergy Books, Canada.

Hanshi, JA 2001, „Use of pesticides and personal protective equipment by applicators in a Kenyan district', *African Newsletter on Occupational Health and Safety,* pp. 74 - 76.

Husy, D; Samson, C 2001, „Promoting Development and Land Reform on South African farms', *Paper presented at the SARPN conference on Land Reform and Poverty Alleviation in Southern Africa',* Pretoria.

Jayaratnam, J 1985a, „Health problems of pesticide usage in the third world', *British Journal of Industrial Medicine,* vol. 42, pp. 505 - 506.

Innes, DF; Fuller, BH; Berger, GMB 1990, „Low serum cholinesterase levels in rural workers exposed to organophosphate pesticide sprays', *South African Medical Journal,* vol. 78, pp. 581 - 583.

Kamel, F & Hoppin, JA 2004, „Association of Pesticide Exposure with Neurologic Dysfunction and Disease', *Environmental Health Perspectives,* vol. 112, no. 9, pp. 950 - 958.

Kruger, A; Lemke, S; Phometsi, M; van't Riet, H; Pienaar, AE; Kotze, G 2006, „Poverty and household food security of black South African farm workers: the legacy of social inequalities', *Public Health Nutrition,* vol. 9 no. 7, pp. 830 - 836.

Lee, WJ; Alavanja, MCR; Hoppin, JA; Rusiecki, JA; Kamel, F; Blair, A; Sandler, DP 2007, „Mortality among Pesticide Applicators Exposed to Chlorpyrifos in the Agricultural Health Study', *Environmental Health Perspective,* vol. 115, no. 4, pp. 528 - 534.

London, L 1992, „Agrichemical hazards in the South African farming sector', *S Afr. Med J,* vol.81, pp. 560 – 564.

London, L; Ehrlich, RI; Rafudien, S; Krige, F; Vurgarellis, P 1994, „Notification of pesticide poisoning in the Western Cape, 1987 – 1991', *South African Medical Journal,* vol. 84, pp. 269 - 272.

London L, 1994, „An investigation into the neurological and neurobehavioural effects of long-term agrichemical exposure amongst deciduous fruit farm workers in the Western Cape, South Africa', PhD Thesis, University of Cape Town.

London, L & Myers, J 1995, „Agrichemical usage patterns and workplace exposure in the major farming sectors in the southern region of South Africa', *South African Journal of Science,* vol. 91, pp. 515 - 522.

London, L & Myers, J 1995, „Critical Issues for Agrichemical Safety in South Africa', *American Journal of Industrial Medicine,* vol. 27, pp. 1 - 14.

London, L & Myers, J 1995, „General patterns of agrichemical usage in the southern region of South Africa', *South African Journal of Science,* vol. 91, pp. 509 - 514.

London, L; Nell, V; Thompson, ML; Myers, JE 1998a, „Health status among farm workers in the Western Cape – collateral evidence from a study of occupational hazards', *South African Medical Journal,* vol. 88, pp.1096 - 1101.

London, L; Saunders, D; te Water Naude, J (ed.) 1998b, „Farm workers in South Africa – a challenge of eradicating abuse and the legacy of the "dop" system', *S Afr. Med J,* vol. 88, pp. 1093 - 1095.

London, L; Bailie, R 1998, „Improving surveillance for acute pesticide poisoning in the Western Cape, South Africa', *Newsletter on Occupational Health and Safety,* vol. 8, pp. 16 - 18.

London, L; Rother, A 1998, „Pesticides in Occupational Health: Implications of Policy Reform', *Occupational Health SA,* vol. 4, no. 4, pp. 30 - 35.

London, L & Rother, A-H 1998, „Pesticides: time to take action', *SA Labour Bulletin,* vol. 22, no. 5, pp. 73-79.

London, L; Dalvie, MA; Cairncross, E; Solomons, A 2000, „The Quality of Surface and Groundwater in the Rural Western Cape with regard to Pesticides', *Water Research Commission Report No. 795/1/00,* University of Cape Town in collaboration with Peninsula Technikon.

London, L; Flisher, AJ; Wesseling, C; Mergler, D; Kromhout, H 2005, „Suicide and Exposure to Organophosphate Insecticides: Cause or Effect?', *American Journal of Industrial Medicine,* vol. 47, pp. 308 - 321.

London, L 2006, „Taking toxins home', *Occupational Health Southern Africa,* vol 12, no. 3, pp. 4 - 10.

López-Valcárcel, A 2001,'New challenges and opportunities for occupational safety and health (OSH) in a globalized world', *African Newsletter on Occupational Health and Safety,* vol. 11, no. 3, pp. 60 - 63.

McNab, C 2006, *Pesticides are a leading suicide method*, media release, World Health Organisation (WHO), Geneva, 9 September 2006. Retrieved September 26, 2006 from http://medilinkz.org/news/news2.asp?NewsID=17774

Meijster, T; Wendel de Joode, B; Major, V; Maruping, M; London, L; Kromhout, H n.d., „Dermal exposure assessment for an epidemiological study among wine – and table grape farm workers', unpublished.

Mishara, BL 2005, *Report on the International Workshop on Secure Access to Pesticides in Conjunction with the Annual Congress of the International Association for Suicide Prevention,* IASP World Health Organization, Geneva

Moschandreas, DJ; Karuchit, S; Kim, Y; Ari, H; Leibowitz, MD; O'Rourke, MK; Gordon, S; Robertson, G 2001, „On predicting multi-route and multimedia residential exposure to chlorpyrifos and diazinon', *Journal of Exposure Analysis and Environmental Epidemiology,* vol. 11, pp. 56 – 6

Ohaya-Mitoko, G 1997, „Occupational pesticide exposure among Kenyan agricultural workers. An epidemiological public health perspective', PhD Thesis, Wageningen University, Holland.

Pesticide Action Network (PAN) –UK 1996, „Organophosphate insecticides', *Pesticides News,* no.34, pp. 20 – 21. Retrieved January 19, 2009 from http://www.pan-uk.org/pestnews/Actives/organoph.htm

PAN Updates Service 1999, „Dirty Dozen pesticides: banned but still traded', Retrieved December 19, 2008 from http://www.Green Left – Dirty Dozen pesticides ban

PAN-UK 2004, 'Pesticides in Your Food' [Poster]. Designed and printed by The Sheepdrove Trust. Retrieved from www.pan-uk.org/poster.htm

PAN-UK 2007, „Hazardous pesticides and health impacts in Africa', *Food & Fairness Briefing No. 6.*

Parrón, T; Hernandáz, AF; Villanueva, E 1996, „Increased risk of suicide with exposure to pesticides in an intensive agricultural area. A 12-year retrospective study', *Forensic Science International,* vol. 79, pp. 53 - 63.

„Production and use of pesticides in Asia' 1999, *Food and Fertilizer Technology Centre,* Taiwan.

Rother, H-A; Hall, R; London, L 2008, „Pesticide Use Among Emerging Farmers in South Africa: Contributing Factors and Stakeholder Perceptions', *Development Southern Africa,* vol. 25, no. 4, pp. 399 - 424.

Schafer, KS 2006, „One more failed U.S. Environmental Policy', *Foreign Policy In Focus (FPIF) Policy Brief,* Silver City, NM & Washington DC.

Sherwood, S; Cole, D; Murray, D 2007, „It's time to ban highly hazardous pesticides', *LEISA Magazine,* vol. 23, pp. 32 - 33.

Schulz, R; Peall, KC; Dabrowski, JM; Reinecke, AJ 2001, „Current-use insecticides, phosphates and suspended solids in the Lourens River, Western Cape, during the first rainfall event of the wet season', *Water SA,* vol. 27, no. 1, pp. 65 - 70.

Schulz, R; Peall, KC; Dabrowski, JM; Reinecke, AJ 2001, „Spray Deposition of Two Insecticides into Surface Waters in a South African Orchard Area' (Technical Report: Ecological Risk Assessment), *Journal of Environmental Quality,* vol. 30, pp. 814 - 822.

Smetherham, J 2007, „Deadly haze drifts in from the vineyards', *Cape Times,* November 2007.

South African Government Information n.d., „About SA – Agriculture and land affairs', http://www.gov.za/about SA

South African Human Rights Commission 2007, „South African farming communities still battle with human rights violations despite various government policies to bring about change', *Report issued by the Information and Communication Programme,* Johannesburg, South Africa.

Stallones, L & Beseler, C 2002, „Pesticide Poisoning and Depressive Symptoms among Farm Residents', *Annals of Epidemiology,* vol. 12, pp. 389 - 394.

Statistics South Africa 2006, *Census of Agriculture Provincial Statistics 2002- Western Cape. Financial and production statistics. Census of commercial agriculture,* Report No. 11-02-02 (2002), Pretoria.

Statistics South Africa 2006, *About Western Cape (WC).*Retrieved September 30, 2008 from http://www.About Wesgro.htm

The Human Ecologist (THE) Supplement 1998, vol.2. Retrieved March 02, 2008 from http://members.aol.com/HEALNatnl/hs0202.html

U.S. Environmental Protection Agency 2003, *About Pesticides*. Retrieved September 29, 2003 from http://www.epa.gov/pesticides/about/index.htm

Van Wendel de Joode, B; van Hemmen, JJ; Meijster, T; Major, V; London, L; Kromhout, H 2005, „Reliability of a semi-quantitative method for dermal exposure assessment: DREAM', *J Expo Anal Environ Epidemiol*, vol. 15, no. 1, pp.111 – 120

Wesgro n.d., *Agricultural Statistics in Brief.* Retrieved October 04, 2008, from http://www.Agri stats in brief_files/welcome.htm.

World Health Organization 1962, *Occupational health in agriculture: Fourth Report of the Joint ILO/WHO Committee on Occupational Health.* World Health Organization, Geneva.

World Health Organization 2004, „The Impact of Pesticides on Health: Preventing Intentional and Unintentional Deaths from Pesticide Poisoning', *SUPRE Suicide Prevention.*

World Health Organization 2006, „Preventing Suicide: A Resource at Work', *Department of Mental Health and Substance Abuse,* WHO, Geneva

World Health Organization 2009, „Suicide Prevention in Different Cultures' *International Association for Suicide Prevention (IASP),* WHO, Geneva.

World Socialist Web Site (WSWS) 2003, *South Africa: report reveals dire conditions facing farm workers.* Retrieved September 21, 2008 from www.wsws.org

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

The economy of many developing countries depends mainly on agriculture, and the majority of these countries' working population are agricultural workers. Agricultural work embraces a broad of range of activities that include preparation of the soil for planting and growing (including pest control); harvesting, processing and storage of all types of crops; transportation of workers, equipment and crops; maintenance and repair of machinery; breeding and caring for animals; and construction of roads, drainage and irrigation requirements and other requirements (El Batawi, 2004). In 1962 the World Health Organization (WHO) defined an agricultural worker as a person engaged either permanently or temporarily in activities related to agriculture (Joint ILO/WHO Committee Report, 1962).

2.2 Pests and Pesticides

In agriculture, pests include insects such as mites, worms and ants; weeds; fungi like mould spores; rodents such as rats and mice; nematodes; bacteria and any other crop destroying microorganisms. There are about 10 000 insects, classified as pests, that could destroy crops and livestock (Grodner, 1996). The battle to protect crops from the ravages of pests is not new. The use of pesticides to control unwanted living organisms can be traced back to 2,000 B.C. when „natural pesticides' were used such as sulphur (brimstone) used by the Chinese as a fumigant, and the ancient Greeks who used the „gall from the green lizard to protect apples from worms and rot' (Grodner, 1996). Pests have been controlled by a wide range of well known toxic agents that have been used as insecticides, rodenticides, fungicides, herbicides and other available pesticides, since the year 1500 A.D. However, the 1930's saw the birth of methods to synthesise chemical compounds and the increased potency of pesticide agents. Hence, the use of chemical compounds to control pests has been in existence for some time, it is only the types of chemicals being used that have changed over time. Increased technological capacity has meant that newer chemicals can be developed much quicker than ever before, outstripping evolutionary mechanisms for biological protection

Pesticides are classified according to the pests they control and may be grouped as insecticides, fungicides, herbicides, larvacides, molluscicides, nematocides, repellents, rodenticides, plant growth regulators, defoliants or dessicants (see glossary). The essential component of a pesticide is the active ingredient, which also determines the toxicity of the chemical substance. This includes organic and inorganic chemicals and other microorganisms of varying composition and function. However, many of the inert substances used as propellants, stickers, spreaders, emulsifiers, wetting agents, penetrating agents and dispersants may be even more toxic than the active ingredients (Hammond, 1999). Pesticides are used in other industries (such as the preservation of wood in the timber industry, domestic fumigation, etcetera), as well, but the largest amounts are used in agriculture.

Just as agrichemicals have the potential to kill or control pests, they can also cause unwanted adverse effects on human health and the environment. All pesticides are toxic substances and the risk of acute and chronic health effects to humans following exposure, is an inherent characteristic of the compounds. The possible hazards associated with pesticide use is sometimes ignored because of the short-term benefits that it generates to the farmer and the economy of the country in terms of profits and productivity, but the toxic and negative effects on the health of the workers applying and handling these agrichemicals, particularly in the agricultural sector where pesticide application is seldom supervised, cannot be ignored. Even pesticides of low acute or chronic toxicity could cause poisoning if the workers using them are subjected to prolonged cumulative exposure, and are not provided with the prescribed safety precautions when working with them (El Batawi, 2004). As stated by Kamel et al (2005), „neurologic dysfunction is the best-documented health effect of pesticide exposure'.

The most lethal of these pesticides are organophosphate insecticides (OP's), which disrupt the nervous systems of insects, and are used to enhance crop production and produce fruits and vegetables that are free of insects and blemishes. Regrettably, the basic neural functioning of mammals is similar to that of insects, making humans equally susceptible to these potent agrichemicals (Environmental Justice Foundation, 2003).

The persons most exposed to OP's and their adverse health effects are mainly farm workers engaged in the processes of handling, mixing and applying pesticides (London, 1994; London & Myers 1995; Dalvie et al, 1999; Meijster et al, n.d.; Environmental Justice Foundation 2003; El Batawi, 2004; Costa et al, 2008). However, workers performing general farming duties, like pruning, thinning of vines, [2]„suiering', harvesting and gardening are equally exposed because of non-compliance with safe re-entry times into the vineyards; contact with pesticide residue on leaves /fruit /branches; and lack of personal protective clothing (London, 1992b; Environmental Justice Foundation, 2003; Coronado et al, 2004).

The hazards of pesticide exposure have not been confined to farm workers and residents only. Some members the general public have also on occasion been subjected to OP exposure, particularly environmental exposure from pesticide spray drift and the negative health effects thereof, as highlighted in a spate of South African newspaper articles during the period 2006 to 2008 (Peters, 2006; Smetherham, 2007; Smetherham, 2008; Béga, 2008).

2.3 Organophosphates

Organophosphates (OP's) are chemical compounds produced by the reaction of alcohols and phosphoric acid. OP compounds are lethal neurotoxic chemicals used globally in industry and agriculture for the control of pests and vector-born diseases. They are also used in the treatment of certain medical conditions, like schistosomiasis, glaucoma and myasthenia gravis. Worldwide, organophosphate insecticides have become the most commonly used insecticides today.

[2] Suiering involves thinning of the vine leaves and is a form of summer pruning

The first organophosphate insecticide, tetraethyl pyrophosphate (TEPP) was synthetically manufactured in 1854. Approximately 2000 OP chemical substances were synthesised between 1934 and 1944. In the 1930's organophosphorous compounds were used as insecticides (Dyro, 2003), but they were developed into chemical weapons of war (nerve agents) before, during and after World War II (Reutter, 1999). The military designations of these nerve agents are GA (tabun), GB (sarin), GD (soman), GF and VX, which have no common names (Sidell & Hurst, 1992). After World War II, OP's were used again globally as pesticides.

An example of the continued use of highly toxic OP's is the very effective and broad-ranging insecticide parathion, which was synthesized in 1944. (*History / Uses of Organophosphates*, 2000). Despite its high degree of toxicity towards humans, it currently remains one of the most commonly used insecticides worldwide, even though it is one of Pesticide Action Network's (PAN) „Dirty Dozen' and associated with most of the fatal pesticide poisonings globally (Green Left, 1999; Organic Emporium, 2006). A recent study in South Africa found that parathion (registered only for certain uses) was still being used in agriculture and was one of the OP's sold to the agricultural sector in 1994 and 1999 (Dalvie et al, 2009). Besides Parathion, there are over 25 different types of OP's, in 55 different formulations, currently registered by the Department of Agriculture in South Africa (Organic Emporium, 2006).

Worldwide there are more than 100 different OP's, and they together with carbamates, are the most frequently used insecticides in agriculture and gardening (Antonijevic & Stojiljkovic, 2007). OP and carbamate insecticides account for 80% of reported toxic exposures globally (Freudenthal, 2003). Both organophosphates and carbamates have the property of inhibiting the enzyme cholinesterase and are therefore known as anticholinesterases (El Batawi, 2004). A more detailed account of the toxicity associated with anticholinesterases is presented below in section 2.3.1.

In South Africa, the total volume of pesticides sold to 5 agricultural sectors (used in a study) increased by 62% over the period 1994 to 1999 (Dalvie et al, 2009). Of the 5 sectors reviewed in the study, the highest increase in mass of pesticides sold in 1999 was to the grape sector (nearly double of the mass in

1994). Second to carbamates, OP's was the chemical group sold in the highest quantities in 1994 and 1999 (Dalvie et al, 2009). Additionally, the study found that the highly toxic pesticides, endosulfan and chlorpyrifos (aka dursban), were amongst the highest quantities active ingredients sold in 1994 and 1999. Chlorpyrifos has been identified as the most commonly used OP insecticide in the grape fruit sector of South Africa. It has also been detected in the rural environmental water system and has been associated with neurotoxic effects in humans (Schulz et al, 2001; Dalvie et al, 2009).

The organophosphate insecticides most commonly used on grape farms in South Africa are listed in Table 2.1 (Agricultural Information Services, 1999).

Table 2.1 Organophosphate insecticides used on Grape Farms in South Africa

Table Grape Farms	Wine Grape Farms
Chlorpyrifos	Chlorpyrifos
Dichlorvos	Dichlorvos
Fenthion	Formothion
Formothion	Methidathion
Methidathion	Mevinphos
Mevinphos	Omethoate
Prothiofos	Prothiofos
Temephos	
Trichlorfon	
Cadusafos	
Fenamiphos	

Source: Agricultural Information Services, 1999

2.3.1 Mechanism of Organophosphate Action

2.3.1.1 Cholinergic Toxic Mechanism

Organophosphates exert their acute toxic effects by inhibiting the enzyme, acetylcholinesterase (AChE) in nervous tissue, which leads to the accumulation of acetylcholine (ACh) in the neuronal junction and interferes with synaptic transmission (Casarett & Douell, 1986; Sultatos, 1994; Fiedler et al, 1995; Dyro, 2003; Abou-Donia, 2003; El Batawi, 2004; Antonijevic & Stojiljkovic, 2007).

For the transmission of nerve impulses to occur, the neurotransmitter acetylcholine (ACh) needs to bind with specific cholinergic (ChE) receptors (membrane proteins in the postsynaptic plasma membrane) in the somatic (voluntary) and autonomic (involuntary) nervous systems (Mearns et al, 1994; Tortora & Grabowski, 2003). The two types of cholinergic receptors which bind with ACh, are nicotinic and muscarinic receptors. Nicotinic receptors are found in the dendrites and cell bodies (Figure 1) of both sympathetic and parasympathetic postganglionic neurons (Figure 2) and in the motor endplate at the neuromuscular junction (NMJ). Muscarinic receptors (Figure 2) are found in smooth muscle, cardiac muscle and glands supplied by parasympathetic postganglionic axons, and sweat glands supplied by sympathetic postganglionic neurons (Tortora & Grabowski, 2003, p. 575). On stimulation, the ACh crosses the Neuromuscular Junction (NMJ) or Neuroeffector Junction (NEJ) gap and binds to the nicotinic or muscarinic receptors (Figure 2), which activates the effector cells to carry out their function(s). The effects initiated by the cholinergic neurons are brief as ACh is rapidly broken down by the enzyme AChE (Organophosphates: Toxicity, 2000; Tortora & Grabowski, 2003, p.286). The greater the amount of neurotransmitter (ACh) in the nerve gap, during activation of the effector cells, the longer and stronger the signal. To ensure that the signal is not too prolonged or too strong, ACh is taken back up into the prejunctional nerve, or the enzyme acetylcholinesterase (AChE) breaks it down into its original components of choline and acetyl (Organophosphates Toxicity, 2000; Tortora & Grabowski, 2003). Acetylcholinesterase is therefore critical to maintaining a steady-state equilibrium in the levels of ACh present in the neuronal junctions.

OP’s and carbamates, also known as anticholinesterase compounds, exert their acute toxic effects by inhibiting the esterase enzymes, most particularly cholinesterase (ChE) by phosphylation (including phosphorylation and phosphonylation) of the serine hydroxyl group, which is situated at the active site of AChE (El Batawi, 2004;, Antonijevic & Stojiljkovic, 2007). While the AChE remains phosphylated, its enzyme activity remains inhibited. As a result, ACh accumulates in the neuronal junction, leading to overstimulation of the muscarinic and nicotinic receptors and poisoning (Minton & Murray, 1988; Antonijevic & Stojiljkovic, 2007).

Figure 2.1 Structure of a Neuron (*source: Kerwin et al, 1997)*

Unipolar / sensory neurons; multipolar / motor neurons

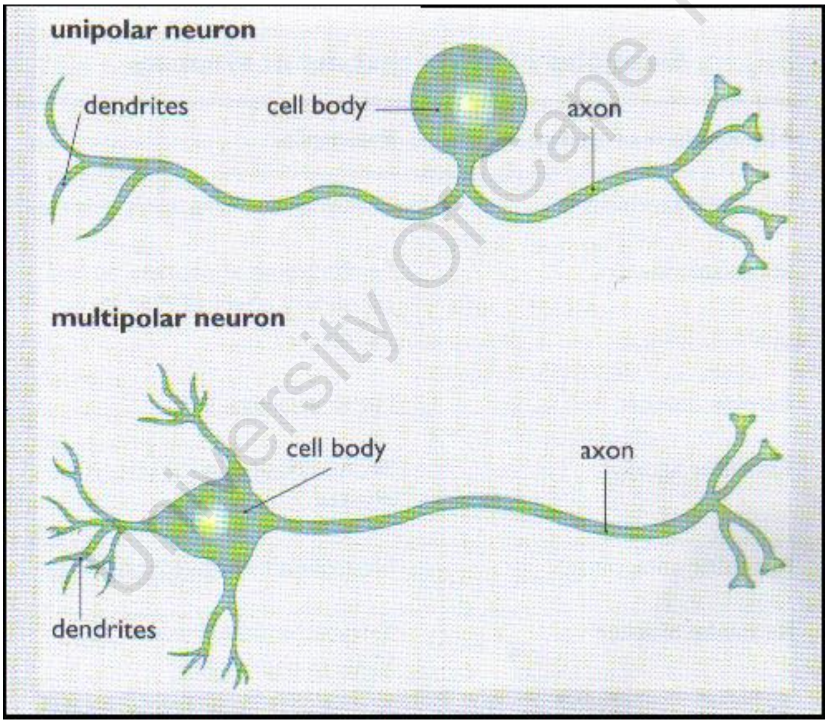
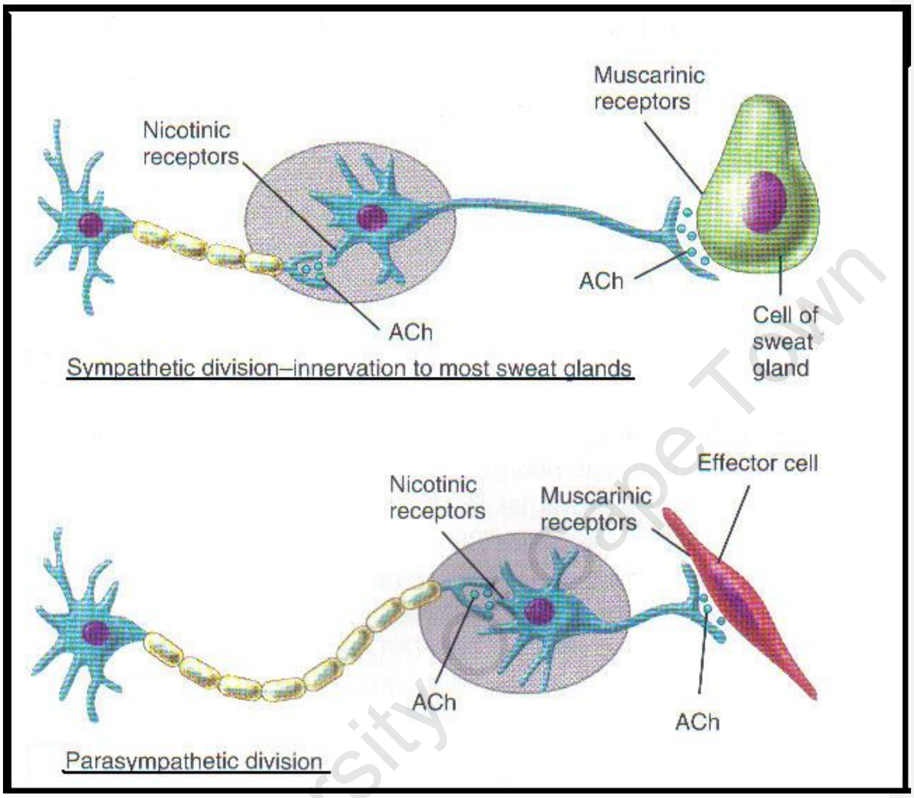


Figure 2.2 Cholinergic Neurons and Receptors
(source: Tortora & Grabowski, 2003)



The onset of toxicity is dependent on the type of OP, dose quantity and concentration, dose absorbed, frequency of exposure, duration of exposure, route of exposure, as well as other factors such as combined exposure to other chemicals and individual sensitivity and susceptibility' (Minton & Murray, 1988; So, 1995; Abou Donia, 2003). It is only after the acute or cumulative exposure has reached a certain level that the neurologic symptoms manifest. In the early stages of toxicity with OP's, the effects on AChE are reversible. However, if an oxime (e.g. Pralidoxime) is not administered within 24 to 36 hours of poisoning, the affected AChE enzymes become irreversibly bound and are permanently inactivated due to so-called „aging' of the enzyme-OP complex (before „aging' the complex can be uncoupled by treatment with oximes, but not so after „aging')

(Minton & Murray, 1988). The recovery of RBC cholinesterase then depends on the production of new red blood cells with uninhibited AChE. In situations where individuals have been exposed to increasingly higher doses of OP's gradually, they may have developed the ability to tolerate toxic levels of OP's, which would normally be associated with symptoms but which, under these circumstances are experienced without the subject demonstrating symptoms warranting medical attention, a phenomenon called tolerance (Hayes et al, cited in Mearns et al, 1994). A similar reaction was observed in animal studies of rats and OP's (Clark, cited in Mearns et al, 1994) and a study of pesticide manufacturers in China (Smith et al, cited in Mearns, 1994).

Acetylcholinesterase („true' cholinesterase) is found in red blood cells (RBC AChE), nicotinic and muscarinic receptors in nerves, muscles and gray matter of the brain. Plasma acetylcholinesterase (pseudocholinesterase) is found in the pancreas, heart and white matter of the central nervous system (CNS) (Dyro 2003; Freudenthal, 2003). Plasma AChE is purported to be the most sensitive indicator of recent exposure to OP's, but RBC AChE levels appear to be a more significant indication of ChE reduction in the nervous system (Mearns et al, 1994). Maximum ChE depression takes place 8 to 24 hours after exposure and the stabilisation of ChE levels could take up to 3 months (Mearns et al, 1994). Moreover, because muscle and nerve AChE are only present in the synaptic gap and cannot be measured directly, RBC AChE levels are usually assessed for diagnostic and monitoring purposes, since it has a structure similar to that of the synaptic enzyme and its measurement can therefore show what is happening at the synaptic site during the course of intoxication (Antonijevic & Stojiljkovic, 2007). Hence, the measurement of RBC AChE activity is an important biologic marker of exposure. However, since recovery of AChE in the brain is faster than in red blood cells, the measurement of RBC AChE levels may produce a result that is an overestimation of the inhibition of AChE activity in the nervous sytem (Lotti, 1995). This theory is based on the explanation that the rate of RBC AChE recovery is estimated at 0.5-1% daily (Dyro, 2003) while „the half-life of AChE resynthesis.in the nervous system has been reported to be 5 to 7 days' (Antonijevic & Stojiljkovic, 2007).

2.3.1.2 *Non Cholinergic Toxic Mechanism*

Besides ACh, some of the major central nervous system (CNS) neurotransmitters are the adrenergic transmitters, norepinephrine (NE) (Figure 3), epinephrine, dopamine (DA) and serotonin (5-hydroxytryptamine – 5-HT) (Kerwin et al, 1997, p. 95). NE, epinephrine, DA and 5-HT are also biogenic amines, which have excitatory or inhibitory properties. NE is considered to play an important role in affective and anxiety disorders. DA is released during emotional and pleasurable experiences and assists with the regulation of skeletal muscle tone and movement. A reduction in central DA concentration can lead to depression (Kerwin et al, 1997, p.109). Serotonin is considered to be involved in control of mood, sensory perception, temperature regulation, appetite and sleep induction (Tortora & Grabowski, 2003, p. 409). „The structural similarity of serotonin to several drugs known to cause mental aberrations, such as lysergic acid diethylamide (LSD), has prompted much speculation as to the role of serotonin in naturally occurring mental disorders such as schizophrenia or depression' (The Columbia Encyclopedia, 2008).

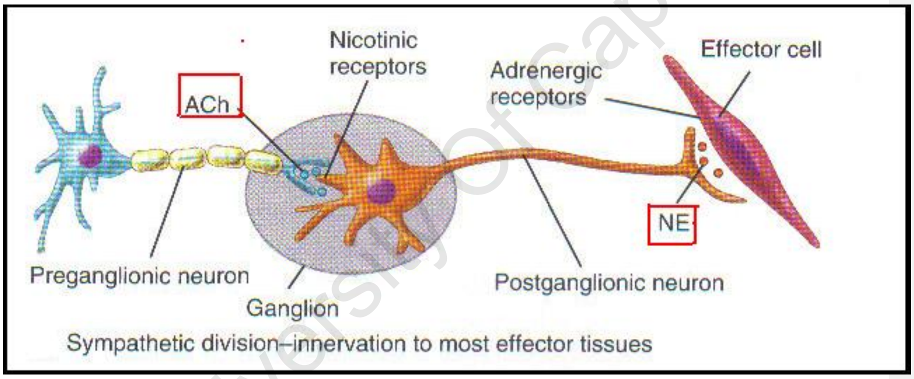
Exposure to OPs may play a role in affecting neurotransmitters other than ACh. A study conducted of rats exposed to chronic administration of the OP, dichlorvos by oral routes (Ali et al, 1979), found that the neurotransmitters, DA, NE and serotonin were significantly decreased after 10 days of exposure. This finding echoes the monoaminergic hypothesis of depression (Davies, 1995; Kerwin et al, 1997, p. 109). Furthermore, Kerwin et al (1997, p. 109) suggested that depression is due to the „functional deficit of a transmitter amine (e.g. norepinephrine, dopamine, 5-HT)'. Davies (2000) also suggested that many of the neuropsychiatric outcomes observed in persons with chronic exposure to anticholinesterase pesticides may be due to mechanisms involving serotonin depletion and not the result of ChE inhibition. The low 5-HT concentrations repeatedly found in the cerebrospinal fluid (CSF) of depressed patients supports the suggestion made by post-mortem studies, that the increased numbers of 5-HT receptors found in the brains of people who have committed suicide, could be attributed to a low 5-HT concentration' „(Kerwin et al, 1997, p. 109). Similarly, existing evidence suggest that depressive (affective) disorders are associated with a decrease of the neurotransmitters serotonin and norepinephrine (or noradrenaline) in the brain (Crow et al 1984; Grohol, 2005).

Therefore, based on the knowledge that OP's are known to affect the central nervous system (CNS) (Minton & Murray, 1988; Singh & Sharma, 2000; Colosio et al, 2003) and evidence from studies on humans that have explored the association between depression, suicide and serotonin levels in the CNS (Oquendo & Mann, 2000; Grohol, 2005), it is reasonable to hypothesise that OP exposure may have some role in the aetiology of non cholinergic psychiatric and affective disorders (London et al, 2005).

There are other animal studies that support a possible link between depression and OP's by demonstrating a link with non-inhibitory cholinesterase levels of OP exposure and serotonin levels and function in the brain. Aldridge and colleagues at Duke University Medical Centre (Aldridge et al, 2003) found that fetal and newborn rats injected with the OP, chlorpyrifos, during different developmental stages at doses lower than those that disrupt the ChE system, exhibited changes in their brain serotonin systems that persisted into adulthood. The maximum effects marked by 30-80% increases above control levels for serotonin receptors and transporters, occurred at a stage in the rats' development that is parallel to the second trimester of human development. These findings suggest the possibility of a noncholinergic mechanism of chlorpyrifos (OP)-induced neurobehavioural anomaly for humans. Similarly, the findings of a study conducted by Slotkin (2005) reinforced the findings of Aldridge et al (2003) that chlorpyrifos exposure at doses below the threshold for maternal or foetal/neonatal toxicity and below the requirement for foetal brain ChE inhibition, affects the synaptic activity of neurotransmitters 5-HT and DA, which were likely to cause behavioural alterations in adolescence and adulthood, suggesting that foetal exposure to chlorpyrifos in humans can have lasting affective consequences. A further study conducted by Slotkin et al (2006) buttressed the concept that certain OP's target specific neurotransmitter systems differently in the developing brain, without the requirement for ChE inhibition. It was found that the effects of the OP, diazinon, on 5-HT receptors were similar to that of chlorpyrifos in direction and magnitude (Aldridge et al, 2003), while Parathion, exhibited a different spectrum of 5-HT disruption to chlorpyrifos and diazinon. These findings cast doubt on the adequacy of ChE inhibition as a biomarker for assessing OP exposure or outcome related to developmental neurotoxicity, as the alterations in neurodevelopment occurred at levels below the threshold for ChE inhibition (Slotkin et al, 2006). These studies also provide evidence to support the general hypothesis of London et al (2005) that „OP effects on mood may be mediated by non-cholinesterase mechanisms involving serotonin'.

Besides depression, lower serotonin levels have also been associated with impulsivity, which has been reported as an important factor associated with suicidal acts (Oquendo & Mann, 2000; China Development Brief, 2000). Anxiety states, aggression, alcoholism and suicidal behaviour have also been associated with lower serotonin levels, but the specific mechanisms of the production of these disorders were still not fully known.(Davies, 1995). However, it has been established that drugs which specifically increase the levels of serotonin in the intrasynaptic space, are effective treatments for all the aforementioned affective conditions (Davies, 1995).

Figure 2.3 **Cholinergic and Adrenergic Neurons**
(*source: Tortora & Grabowski, 2003)*



Cholinergic neurons release ACh; adrenergic neurons release norepinephrine (NE)

2.3.2 Routes of Exposure to Pesticides

The route of exposure for any pesticide is affected by the extent of absorption and hence the dose absorbed, of a particular chemical substance. The time taken for the onset of toxic effects is influenced by the route of exposure, dose absorbed, and other factors like the ambient temperature, environmental humidity, availability, use and condition of protective clothing (e.g. a pesticide spray leaking into a broken or wrist-length glove is more damaging than not wearing a glove).

Dermal contact is the main route of exposure to all pesticides, with air exposure contributing a few percent of the total exposure (Brouwer et al, 1994). Since agricultural activities occur mainly in the open, the skin is a main site of absorption, followed by the lungs and the gastro-intestinal tract (Minton & Murray, 1988; Hammad & Manocha, 1995).

Both occupational and non-occupational pathways for absorption have been outlined (London, 1994; London & Myers, 1995; London & Myers, 1998; London & Rother, 1998; Hammond, 1999; London et al, 2000; Pesticides and You, 2000 - 2001; Schulz et al, 2001; Coronado et al, 2004; Meijster et al, n.d.).

Activities constituting occupational risks of exposure and absorption are:

- Handling pesticides – storing, packing, carrying
- Applying pesticides – weighing/loading, mixing, spraying (tractor, walking behind tractor with hand-held apparatus, backpack apparatus, aerial)
- Dipping of cattle, sheep and other animals
- Maintenance work in orchards, vineyards, crop fields (pruning, thinning, „suiering', trimming) allows farm workers to come into contact with pesticide residue on leaves, branches and crops because the correct re-entry times are not adhered to
- Harvesting / picking of sprayed crops.
- Contamination with pesticide spray drift as a result of farm workers being in the orchards, vineyards or fields while pesticide spraying is taking place
- Washing / cleaning of contaminated spraying machinery and equipment, pesticide handlers' and spray persons' overalls and other protective clothing
- Empty pesticide containers that have not been cleaned in the prescribed manner and still containing pesticide residue, used for storing foodstuffs and water or washing work clothes
- Eating with pesticide-covered fingers and hands

Forms of environmental exposure include

- Pesticide spray drift from tractor mist blowers and aerial spraying can enter the farm workers homes if windows or doors are open during spraying
- Pesticide spray drift can contaminate clothes that are hanging on wash-lines in the yards of farm workers homes on spraying days
- The source of drinking water on farms can become contaminated from pesticide spray drift
- Swimming in rivers and dams contaminated by pesticide spray drift
- Ingestion of fruits and other produce containing high levels of pesticide residue because they are picked and eaten directly from the crop

Other pathways for indirect pesticide exposure are washing pesticide contaminated clothing with the rest of the household's clothing, and farm workers bringing the pesticide residues into their homes via their contaminated work footwear.

2.3.2.1 Dermal / Percutaneous Absorption

Dermal or percutaneous absorption as a route of pesticide exposure is a significant occupational hazard. Dermal absorption is determined by the concentration of the pesticide, duration of contact with the contaminated area, size of cutaneous surface area affected, presence of other compounds that may assist with the passage of the chemical through the skin, lipid solubility, and permeability of the skin (Hammad & Manocha, 1995; Harvey & Hogan, 1995; Moschandreas et al, 2001).

In agriculture, dermal exposure takes place with the handling and application of pesticides; maintenance and handling of sprayed orchards, vineyards, and other crops; dipping of animals; cleaning of contaminated machinery and equipment; aerial spraying; washing of contaminated protective clothing; spray drift contamination; and swimming / bathing in contaminated water. Wet clothes (due to aerial mists, vapours and sweating) increase the absorption of pesticides. This is therefore another route of dermal absorption because of the deposition of droplets on clothing and OP's ability to penetrate clothing. Many OP's are also able to penetrate the intact skin and mucous membranes, including the cornea of the eye (Minton & Murray, 1988).

2.3.2.2 *Inhalation Absorption*

Inhalation or respiratory absorption is based on the duration of exposure to the contaminant, the concentration of contaminant or pesticide in the inspired air, and rate of inhalation of the exposed worker. Inhalation exposure occurs when the air being inhaled has been polluted indoors, environmentally or occupationally in the work environment (Hammad & Manocha, 1995; Moschandreas et al, 2001). Airborne pollutants are present in gases and vapours, liquid droplets and particulates and fibres (Dyro, 2003). Farm workers involved in the weighing, mixing and dispensing of pesticides, particularly indoors, are at greatest risk of inhalation absorption. Many organophosphates cause irritation of the upper respiratory tract. Even though the irritation is usually confined to the upper airways, associated wheezing and tightness of the chest have occurred in some instances (O'Malley, 1997).

2.3.2.3 *Intestinal Absorption*

Intestinal absorption occurs as a result of ingestion of pesticides either accidentally or intentionally. Accidental ingestion can occur as a result of poor food hygiene and eating foods with pesticide contaminated hands, eating contaminated crops and drinking water that have been contaminated by deposition from pesticide spray drift and agriculture run-off water (Schulz et al, 2001; Dalvie et al, 2004). Intentional ingestion of pesticides resulting in poisoning and sometimes death (self-poisoning), has become a global public health problem, particularly in low and middle-income countries like Sri Lanka, Malaysia, India, China and South East Asia (Singh & Sharma, 2000; Smit et al, 2003; Bertolote et al, 2006; Konradsen, 2007).

2.3.3 Effects of Organophosphate Pesticide Exposure

Organophosphorous compounds are neurotoxic to humans and animals. According to Costa et al (2008) „neurotoxicity can be defined as any adverse effect on the central or peripheral nervous system caused by chemical, biological or physical agents'. Exposure to OP compounds can cause the following clinical syndromes: (1) acute cholinergic neurotoxicity as a result of AChE inhibition, (2) intermediate syndrome, (3) organophosphorus ester-induced delayed neuropathy (OPIDN) due to the inhibition of neuropathy target esterase (NTE) and (4) organophosphorus ester-induced chronic neurotoxicity (OPICN) due to long-term low-level exposure (Rosenstock et al, 1991; Singh & Sharma, 2000; Abou Donia, 2003; Delgado et al, 2004; Antonijevic & Stojiljkovic, 2007).

2.3.3.1 Acute Cholinergic Neurotoxicity

The clinical manifestations of acute cholinergic toxicity usually appear after exposure to a single large dose of short duration of OP insecticides, and is due to accumulation of acetylcholine (ACh) at the nerve endings. The onset of symptoms can occur immediately or within hours of exposure, although this may be delayed for up to five (5) days (O'Donoghue, 1983; Minton & Murray, 1988; Lotti, 1992; So, 1995; Dyro, 2003; Antonijevic & Stojiljkovic, 2007). The severity of the symptoms of neurotoxicity depends on the route of exposure, age of the exposed person and the specific agrichemical (see Appendix D for the clinical features of OP toxicity). The irreversible binding of OP's to ACh can be prevented by the administration of Oximes in the early phase of intoxication (Poojara et al, 2003; Antonijevic & Stojiljkovic, 2007) corresponding to the period when the binding of enzyme-OP complex is still reversible (See Section 2.3.1).

The symptoms of continued OP exposure (dizziness, headache, nausea, vomiting, diarrhoea) can be mistaken for the symptoms of other communicable diseases (that commonly affect marginalized impoverished communities like farm workers, e.g. bilharzia and gastro-enteritis), resulting in the affected person(s) being misdiagnosed and receiving the incorrect medical intervention (Bwititi et al, 1987). Farm workers may also not report their symptoms of OP poisoning because of fear of losing their jobs, or they are ignorant of the link between their ill-health and their occupational exposure (Gomes et al, 1998).

The diagnosis of acute organophosphate intoxication is based on a history of exposure and depression or inhibition of RBC or plasma ChE activity level. Serum / plasma ChE (PChE) levels of activity are a measure of recent OP exposure, while RBC-ChE levels measure acute toxicity (RBC-AChE give an indication of effect over one or two months duration). When there is exposure to anticholinesterase compounds, the RBC-ChE activity may be depressed at sub-clinical levels (Cholinesterase Reference Laboratory n.d.). A study conducted in 1998 found that farm workers exposed to cumulative low doses of OP's had inhibited AChE activity levels without manifestations of acute clinical toxicity (Gomes et al, 1998).

A study conducted in 1990 in Somerset West, Western Cape Province, South Africa, found depressed plasma cholinesterase levels in farm workers exposed to a range of pesticides including two OP insecticides (chlorpyrifos and azinphos-methyl), without them exhibiting any clinical signs and symptoms of acute intoxication. After removing them from their spraying duties for 6 weeks, and then retesting them, there was a marked increase in the ChE levels of these workers (Innes et al, 1990). A sub-set of OP insecticides, the phosphorothioates (such as chlorpyrifos), have a slower onset of toxic symptoms than other organophosphates. In severe cases they may remain in the body for numerous days or weeks, and being fat-soluble may provoke a secondary recurrence of clinical symptoms after an initial period of apparent recovery (Minton & Murray, 1988; Bardin et al, 1994).

2.3.3.2 Intermediate Syndrome (IMS)

The IMS follows an acute cholinergic incident of severe OP intoxication (in 20-60% of individuals) and is characterised by symptoms indicative of a prolonged action of AChE on the nicotinic receptors, which usually manifests 12 to 96 hours after exposure (Singh & Sharma, 2000; Poojara et al, 2003; Delgado et al, 2004). Senanayake and Karalliede (1987) coined the term IMS because the symptoms occur „after the acute cholinergic crisis and before the expected onset of the delayed neuropathy'. The first clue to onset of the syndrome may be weakness of the respiratory muscles developing into paralysis and respiratory depression requiring ventilatory support. Weakness of the muscles of the eyes, neck and proximal limbs may also occur and cranial nerve palsies are common. The sensory functions usually remain intact and full recovery is 4 to 18 days. The OP compounds commonly associated with IMS are diazinon, dimethoate, methylparathion, methamidaphos, monocrotophos, fenthion and ethylparathion (Senanayake & Karalliede, 1987; Singh & Sharma, 2000; Poojara et al, 2003; Delgado et al, 2004; Yang & Deng, 2007). IMS has been well recognised as a disorder of NMJ's, but its exact pathophysiology has not yet been fully established. The early recognition and treatment of respiratory failure is vital to a favourable prognosis for IMS.

2.3.3.3 Organophosphorous Ester-Induced Delayed Neuropathy (OPIDN)

Polyneuropathy (a paralysis and degeneration of predominantly motor nerves in the extremities), may occur 1-4 weeks after a single large dose or repeated smaller doses of certain OP's, and is another possible consequence of OP exposure (Minton & Murray, 1988; Mearns et al, 1994; Harp et al, 1997; Singh & Sharma, 2000; Dyro, 2003; Lotti & Moretto, 2005; Kart, 2007). This condition, known as Organophosphate Induced Delayed Neuropathy (OPIDN), has no direct relationship to the inhibition of AChE. OPIDN is characterised by „a distal "dying back" or Wallerian-type degeneration of long axons in certain central and peripheral nerve tracts' (Johnson, 1982 cited in Harp et al, 1997). The delayed neurotoxicity has been associated with phosphorylation (inhibition) of the receptor protein neurotoxic esterase, neuropathy-target esterase (NTE), followed by „aging' of the phosphorylated enzyme, which is necessary to produce the neuropathic effects (Singh & Sharma, 2000; Dyro, 2003; Abou-Donia, 2003; Lotti & Moretto, 2005). Kart (2005) reports that all OP's which are capable of inhibiting NTE do not cause OPIDN. NTE is found in neuronal tissue mainly in the brain, but also occurs in the spinal cord and peripheral nervous system, as well as in non-neuronal tissue, like the spleen and lymphocytes, which accounts for the use of lymphocyte NTE as a biomarker for OPIDN. NTE's biochemical and physiological function, however, has not been clearly defined (Singh & Sharma, 2000; Abou-Donia, 2003; Kart, 2005). Animal studies on 8-week old chickens showed that OPIDN affected the central and peripheral nerves resulting in changes defined as „central-peripheral distal sensory-motor axonopathy' (Harp et al, 1997; Abou-Donia, 2003; Kart, 2005). The clinical signs of OPIDN are initially paraesthesia and calf pain, followed by foot drop due to weakness in the distal leg muscles, extending to the muscles of the hand causing claw hand. Weakness could continue to extend proximally accompanied by sensory and motor loss with gait ataxia. The neuropathy is subacute in onset with a slow progression over two weeks (Minton & Murray, 1988; Singh & Sharma, 2000). The OP compounds involved in OPIDN are triorthocresylphosphate (TOCP), phosphorothioates (e.g. chlorpyrifos), methamidophos, trichlorfon, trichloronate and fenthions (Minton & Murray, 1988; Davies, 1990; Singh & Sharma, 2000; Abou-Donia, 2003; Delgado et al, 2004; Lotti & Moretto, 2005). Some of these OP compounds are in current use on grape farms in South Africa (see Table 2.1).

2.3.3.4 Chronic Neurotoxicity following Intoxication with Organophosphorous Compounds (OPICN)

Various epidemiological studies have shown that, individuals who have been exposed to either a large toxic dose or small subclinical doses of OP's may develop a chronic neurotoxic condition different to acute cholinergic toxicity and OPIDN (Savage et al, 1988; Rosenstock et al, 1991; Ames et al, 1995; Ahmed & Davies, 1997; Singh & Sharma, 2000; Davies et al, 2000; Jamal et al, 2002; Stallones & Beseler 2002; Delgado et al, 2003; Colosio et al, 2003; Abou-Donia, 2003), that could continue for many years after exposure. Abou-Donia (2003) describes this condition as „a nervous system disorder induced by organophosphorous compounds which involves neuronal degeneration and subsequent neurological, neurobehavioral, and neuropsychological consequences' and refers to it as „organophosphorous ester-induced chronic neurotoxicity' or OPICN. With this condition there may be damage to both the peripheral and central nervous systems with more emphasis on CNS injury. The effects of the resultant neuropathological changes may continue for weeks to years after exposure as recovery is slow and may never be complete (Abou-Donia, 2003). OPICN could follow the development of acute cholinergic neurotoxicity, OPIDN (in some cases) and after long-term low-level (LTLL) exposure in the absence of acute neurotoxicity (subclinical doses of OP's).

2.3.3.4.1 OPICN following acute OP poisoning

Several studies have documented the long-term adverse effects following acute episodes of OP poisoning with or without AChE inhibition. Savage et al (1988) reported chronic neurological sequelae in the cognitive and motor skills fields in a group of persons who had previously experienced acute OP poisoning. Other studies evaluating the effects of long-term OP exposure, have also reported persistent abnormalities in affect, particularly anxiety and continued depression for years after the pesticide poisoning, as well as difficulties with memory and impaired concentration (Savage et al, 1988; Gershon & Shaw, 1961, cited by Rosenstock et al, 1991; Sereda & Gromov, 1994, cited by Gomes et al, 1998).

A study conducted by Rosenstock et al, between 1986 and 1988, found neuropsychological dysfunction (e.g. reduction of verbal attention and visual memory) two years after a single episode of clinically significant organophosphate poisoning (Rosenstock et al, 1991). Another finding of the study was a borderline increase in somatic symptoms on the BSI amongst the exposed group of participants, but no other differences in psychiatric symptoms between the two study groups.

Reidy et al (1992) found that migrant Hispanic farm workers, acutely exposed on two occasions to Phosdrin (organophosphate), Lannate (carbamate) and Maneb (organomanganese compound), reported significantly higher scores on a 28-item Neurotoxic Anxiety and Depression Scale constructed from the Spanish version of the Minnesota Multiphasic Personality Inventory (MMPI; 23 anxiety items and 5 depression and psychomotor retardation items), than the controls used in the study. A larger proportion of the exposed than the control group reported symptoms of irritability (exposed 76.2%; control 9.1%), difficulty concentrating (exposed 85.7%; control 0%), confusion (exposed 66.7%; control 0%) and memory problems (exposed 71.4%; control 0%). These findings, however, were weakened because the exposed subjects were involved in litigation at the time of the study, which may have increased their anxiety and depression levels resulting in over-reporting of pesticide poisoning (Mearns et al, 1994).

Kaplan et al (1993) found that five patients poisoned with chlorpyrifos reported CNS nicotinic effects of deficiencies in concentration, word-finding and memory (cited in Colosio et al, 2003).

Yokoyama et al (1998) reported on the long-term sequelae of 18 individuals (9 males and 9 females) exposed through inhalation to the OP nerve agent, sarin, in 1995. At the time of the intoxication, highly exposed persons developed clinical signs of the nicotinic effects of OP intoxication (muscle fasciculation, tachycardia, hypertension, respiratory compromise) and those with mild exposure showed some of the CNS effects (headaches, dizziness). RBC AChE inhibition was also a more reliable indicator of exposure than plasma ChE activity (Abou-Donia, 2003). Three years later, a reduction in psychomotor performance and impaired general health, chronic fatigue and posttraumatic stress were observed in the 18 exposed individuals (Yokoyama et al, cited in Colosio et al, 2003)

A study conducted by Stallones and Beseler concluded that farmers followed up between 1992 and 1997 who experienced episodes of acute OP poisoning had a six-fold risk (OR=5.95; 95% CI = 2.56-13.84) of suffering depression in the months after their poisoning (Stallone & Beseler, 2002).

2.3.3.4.2 OPICN following subclinical exposures to OP compounds

There are some studies that have been conducted on the chronic neurotoxic effects of long-term low-level (LTLL) exposure (or subclinical exposure) to OP's, in the absence of an acute poisoning episode.

In a study carried out by Ames et al (1995) on a subset from the large-scale joint National Institute of Occupational Safety and Health (NIOSH)-California study, a group of 45 male subjects with prior history of documented ChE inhibition below worker removal thresholds but with no evidence of clinical OP poisoning (i.e. asymptomatic), was compared to 90 male subjects who had neither past ChE inhibition nor current pesticide exposure. They found no evidence of an association between moderate OP exposure, (i.e. inhibited cholinesterase activity but no clinical manifestation of acute poisoning) and chronic neurological effects.

In a study of migrant farm workers chronically exposed to low levels of pesticides, Gomes et al (1998) found that the positive association between low scores on the aiming and digit symbol tests and inhibited AChE activity, supported their hypothesis of the presence of subclinical neurological dysfunction and memory disorders among the more established (exposed) farm workers compared to the unexposed workers. They therefore concluded that farm workers with long-term exposure to pesticides were potential candidates for neurological and memory disorders.

Additionally, Abou-Donia (2003) has noted that OPICN and Alzheimer's Disease share a common symptom of memory impairment and suggested that the aging process in humans may be hastened following exposure to OP compounds causing OPICN.

A cross-sectional study carried out by Pilkington et al (1999) that compared 612 sheep-dippers exposed to OP's with a large group of unexposed subjects, and where all investigators were blinded to the identity and category of the study subjects, their exposure history or the outcome of the field study, as well as each other's findings, found a positive link between LTLL exposure to OP's and chronic neurotoxicity in the form of distal axonal peripheral neuropathy, which was approximately 40 times higher in the subjects exposed to OP's. The study concluded that up to a fifth of sheep-dippers could suffer some degree of neurological damage after chronic exposure to OP sheep-dip. Another study by Pilkington et al (2001) on sheep farmers and dippers to examine the relationship between OP exposure and a broad range of neurological symptoms found limited evidence of a chronic effect of low-dose cumulative exposure to OP's in sheep dip. The study did however find that peripheral sensory symptoms (OR = 5.4) rather than muscle weakness (OR = 2.0) or autonomic symptoms (OR = 2.2), were more commonly found amongst OP concentrate handlers than non-handlers. Additionally, it was suggested that repeated exposures to concentrated forms of OP's above a certain threshold could be associated with long-term health effects in exposed individuals, without them manifesting cholinergic effects.

Furthermore, in a study of sheep farmers and dippers conducted by Jamal et al (2002), it was found that sheep dippers who handled concentrated OP dip reported more neuropathic symptoms than individuals who did not handle the concentrate. Their neuropathic findings were of a predominantly sensory type symptomatically and neurophysiologically with no acute features and distal chronic axonopathy, which contrasted with the neuropathy of OPIDN where there is mainly involvement of motor fibres resulting in muscle weakness and paralysis, and participants were identified as having probable peripheral neuropathy. Similarly, a study amongst farm workers in Florida of pesticide related neurotoxicity confirmed neuropsychological deficits associated with farm work, but without specificity for cumulative OP exposure (Kamel et al, 2004).

In a study conducted by Rothlein et al (2006), it was observed that the neurobehavioural performance of Hispanic immigrant farm workers, with low levels of pesticide exposure, was diminished when compared to a group of non-agricultural Hispanic immigrants, and a positive correlation was found between urinary OP metabolite levels and poorer performance on neurobehavioural tests. Moreover, Screenivasan and Stephens (2004) carried out a study on orchard sprayers in England, who after 14 years of low-level cumulative OP exposure, showed evidence of slowed neuropsychological performance. In contrast to this, London et al (1997) found no association between long-term agrichemical exposure, in the absence of an acute poisoning episode, and adverse chronic nervous system effects in deciduous fruit farm workers in the Western Cape Province of South Africa.

In their review, Kamel and Hoppin (2004) discussed the occurrence of increased central and peripheral neurologic symptoms in moderate pesticide exposure and suggested that the increased symptoms might be an early indication of neurological dysfunction before the manifestation of clinically measurable signs. They had also observed that the initial or most common response to moderate pesticide neurotoxicity may be in the form of a general malaise, lacking in specificity and similar to the mild cognitive dysfunction described for the Gulf War syndrome. In a similar study of white male licensed private pesticide applicators in Iowa and North Carolina, Kamel et al (2005) found that cumulative lifetime use of moderate amounts of fumigants and OP and organochlorine insecticides were associated with increased neurologic symptoms irrespective of recent pesticide exposure. These associations were present in the absence of a history of pesticide poisoning or a high pesticide exposure event.

Despite the findings of the above studies, Colosio et al (2003) reported that the limitations of such studies were due to „uncertainty on quantitative exposure definition, inappropriate selection of control subjects, lack of consistency among the results of different studies, and difficulties in the interpretation of some results in terms of health outcomes'. Aspects of this statement are echoed by

Kamel & Hoppin (2004), who also expressed reservations regarding the ability of past studies to assess quantitative and qualitative aspects of pesticide exposure. On the other hand, contrary to Colosio et al's conclusions (2003) that „there is no firm and consistent evidence that OP compounds are able to cause neurobehavioral effects after long-term low-dose exposure', Jamal et al (2002) found that all animal and human studies completed by the year 2000 showed a positive link between long-term low-level exposure to OP's (without a prior acute cholinergic episode) and the development of chronic neurotoxic effects. One of the arguments cited against the association of LTLL exposure to OP's and neurotoxicity has been the lack of a dose-response relationship in completed studies, which should be an area of focus for future studies.

2.3.3.4.3 Chronic Organophosphate-Induced Neuropsychiatric Disorder (COPIND)

Ahmed & Davies (1997) suggested a condition characterised by significant histories of LTLL exposure to organophosphate pesticides (with or without acute cholinergic episodes) known as chronic organophosphate-induced neuropsychiatric disorder (COPIND), and which they described as a syndrome characterised by a combination of various neuropsychiatric symptoms (Ahmed & Davies, 1997; Davies et al, 2000). There appears to be similarities in the characteristics of OPICN and COPIND, which is made apparent by the review of studies concerning the chronic effects of OP esters (Jamal et al, 2002), wherein the authors also allude to COPIND.

2.3.4 Personal Protective Equipment (PPE)

Because the use of personal protective equipment / clothing (PPE), as a means of protection against the adverse effects of agrichemicals, may act as a confounder or effect modifier of exposure to organophosphate pesticides in epidemiological studies, it is important to consider the role of PPE in reducing (or aggravating) exposure to pesticides.

The improper handling of pesticides increases the risk of exposure to and contamination of the worker handling the substance. When handling and applying pesticides, the use of the appropriate PPE and clothing can minimize or eliminate the health risks of exposure (Bwititi, 1987; El Batawi, 2003; Association of Veterinary and Crop Associations of South Africa (AVCASA), 2003), but this cannot be the only means of controlling these risks (Spruit & van Puijvelde, 1998; El Batawi, 2003). In fact 'protective clothing should always be considered as the last line of defence against hazards, not as a substitute for poor equipment or procedures' (AVCASA, 2003). Therefore, when attempting to reduce the risk of pesticide exposure, the principles of risk control as described in the Occupational Health and Safety Assessment Series for Health and Safety Management Systems (OHSAS 18001), should also be considered in agriculture (see Appendix D). In South Africa, the publication „Guidelines for the Responsible Use of Crop Protection and Animal Health Products' (2003), and the „South African Standard, Code of practice for the Safe Handling of Pesticides (SABS 072: 1993)', Sections 6 and 11, give guidance on precautions to be taken when handling pesticides, including the use of relevant types of PPE and protective clothing.

In a cross-sectional study conducted on deciduous fruit farms in the Ceres / Koue Bokkeveld area in 1993, PPE was measured as a possible effect modifier of OP exposure. It was identified that 75% of pesticide applicators, in the study population used some form of PPE, and 22% used the maximum of five items. The study concluded that long-term agricultural exposure was not associated with adverse chronic nervous system effects and that use of PPE played no role in affecting health outcomes (London et al, 1998).

In 2001, Meijster et al carried out an epidemiological study on dermal exposure assessment among wine- and table grape farm workers in the Western Cape, South Africa, and found that the tasks „mixing and spraying of pesticides' had the highest exposure estimates. However, the PPE and clothing worn by farm workers (particularly gloves) during these activities, appeared to have a „protective effect for all the tasks' and caused a difference between the calculation of potential and actual exposure. The study also found that PPE was used more frequently by workers on table grape farms rather than wine grape farms.

Agricultural studies conducted in other African countries support the protective role that the correct provision and use of PPE play in modifying / minimising exposure to pesticides. These studies also provide some reasons for the inappropriate use of PPE in African countries.

In 1987, Bwititi et al found that 5 out of 16 workers' committees thought that their pesticide exposure problem resulted from a lack of protective clothing. Farmers agreed that some of the causes of pesticide poisoning were the inadequate provision of protective clothing, workers not wearing PPE because of the environmental heat, and leaking pesticide application equipment.

In a study conducted in Kenya in 2001, 77% of farmers reported becoming ill on one or more occasions ostensibly due to the unsafe use of pesticides. Additionally, the study found that 83% of the study participants reported the following reasons for not using PPE: 40% stated that the climate was too hot to wear PPE; 36% reported a lack of purchasing power and that PPE was too costly to purchase; 24% did not know the importance of PPE (Hanshi, 2001).

Abebe and Mekonnen (2005) found that the use of personal protectors by farm workers in Ethiopia was not satisfactory. Some of the reasons given were that some of the PPE were uncomfortable in the hot climate, and in a few instances incorrect PPE had been supplied in that respirators allocated to farm workers had allowed fumigants to pass through and be inhaled.

The findings of some global studies, however, contradict the postulated protective effects of PPE.

In 1964, Dille & Smith reported that, despite pilots involved in OP aerial spraying wearing PPE that included carbon filter respirators, rubber gauntlets, coveralls and being in closed cockpits, they developed the symptoms of major affective disorders.

A study carried out in Costa Rica to evaluate the effectiveness of protective equipment used during herbicide (paraquat) application on banana plantations, examined particularly the dermal exposure of workers, the use of PPE and work practices of workers. It was found that none of the protective clothing worn by the workers provided 100% dermal protection. All of the clothing showed leaks in the armhole and joint areas (Spruit & van Puijvelde, 1998). The work practices and working conditions were identified as important determinants of dermal exposure, as well. It was confirmed that the use PPE should form part of the process of health and safety risk management within the workplace, and not be used as the only mechanism for risk control.

A review by Kamel and Hoppin (2004) of neurotoxicity of pesticides makes reference to factors such as personal protective equipment, work practices related to hygiene and pesticide spills, and attitudes toward occupational risks, which all influence the dose or amount of pesticide exposure in a given task or job (London & Myers, 1998; Spruit & van Puijvelde, 1998). The review makes the observation that inappropriate or faulty items of protective clothing, like incorrect gloves, can enhance pesticide exposure and absorption instead of protecting the worker from its ill effects (Kamel and Hoppin, 2004) and supports the findings of the study in Costa Rica.

On the other hand, Beseler et al (2008) found in a study involving private pesticide applicators in Iowa and North Carolina, that merely wearing chemically resistant gloves was protective against the likelihood of becoming depressed (OR: 0.79; CI: 0.64 – 0.97).

2.4 Suicide and Depression

Mental health is the foundation for the well-being and effective functioning of individuals. It is a state of balance within the individual and not merely the absence of mental disorder. Mental health encompasses physical, psychological, social, cultural and spiritual well-being (WHO, 2001). Demyttenaere et al (2004) reported that South Africa had a higher prevalence of mental disorders than most developing countries, with the prevalence of substance abuse being particularly high.

2.4.1 Depression

It has been predicted that the global burden of disease due to mental illness will increase from 12% in 2000 to 15% in 2020, and by 2030 unipolar depression will be the world's second most disabling health condition (Lund et al, 2008). Mental disorders often result in various forms of distress and debilitation. The prevalence of mental disorders in South Africa is high with approximately 16.5% of South Africans having suffered from a common mental disorder (e.g.

depression, anxiety and somotoform disorders) (Lund et al, 2008; Grimsrud et al, 2009). Amongst the neuropsychiatric conditions ranked in the top 20 causes of disability, unipolar depressive disorders ranked second, alcohol abuse was sixth and bipolar affective disorders ninth (Lund et al, 2008). Depression is one of the most serious mental disorders that will touch most people's lives directly or indirectly at some time in their lifetime. A study completed in Cape Town, South Africa by Muller et al (2008) on 51 adult out-patients diagnosed with multisomatoform disorder (MSD), found that 60.8% of their study population reported a current or lifetime anxiety or depressive disorder and 74.5% participants presented with a current or lifetime co-morbid depressive or anxiety disorder. With early recognition, depression can usually be treated effectively in over 80% of sufferers (Feightner & Worrall, 1990; Grohol, 2005). But, because the condition often goes unnoticed, most people do not get the assistance they require, and they are subjected to the debilitating consequences of depression for all or most of their lives. Furthermore, globally (Demyttenaere et al, 2004) and in South Africa (Lund et al, 2008; Herman et al, 2009) there appears to be an insufficient allocation of treatment resources to cope with the proportion of mental illness in the respective countries. When compared to other countries in the World Mental Health Survey (WMH), South Africa has a relatively high 12-month prevalence of anxiety (8.1%) and mood disorders (4.5%) (Herman et al, 2009).

The lifetime prevalence of depression is usually twice higher for women than for men, with the peak prevalence for women occurring between 35 and 45 years of age. Grimsrud et al (2009) found that females in South Africa had a twofold risk of having a 12-month anxiety (OR = 2.2) or depressive disorder (OR = 2.3), and a greater than 7 times likelihood of having a comorbid anxiety-depression disorder (OR = 7.4), than men. For men, the prevalence of depression increases with age (Winokaur, 1979; Klerman, 1980). It has been suggested by Studemire et al (1986) that depression was causally related to 60% of suicides, placing females in South Africa in a high risk category for suicide. Grimsrud et al (2009) also found that individuals with mental disorders reported increased chronic conditions, of which hypertension was the most significant.

There is also a growing awareness of neurological syndromes, like depression, being associated with pesticides (Singh & Sharma, 2000; van Wijngaarden, 2003; Colosio et al, 2003), as well as other neurotoxins such as solvents and heavy metals (So, 1995; The Toxic Chemicals Most Linked to Depression, n.d.).

2.4.1.1 The Neurophysiological basis for Depression

Janowsky et al (1972) hypothesised that „a given affective state may represent a balance between central cholinergic and adrenergic neurotransmitter activity in those areas of the brain which regulate affect, with depression being a disease of cholinergic dominance'. Acetylcholine (ACh) is a cholinergic neurotransmitter in both the peripheral and central nervous systems, and norepinephrine, dopamine, and serotonin (5-hydroxy tryptamine) are adrenergic neurotransmitters. ACh plays an important role in the affect (mood) area, and the movement and memory areas of the brain (Smits, 2000). Depression occurs when there is a decrease of the neurotransmitters serotonin and norepinephrine and dopamine in the brain (see section 2.3.1.2, non-cholinergic mechanism of organophosphate action).

2.4.1.2 Organophosphate pesticides (OP's) as a cause of depression

It is likely that many cases of affective disorders related to OP exposure go unreported because of the lack of clinical acumen of the diagnosing medical or nursing practitioner. There are some cholinesterase inhibiting OP's used for agricultural and domestic purposes that affect the function of neurons and interfere with the transmission of information through the CNS, which could lead to affective disorders like anxiety and depression.

According to Corrigan et al (1994), OP's could adversely affect the mental health of individuals because of recognised effects on cholinergic functions (see section 2.3.1, page 28) that may have widespread effects on other neurotransmitter systems. Davies (1995) proposed that since OP's appear to be able to disrupt systems involved in the regulation of mood (affect) at all levels, they can induce a „depressive and destabilising effect on mood'.

The first cases of OP – induced depression were reported fifteen years after the introduction of OP's (Smits, 2000). In 1963, Spiegelberg reported that workers in the German chemical industry who had been exposed to the early OP nerve agents between 1936 and 1935 were often found to be in states of depression and mood lability (Davies, 1995). Also, Ali et al (1979) reported a significant decrease in the levels of neurotransmitters, dopamine, noradrenaline and serotonin, in the cerebral hemispheres and brain stem of rats after ten days of oral exposure to the OP, diclorvos.

Davies (1995) reported depressive mood swings, bouts of irritability, brief hypomanic-like episodes, aggressive outbursts and episodes of extreme and intense suicidal ideation in more than twenty persons, who reported significant OP exposure. He stressed that the information on suicidal ideation was given reluctantly and only after direct questioning.

The neurotoxicity of OP's is further emphasized by an incident that occurred in 1994, when the interior of more than 1500 homes and businesses in Mississippi and Ohio were illegally sprayed with the pesticide methyl parathion, by unlicensed pest control operators. A study that monitored the ensuing depressive symptoms of the 1100 people affected by the pesticide spraying, found that years later half the affected persons still reported symptoms indicative of clinical depression (The Toxic Chemicals Most Linked to Depression, n.d.). In both these studies the circumstances of the pesticide exposure need to be considered as the depressive symptoms may be a response to the stressful circumstances (exposure or poisoning) and not caused by the OP itself.

A study of farmers in the United Kingdom with long-term exposure to OP's in sheep dips, found that farmers showed greater vulnerability to psychiatric disorders as measured by the General Health Questionnaire when compared to quarry worker controls (Stephens et al, 1995). Similarly, in a study of sheep farmers and dippers conducted by Jamal et al (2002), it was found that sheep dippers who handled concentrated OP dip reported more neuropathic symptoms than individuals who did not handle the concentrate (see section 2.3.3.4.2). The group of participants who, on examination, were identified as having probable peripheral neuropathy, also reported significant symptoms of anxiety and depression on the General Health Questionnaire and Hospital Anxiety and Depression Scales, which supports the findings of Levin et al (1976) and

Bazylewicz-Walczak et al (1999). Additionally, a cross-sectional study carried out by Pilkington et al (1999), wherein 612 sheep-dippers exposed to OP's were compared with a large group of unexposed subjects, found a positive link between LTLL exposure to OP's and chronic neurotoxicity (in the form of distal axonal peripheral neuropathy), as well as a positive correlation between abnormal neurological tests and evidence of anxiety and depression, in individuals exposed to OP's (see section 2.3.3.4.2).

A study conducted in Egypt of 208 pesticide formulators, 172 pesticide applicators and 223 control subjects (Amr et al, 1997) that aimed to screen for psychiatric morbidity in the study population, using the GHQ-28 and DSM-III-R, found a significant increase in the frequency of psychiatric disorders on the GHQ in pesticide formulators (50%) compared to the control group (32%), and in pesticide applicators (30.7%) compared to the control group (17.2%). Additionally, pesticide applicators reported higher dysthymic[3] disorders (23.8%) than the control group (14.6%). The pesticide formulators and applicators were exposed to a mixture of pesticides, including OP's and carbamates, and therefore the findings could not be specifically from OP exposure.

In a case-control study involving the female spouses of private pesticide applicators, Beseler et al (2006) found a stronger association with self-reported, physician-diagnosed depression among the spouses of the applicators (OR = 3.97) compared to those who did not report such episodes. They also reported that the female spouses showed a significant association between incident(s) of previous pesticide poisoning and self-reported, physician-diagnosed depression (OR: 3.26; CI: 1.72 – 6.19), after controlling for risk factors of race, age, alcohol use, cigarette smoking, number of doctor visits in past year, solvent exposure and history of pesticide poisoning. Diagnosed depression was positively associated with domestic use of insecticides (OR = 1.17), fungicides (OR = 1.25) and fumigants (OR = 1.37). However, with low (≤ 225 days) and high (226 - 7000 days) cumulative levels of pesticide exposure, no association with depression was observed.

[3] Dysthmia: A less severe but longer lasting type of depression, which could persist for a minimum of two years in adults and one year in children and adolescents. The condition is not disabling, but it prevents affected persons from functioning effectively (Smits 2000; Grohol 2005).

Further, in 2008, Beseler et al reported that high cumulative pesticide exposure was significantly associated with diagnosed depression (OR: 1.54; CI: 1.16 – 2.04), among private pesticide applicators enrolled in an Agricultural Health Study in Iowa and North Carolina. After adjusting for important covariates, depression was also associated with a history of pesticide poisoning or an unusually high pesticide exposure event (HPEE). Additionally, the study reported an association between depression and chronic pesticide exposure in the absence of a medically diagnosed pesticide poisoning.

On the other hand, a study conducted by Solomon et al (2007), which explored the prevalence and pattern of neuropsychiatric symptoms in past users of sheep dip and other pesticides in England and Wales, used a questionnaire that included symptoms of anxiety and depression (taken from the Hospital Anxiety and Depression Scale) in the past 7 days; 5 somatic symptoms (taken from the Brief Symptom Inventory) experienced in the past 7 days; and 4 categories of health problems from the postulated COPIND syndrome (viz. change in personality, difficulty speaking, difficulty with handwriting and thoughts about self-harm or suicide). The study found that 20.2% of male participants had symptoms of anxiety and 11.8% showed symptoms of depression, but there was no evidence for an association with a specific pesticide exposure.

Contrary to the findings of Beseler et al's studies (2006 and 2008), Levin et al (1976) reported that neither the 13 commercial applicators nor the OP-exposed farmers.in their study had scores of even mild depression. The study did however find significantly higher anxiety scores for the commercial pesticide applicators compared to the OP-exposed farmers ($t = 2.28$, $p < 0.05$). At the time of the study, it was suggested that the increased anxiety levels could have been related to occupational stress associated with the daily pesticide spraying experienced by the commercial applicators, rather than a specific pharmacologic action.

Research has shown that depression often co-exists with anxiety disorders and there is an increased risk of suicide attempts in people with co-occurring depression and panic disorders (Grohol, 2005). Symptoms of anxiety and depression in pesticide-poisoned individuals have been reported in a number of studies (Savage et al, 1988; Reidy et al, 1992; Stallones & Beseler, 2002). Similarly, a study that analysed fifteen years of research on depression in Zimbabwe, showed a strong relationship between anxiety, depression and panic-phobias (Patel et al, 2001).

What appears to be common to all the above studies is that cumulative pesticide exposure (in the absence of an acute exposure) may be positively associated with depression and other neuropsychiatric disorders, like increased psychiatric disorders, irrespective of whether it is a cumulative OP (Bazylewicz-Walczak et al, 1999; Pilkington et al, 1999; Beseler et al, 2008) or cumulative mixed pesticide (including OP's and carbamates) exposure (Amr et al, 1997; Kamel et al, 2005; Beseler at al, 2006; Solomon et al, 2007). Additional to these studies are the findings of Ali et al (1979) of the neurotransmitters, DA, NE and serotonin being significantly decreased in rats after 10 days of exposure to OP's, coupled with the theory that depression occurs when there is a decrease of the neurotransmitters serotonin, NE and DA in the brain. All these facts suggest that OP exposure may have some role in the aetiology of non cholinergic psychiatric and affective disorders (London et al, 2005). These findings are also consistent with Davies' (2000) suggestion that many of the neuropsychiatric outcomes observed in persons with chronic exposure to anticholinesterase pesticides may be due to mechanisms involving serotonin depletion and not the result of ChE inhibition, which gives credence to the suggestion that cumulative OP exposure (in the absence of acute toxicity) may result in suicidality amongst exposed farm workers perhaps through the pathway of depression, impulsivity, aggression or some combination of these factors.

2.4.2 Suicide

Suicide is the act of an individual intentionally taking his or her own life and may occur for a number of reasons, including difficulty coping with depression, shame, guilt, desperation, physical pain, emotional pain or pressure, anxiety, financial difficulties, and other reasons. With nearly 900 000 deaths from suicide annually worldwide (WHO, 2003), suicide takes more lives than homicides and wars combined (Bertolote et al, 2006). According to the WHO, the „global' mortality rate of suicide is approximately 16.7 per 100 000 persons per year, or one death every 40 seconds, and is the 14th-leading cause of death worldwide (Nock et al, 2008). In 1998, suicide worldwide was estimated to represent 1.8% of the total global burden of disease, with a predicted rise to 2.4% in certain countries by 2020 (WHO, 2008).

Globally, suicide rates have increased by 60% in the last 45 years, with most suicides occurring in Asian countries like China, South Korea, India, Sri Lanka and Japan (WHO, 2008; Bhatia, 2008). Suicide rates amongst rural women in China are extremely high and account for half the world total of female suicides. A high proportion of these suicides are among young women aged 16 – 26 years (China Development Brief, 2000; Gunnell & Eddlestone, 2003; Mudie, 2006; Konradsen, 2007; Zhang et al, 2009).

Suicide is among the 3 leading causes of death in all individuals (both sexes) aged 15 - 44 years, and mental disorders (particularly depression and alcohol abuse) are associated with more than 90% of all suicide cases (WHO, 2008). In South Africa, 8% of all deaths are suicide related. Suicide accounted for 11.48% of the 22 248 non-natural deaths reported in 2003 (South Africa National Injury Mortality Surveillance System (NIMS), 2003).

It is commonly acknowledged that worldwide there is a degree of underreporting of suicide and therefore the magnitude of the problem is not fully realised (Bertolote et al, 2006; Ajdacic-Gross, 2008). In a study that analysed the WHO mortality database of underlying cause of death in all Member States, stemming from 1950 until 17 November 2006, it was found that data on suicide for developed countries were the most complete, and there was a significant lack of or completely missing data for developing countries and conflict regions. South Africa was the only country in Africa that had submitted suicide data, and that was for the years 1996 and 2004 (Ajdacic-Gross, 2008).

For the last century, mortality from suicide has been higher in males than females (Ajdacic-Gross et al, 2008), although females tend to attempt suicide more often. According to Alan Spedding of RuSource (2008), male farmers in the UK are three times more likely to take their own lives than women. The increased suicide mortality for men has been attributed to the fact that males use more violent and highly lethal methods to end their lives (guns, knives, hanging), while women tend to use more failure-prone methods like drug or medicine overdosing and drowning (Ajdacic-Gross, 2008; Anonymous, 2009).

Mental disorders (particularly depression and substance abuse) are associated with more than 90% of all cases of suicide (WHO 2008). In 2006, depression ranked fourth in the world as a major illness affecting individuals' productivity of life (Mudie 2006). Persons experiencing symptoms of major depression and extreme dysthmia are more prone to suicide attempts. Sometimes, these suicide attempts are the depressed individuals' means of trying to communicate their feelings of hopelessness, despair, anger, frustration and self-hatred (Bernstein et al, 1991; Diekstra & Gulbinat, 1993).

The risk factors for suicide are unipolar (major) depression, which has been associated with a higher than average rate of suicide particularly for men; and bipolar disorder, where affected individuals may impulsively perform a suicidal act because of their extreme mood swings. Cognizance however, should also be taken of other predisposing factors for suicidality (suicide threats or repeated statements about his/her death) like social isolation, hopelessness, alcoholism, and easy accessibility to lethal weapons (e.g. guns) and toxic substances in the workplace and home (e.g. pesticides with agricultural workers) (WHO, 1999), as well as other social and psychiatric factors like poverty, instability, constant stress, marital problems, psychiatric and physical illnesses, to name but a few (Smits, 2000).

In a recent study conducted in South Africa, it was found that the risk for attempted suicide was highest amongst the Coloured population, younger females in the age group of 18 – 34 years with a lower level of education (Joe et al, 2008). Additionally, the study found that 43% of individuals made the transition from suicide ideation to a plan, 65% from a plan to a suicide attempt and 12% from suicide ideation to an unplanned attempt. Approximately 7.5% of unplanned and 50% of planned first suicide attempts took place within one year of the onset of suicide ideation (Joe et al, 2008).

2.4.2.1 Suicidal Ideation

Individuals with risk factors for suicide may experience suicidal ideation, which is the medical term for thoughts about suicide, without performing the suicidal act. The range of suicidal ideation varies from fleeting thoughts to formulating a detailed suicide plan, role playing and unsuccessful attempts (Gliatto & Rai, 1999). A study conducted in Finland, found that 22% of suicides examined had discussed suicidal intent with a health care professional in their last health visit (Halgin & Whitbourne, 2006).

Suicidal ideation often occurs in a cluster of symptoms including hopelessness, insomnia, severe anxiety, impaired concentration, psychomotor agitation and panic attacks. This clustering of suicidal ideation and depressive symptoms is evident in a study conducted by Stallone and Beseler (2002), where some of the symptoms of suicide ideation (anxiety, impaired concentration) were reported by farm workers in Colorado who were found to have a sixfold greater lijkelihood of developing depression after being acutely exposed to OP's.

A study conducted by Goldney et al (2000) found that 46.9% of suicidal ideation was associated with clinical depression, which „emphasised the importance of clinical depression as the most significant single contributing factor to suicidal ideation' (Goldney et al, 2000).

Dervic et al (2004) on the other hand, found that amongst depressed in-patients individuals with a religious affiliation reported less suicidal ideation, whereas patients who had no religious affiliation had more lifetime impulsivity, aggression and past substance use disorders.

2.4.2.2 Occupation and Suicide

Several studies have evaluated the risk of suicide in relation to specific occupations (Boxer et al 1995).

Van Wijngaarden (2003) conducted a study to evaluate the association between suicide and occupations involving exposure to jobs in the electro-magnetic fields, hydrocarbon solvents and pesticides. The study found that males were more at risk than females. Occupations that showed an increased risk of suicide (OR ≥ 1.5) among the whole study population were those of dentist, electrician, fisherman, logger, metal miner and welder. When stratifying for age, the highest risk of suicide in relation to pesticide exposure was among the ages of 35 and 49 years. The study found a weakly elevated risk (OR = 1.1) for those who held jobs that involved pesticide exposure, with the highest risk in females between the ages of 20 to 50 years (OR = 1.8).

Nishimura (2004) conducted a study in Japan that explored the relationship between occupation and suicide, and found that the suicide rate was positively correlated with primary industry workers (farmers, fishermen and forest workers), which suggested that occupational factors associated with farming, fishing and forest work may be related to suicide.

In agreement with Nishimura's findings regarding the relationship between farming and suicide, is a study conducted by Parrón et al (1996) that reported on the findings of a 12-year retrospective ecological study on farmers with chronic exposure to pesticides and at risk of developing mood disorders (mainly depression) in an intensive pesticide-usage agricultural area in Spain. The study showed that the suicide rates in the intensive agricultural area were significantly higher than the suicide rates from other geographic areas with similar socioeconomic and demographic features, but less pesticide use. Also, farmers were found to be at higher risk of suicide than the general population. These findings are supported by studies conducted in the UK that identify farming as being one of the highest risk occupations for suicide (Malmberg et al 1997; Booth et al 2000; Gregoire 2002). Farmers account for 1% of suicides in England and Wales.

Moreover, in a study of pesticide applicators in Iowa and North Carolina, Lee et al (2007) found that any exposure to the organophosphate, chlorpyrifos, was associated with increased risk of death from suicide (RR = 1.45; 95% CI: 0.80-2.63). Additionally, a possible association was suggested between chlorpyrifos exposure and non-motor vehicle accidents amongst pesticide applicators, particularly those working on small farms.

Contrary to the above studies, Pickett et al (1998) found that exposure to pesticides was not a risk factor for suicide among Canadian farmers when they assessed suicide mortality in relation to pesticide use in this population. The study did however find suggestions of an elevated suicide risk for a subgroup of farm operators involved with herbicide and insecticide spraying (Pickett et al 1998). A further study conducted by Pickett et al (2000) found that after adjusting for age differences, provincial suicide rates among male farm operators were lower than or equivalent to the rates of the general male population. Also, a study conducted in England (Screenivasan & Stephens, 2004) wherein the GHQ, Subjective Memory Questionnaire (SMQ) and 7 computerised neuropsychological tests were administered to a group of 37 male orchard sprayers, 26 male pig farm workers and 31 male construction workers, found that relative to the construction workers, orchard sprayers were significantly slower on negative statements of the syntactic reasoning test but no neurotoxic mechanism for this finding could be identified. Additionally, no relationship was found between cumulative exposure and the rest of the test responses. Also, of the individuals vulnerable to psychiatric disorders on the GHQ, orchard sprayers had the lowest number (n = 3) compared to the pig farm workers (n = 7) and construction workers (n = 9).

2.4.2.3 Methods of Suicide

The accessibility or availability and acceptability of suicide methods, plays an important role in the method of suicide employed by the individual. International studies show that preferred suicide methods vary between countries, but the most dominant methods are hanging, pesticide ingestion and firearm suicide. It was found that hanging was the most common method of suicide in most countries, including South Africa, with the highest proportion being in men. Hanging was also common in those countries with a high percentage of pesticide-related suicide (Ajdacic-Gross et al, 2008).

Hawton et al (1998) reported that firearms were involved in 40% of suicides amongst farmers in England and Wales between 1981 and 1993, followed by hanging and carbon monoxide poisoning. 8% of suicide amongst farmers in the UK was due to poisoning with agricultural and horticultural poisons.

Suicide by pesticide ingestion was found to be a common occurrence, mainly amongst women, in the rural Latin American countries (e.g. El Salvador, Nicaragua and Peru), Asian countries (e.g. the Republic of Korea, China and

Thailand) and in Portugal. In South Africa, pesticide-related suicide also occurred more commonly amongst women than men (women 12.6%; men 3.6%) (Ajdacic-Gross et al, 2008).

Gunnell and Eddlestone (2003) estimated that annually there may be about 300 000 deaths from intentional pesticide poisoning, in the rural areas of China and South East Asia, which supports the findings of Ajdacic-Gross et al (2008).

The ready availability of pesticides facilitates unplanned and impulsive suicide acts (Gunnell & Eddlestone, 2003; Bertolote et al, 2006), as demonstrated in China, which is the only country in the world where the suicide rate for women is higher than for men, and where 65% of pesticide suicides used chemicals stored in the home (Phillips et al, 2002; Konradsen, 2007). Ingestion of lethal doses of pesticides is the method used by 90% of Chinese women living in the rural areas, particularly women aged in the 16 – 26 age range. Pesticide ingestion was implicated in 62% of suicides in China between 1996 and 2000, which amounts to approximately 175 000 suicides per year (Zhang et al, 2009).

Impulsivity, and not mental disorders, is an earmark of most of these suicide acts (Gunnell & Eddlestone, 2003; Bertolote et al, 2006). In China 29% of non-fatal suicide individuals reported that they had decided to kill themselves ten or less minutes before they made the attempt, and 50% of survivors had thought about the suicide act for less than two hours before committing the deed (Anonymous, 2000; Mudie, 2006).

The act of pesticide ingestion as a common method of suicide has been reported in rural India, as well. Newman (2006) and Bhatia (2008) reported that between 1993 and 2003 as many as 100 000 Indian farmers took their own lives, consuming the same pesticides they used on their farm fields. The main cause of suicide amongst farmers in India is debt and the resulting harassment at the hands of money lenders (Mishra, 2006; Bhatia, 2008). Mishra (2006) reported that after adjusting for family and land size, the average amount of outstanding indebtedness was 3.0 – 3.5 times higher among suicide households compared to non-suicide controls. The increasing frequency of young people in rural southern India engaging in self-poisoning using pesticides, has also reached alarming rates. Aaron et al (2004) analysed the mortality rates for the period 1992 -2001 of the age group 10 – 19 years in Vellore, Southern India. They reported that for this age group, suicide accounted for a quarter of all male deaths, and 50 – 70% of all female deaths.

The situation of China and India is echoed in Sri Lanka where intentional self-poisoning using pesticides is a common occurrence (Eddleston et al, 1998; Gunnell & Eddleston, 2003; Konradsen, 2007; Bertolote et al, 2006; Manuel et al, 2008; Ajdacic-Gross et al, 2008). Self poisoning is the commonest cause of inpatient death in some rural Sri Lankan districts, but this is a rare occurrence in the central city areas (Eddlestone & Phillips, 2004). Of the 60% of suicides caused by intentional self-poisoning, 90% are due to deliberate pesticide ingestion (Manuel et al, 2008).

A study conducted in South Africa, involving the record review of nine mortuaries in the Boland-Overberg region, a rural area of the Western Cape Province, South Africa, for the period January 1995 to December 1999 (Maruping et al, n.d.), reported that farm workers constituted 19% of unnatural deaths. Slightly over 75% of all unnatural deaths were males, with peak age predominance in the range of 25 to 29 years for both males and females. Four percent (4%) of deaths where the unnatural causes were known were due to suicide. For this time period (1995 to 1999), the most common methods of suicide were hanging, firearms, exhaust fumes and medicine overdose. The intentional ingestion of pesticides, as a method of suicide, was found in 5% of suicide cases, of which 12.5% were farm worker suicides and 2.6% were non-farm worker suicides. The study found that farm workers were fivefold more likely to use pesticide ingestion as a suicide method (OR: 5.29; CI: 0.96 – 35.28) than non-farm workers. The suicide rate of farm workers are twice as high as other high-risk groups, such as white adult South African males (Flisher & Parry, 1994) and the Sri Lankan population (Eddlestone et al, 1998). The findings of this study is supported by the findings of Adjacic-Gross et al (2008) that pesticide poisoning was the fifth highest suicide method in South Africa, for the years 1996 and 2004. According to London et al (2005) the increasing intensification of agricultural production in Africa and the more widespread use of pesticides may eventually result in an increase in the number of acute pesticide poisonings.

2.4.3 Neuropsychiatric Instruments used in the Detection of Depression and Suicidality

Despite depression being a fairly common mental disorder, physicians and nurse practitioners may experience difficulty detecting the condition, particularly in its early stages (Feightner & Worrall, 1990). Early recognition of depression allows for effective treatment and management of the condition (Feightner & Worrall, 1990; Grohol, 2005), and the possible prevention of acts of suicide. According to McCall (2001), individuals who are clinically depressed will answer 'OK' if asked how they are. They need to be asked specific questions about suicidal thoughts, hours of sleep, recreation activities and have they laughed lately. Davies (1995) similarly found that on assessment of twenty persons who reported significant organophosphate exposure, information on suicidal ideation was given reluctantly and only after direct questioning. These facts make a case for the non-recognition or missed diagnosis of depression in patients who at a primary care level present with non-psychological complaints (Mitchell-Heggs, 1971; Zung & King, 1983). This is where self-report symptom-inventory instruments are of assistance, as they are designed to obtain exclusive information from the individual (particularly concerning psychological distress) that is often unavailable to the external observer (Derogatis, 1993). The self-report instrument should not take longer than 15 minutes to complete.

Most self-administered instruments are designed for routine screening purposes and not as diagnostic aids. They should therefore be of acceptable quality, clear and concise, user-friendly, and at a primary care level (Feightner and Worrall, 1990). (See Appendix D, for the criteria developed by Feightner and Worrall, for the selection of applicable self-administered instruments to screen for depression).

A MEDLINE and Science Citation Index search for instruments that matched the developed criteria, identified seven instruments: Beck Depression Inventory (BDI); General Health Questionnaire (GHQ); Center for Epidemiologic Studies Depression Scale (CES-D); Zung Self-Assessment Depression Scale (SDS); Hopkins Symptom Checklist; Mental Health Inventory (MHI) and Hospital Anxiety and Depression Scale (HADS). There are correlations between some of these screening instruments, which allow them to measure similar constructs, e.g. the GHQ and HADS both assess for anxiety and depression symptoms (Bartlett & Coles, 1998a); the BDI, CES-D, SDS and HADS all screen for psychological well-being (Bartlett & Coles, 1998a). However, the instruments often have different timescales for measurement of the construct(s).

2.4.3.1 Neuropsychiatric Instruments used in this study

For the purposes of this study, the GHQ-28, BDI-IA and Brief Symptom Inventory (BSI) were used to measure the levels of depression, as well as psychiatric morbidity and physical, physiological and psychological distress (general distress) of the study population. Additionally, because of the link between depression, impulsivity and suicidal ideation (Swann et al, 2008) and impulsivity and suicidal ideation, in the absence of depression (Gunnell & Eddlestone 2003; Bertolote et al 2006, Mudie, 2006), impulsiveness of the study population was measured using the Barratt Impulsiveness Scale (BIS-II) and suicidal ideation / suicidality was measured by the Scale for Suicide Ideation (SSI). Because the relationship between aggressive behaviour and high impulsivity commonly occurs (Lee & Coccaro, 2001 cited in Houston & Stanford, 2004) and suicidal behaviour may be characterised by aggressive and violent outbursts (Garrison et al, 1993), aggression in the study population was also measured using the Refined Four-Factor Measurement Model of the Aggression Questionnaire. Please, see Appendix D for details regarding the psychometric characteristics (validity, repeatability, factor analysis, internal consistency, Cronbach's, etcetra) of the neuropsychiatric instruments used in this study.

2.4.3.1.1 The General Health Questionnaire (GHQ)

The GHQ was specifically designed to detect psychiatric disorders in primary care and non-psychiatric clinical settings. The original version of the GHQ comprised of 60 questions, but shorter versions of 30, 28, 20 and 12 items have been developed. It is a self-administered psychiatric screening instrument formulated for use in a clinical setting (Goldberg 1972). The 60-item GHQ consists of six subscales: general illness, somatic symptoms, sleep disturbance, social dysfunction, anxiety and dysphoria, and suicidal depression (Goldberg & Hillier 1979).

The shorter 28-item GHQ instrument comprising of four 7-item sub-scales: A scale „somatic symptoms', B scale „anxiety and insomnia', C scale „social dysfunction', and D scale „severe depression', was developed by Goldberg and Hillier (1979). The 28-item GHQ „scaled version of the GHQ is intended for studies in which an investigator requires more information than is provided by a single severity score' (Goldberg & Hillier 1979). The GHQ has been translated into 10 languages and the validity of the GHQ-28 and the GHQ-12 were applied in 15 countries, where no significant differences in validity results by age, sex, education or in contrast between developing and developed countries, were found (Goldberg et al, 1997). The questionnaire is scored such that the higher the score, the higher the levels of psychiatric morbidity.

The GHQ-28 has been used in South Africa for the identification of anxiety and depression in a representative sample of individuals working in the prehospital emergency services in the Western Cape Province (Ward et al, 2006), and psychiatric disorders in patients in medical, surgical and gynaecological wards in a general hospital in Kwazulu Natal (Nair & Pillay, 1997).

The GHQ-28 has also been used globally in studies that investigated the relationship between OP exposure and depression and / or psychiatric disorders (Stephens et al 1995; Amr et al, 1996; Jamal et al 2002; Screenivasan & Stephens, 2004) (see section 2.4.1.2, „OP's as a cause of depression' and 2.4.2.2, , „Occupation and Suicide'). In a more recent study in rural China, where the Chinese version of the GHQ-12 was used to investigate the relationship between the storage of pesticides at home and recent suicidal ideation (2 years prior to the study), a positive association was found after adjusting for the identified variables (OR: 1.63; 95% CI: 1.13 - 2.35). The GHQ-12 has been found to be robust and to work as well as the GHQ-28 (Goldberg et al, 1997).

Furthermore, the GHQ-28 has been used to estimate the prevalence of depression in psychiatric settings (Kessler et al, 1999; Goldney et al, 2000); psychiatric disorders in non-psychiatric settings (Johnstone & Goldberg, 1976; Nair & Pillay, 1997; Makowska et al, 2002) and suicidal ideation in non-psychiatric settings (Hamilton & Schweitzer, 2000; Goldney et al, 2000).

2.4.3.1.2 *The Beck Depression Inventory (BDI)*

The BDI was introduced in 1961 as an instrument for use specifically in a clinical setting to identify depression, and measure the characteristic attitudes and symptoms of depression (Beck et al 1961). The content of the BDI was devised from clinicians' consensus regarding symptoms of depressed patients (Beck et al 1961. The original BDI was revised in 1971 as the BDI-1A (Groth-Marnat 1990; Beck & Steer, 1993b). At the time, a comparison of the BDI-IA with the DISM-III found that the BDI-IA met only 6 of the 9 DISM-III criteria (Beck et al, 1996). This resulted in the BDI-1A being upgraded to the BDI-II in 1996 (Beck et al 1996; Steer et al 2000) to make the instrument more consonant with the DSM-III-R / DSM-IV (Diagnostic and Statistical Manual of Mental Disorders 3rd and 4th editions respectfully). Also, moderate correlations have been reported between the BDI-1A / BDI-II and the Hamilton Rating Scale for Depression (Pearson r = 0.71 – 0.73), and the BDI-1A and the Zung Self Reported Depression Scale (Pearson r = 0.76) and Symptom Checklist 90-R (SCL-90-R) (Pearson r = 0.80) (Groth-Marnat, 1990).

All 3 versions of the BDI consist of 21 questions and a scaled down 13-item version is also available. They are all self-administered self-report instruments that can be completed in about ten minutes.

The BDI and BDI-IA assess individuals' emotional states for the past week and have been found to be reliable in the assessment of severity of depression in clinical and non-clinical populations (Beck et al, 1996). The BDI-II, in line with the DISM-IV, assesses the individual's emotional state for the past 2 weeks.

There is a paucity of evidence of the BDI having been used in agricultural studies globally and in South Africa, but the instrument was used in a study of 250 randomly selected university students in Transkei, South Africa, who presented with somatic symptoms and were diagnosed with mild to severe depression (53%) and moderately to severe depression (14%). Females were more affected (3:1) (Mkize et al, 1998). In another non-agricultural study in South Africa, the BDI-II was found to be reliable and valid in the diagnosing of depression among African patients (Fisha, 2002). Additionally, in a study conducted in Uganda, it was found that the BDI and Beck's Scale for Suicide Ideation (SSI) correlated with the 100-item and the shortened 36-item Response Inventory for Stressful Life Events (RISLE) (an indigenous mental health screening instrument developed in Uganda) (Ovuga et al, 2005). Based on these studies, it can therefore be postulated that the BDI is suitable for assessing depression in a study population of Coloured[4] rural individuals.

Besides being used for the assessment of depressive symptoms (Malone et al, 2000; Dervic et al, 2004), the BDI (item 9) has also been used to measure severity of suicidal ideation in the general population (urban and rural), in a cross-sectional sub-study of the Outcome of Depression International Network (ODIN) study, involving 5 countries in Europe (Spain, Norway, Finland, Wales and Ireland) (Casey et al, 2006).

2.4.3.1.3 The Brief Symptom Inventory (BSI)

The BSI is a 53-item self-report symptom inventory designed to quickly assess an individual's type and severity of self-reported psychological symptoms over a one week period. It is a shortened version of the Symptom Checklist-90-R (SCL-90-R) designed to be used with a clinical population (psychiatric and medical patients) and the general public (Derogatis & Melisaratos, 1983), and can be administered in 8 – 10 minutes.

The BSI has been normed on 4 distinctly separate samples, viz. 423 adult psychiatric in-patients, 1002 adult psychiatric out-patients, 974 adult non-patients, and 2408 adolescent non-patients (males and females of each population normed separately) (Derogatis, 1993). The adult non-patient norms were used in this study. Of the 974 individuals, 494 were males and 480 females. The largest part of the sample (85.5%) was white, 11.4% was black and 3.1% was „other'. The mean age was 46 years (SD 14.7) and 60% of the sample was married. Further detailed demography for this sample was not available (Derogatis, 1993)

The BSI profiles nine primary symptom dimensions and three global indices of distress (Derogatis, 1993). The primary symptom dimensions highlight specific areas of psychopathology, and the global indices measure the level or depth of distress currently being experienced by the individual.

The 9 symptom dimensions are: somatization (SOM); obsessive-compulsive (O-C); interpersonal sensitivity (I-S); depression (DEP); anxiety (ANX); phobic anxiety (PHOB); paranoid ideation (PAR); psychoticism (PSY).

---

[4]Coloured individuals (so-called mixed race origins) form the bulk of farm workers in the study area used in this study (see chapter 3, section 3.1).

The global indices of distress are:

- The General Severity Index (GSI) – combines all the measures of the symptom dimensions and the severity of perceived distress. It is considered the single best indicator of current distress levels.
- The Positive Symptom Distress Index (PSDI) – is a pure intensity measure that does not include the number of symptoms.
- The Positive Symptom Total (PST) – is a count of the symptoms that the patient reports.

Psychometric evaluation shows that the BSI is an acceptable short alternative to the SCL-90-R. The internal structure and construct validity of the BSI are moderately strong, indicating that the BSI measures what it is supposed to measure (Derogatis, 1993). The predictive validity of the SCL-90-R and BSI has been substantiated in approximately 700 research reports involving the SCL-90-R for the period 1975 to 1992 (Derogatis, 1993b cited in Derogatis, 1993), and about 200 published reports involving the BSI (Derogatis, 1993a cited in Derogatis, 1993).

The BSI has been used in studies of pesticide-exposed subjects. Rosenstock et al (1991) found that during an investigation of the chronic effects of acute OP poisoning on the central nervous system, the exposed (poisoned) group reported a greater number of somatic complaints on the BSI Somatisation Symptom Dimension. The poisoned group also did less well than the control group on six additional tests of neuropsychological function.

The BSI Somatisation Symptom Dimension was also used by Solomon et al (2007) to derive a „somatising tendency' score in a study of past users of sheep dip and other pesticides. The study found that the prevalence of anxiety and depression increased steeply with somatising tendency, and there was an even stronger relationship between multiple neurological symptoms and somatising tendency in excess of 15 for the highest score, for past users of sheep dip. The authors noted that the association between depression and somatising tendency was not unusual as „somatic illnesses can often be depressing, especially if severe, while in the reverse direction, low mood may lead to a heightened awareness of somatic symptoms'.

The BSI has also been used in a non-agricultural study in South Africa that assessed the chronic neurobehavioural effects of mercury poisoning in a group of Zulu chemical workers employed by a mercury processing plant (Powell, 2000).

2.4.3.1.4 The Refined Four-Factor Measurement Model of the Aggression Questionnaire (12-item AQ)

The 29-item self-report Aggression Questionnaire (AQ) was developed by Buss and Perry (1992) from the original 75-item self-report Buss-Durkee Hostility Inventory (frequently used by aggression researchers), which was published in 1957 (Buss & Durkee, 1957 cited in Bryant & Smith, 2001). The 29-item model became one of the most popular instruments for measuring aggression (Ang, 2007).

Bryant and Smith (2001) refined the 29-item AQ and developed the 12-item four-factor measurement model of the AQ, which reflects the same underlying constructs (physical aggression, verbal aggression, anger and hostility) as the original 29-item model. According to Ang (2007), the 12-item AQ maintained the conceptual content of the original 29-item questionnaire, but was psychometrically superior to the original model. A comparison of the original 29-item Aggression Questionnaire and the 12-item refined measurement model, show that the pattern of correlations are very similar for all four factors. Bryant & Smith (2001) found that the construct validity of the refined measurement model appeared to be as good as the original 29-item AQ. In fact, the refined factors had only slightly lower internal consistency reliabilities than the original factors, and therefore the refined measurement model appeared to be a valid and reliable instrument for measuring the four aggression subtraits (Bryant & Smith, 2001).

There is no evidence of the AQ having been used in agricultural studies, but the instrument has been used in non-agricultural studies in South Africa and elsewhere in the world. The 29-item AQ was used to measure aggression in 344 (age 13 -19 years) Afrikaans speaking learners in 3 high schools, which catered for learners from mid to low socio-economic communities in the peri-urban area of Worcester, South Africa (Willemse, 2008). The study found that males reported significantly higher physical aggression scores than females (male mean 20.10 (SD 4.72) versus female mean 17.62 (SD 4.35)), whereas females reported significantly higher hostility scores than males (female mean 17.90 (SD

4.02) versus male mean 16.49 (SD 4.12)). This study was conducted in the same area as the current research study.

In another South African study, the physical and verbal aggression questions from the 29-item AQ were administered to 132 Grade 2 and 3 (mean age 7.75 years) learners of 3 primary schools in the Chatsworth district of Kwazulu-Natal, South Africa (Budhal, 2006).

In a study conducted on two Asian adolescent samples using the 12-item refined AQ, Ang (2007) found that males were more physically and verbally aggressive than females, which was consistent with the findings of Buss and Perry (1992) using the original 29-item AQ and supports the conducted by Willemse (2008).

A study conducted by Felsten and Hill (1999) on a group of college students found that hostility influenced anxiety and depression.

2.4.3.1.5 The Barratt Impulsiveness Scale (BIS)

The original BIS, first published in 1959, was developed in an attempt to relate anxiety and impulsiveness to psychomotor efficiency (Barratt, 1959). This version was later reviewed and the BIS-10 (a 34-item questionnaire designed to measure impulsiveness) was birthed out of Barratt's realization that impulsiveness was not unidimensional as previously understood (Barratt, 1985). Barratt (1985) suggested that impulsiveness was made up of three subtraits (subfactors) viz. "cognitive impulsiveness, motor impulsiveness and nonplanning impulsiveness". Cognitive impulsiveness involved making quick cognitive decisions, motor impulsiveness involved acting without thinking, and nonplanning impulsiveness involved a lack of planning for the future.

Subsequently, Barratt re-defined the BIS and developed the BIS-II, which according to Patton et al (1995) is the most updated and psychometrically sound version of the Barratt Impulsiveness Scale. It is a 30-item self-report questionnaire designed to assess general impulsiveness. The BIS-11 allows for the assessment of six first-order factors (attention, motor, self-control, cognitive complexity, perseverance and cognitive instability); and three second-order factors: attentional impulsiveness (attention and cognitive instability); motor impulsiveness (motor and perseverance); and nonplanning impulsiveness (self-control and cognitive complexity). With the development of the factor structure, it was found that items 19, 26, 27, 29 and 33 of the BIS-10 did not meet the criterion of a significant correlated item-total correlation. These five items were omitted in the BIS-11 (Patton et al, 1995).

Despite impulsiveness being linked to acts of suicide in rural China, India and Sri Lanka, and ingestion of pesticides being the method used (Gunnell & Eddlestone, 2003; Bertolote et al, 2006; Mudie 2006) (see section 2.4.2.3 „Methods of Suicide'), there is a paucity of evidence of the BIS having been used to measure impulsiveness in the agricultural sector globally, including South Africa.

A study conducted by Baca-Garcia et al (2005), which found that attempter impulsivity was not a good predictor of attempt impulsivity and that impulsive suicidal attempts were associated with low lethality and lack of depression, supports the findings of Bertolote et al (2006), who found that a large proportion of deaths in Asia were from impulsive acts of self-harm, and the association of mental disorders with suicide were found less frequently in Asian than in Western countries. Lethality, however, was high in impulsive suicide attempts in Asia because of the use of easily accessible lethal pesticides.

2.4.3.1.6 The Scale for Suicide Ideation (SSI)

The Scale for Suicide Ideation (SSI) was developed in response to a need for a valid research instrument to identify individuals who were suicidal ideators, and to investigate meaningful correlates of suicide ideation (Beck et al, 1979).

The SSI is a 19-item clinical research instrument designed to quantify the intensity of current conscious suicidal intent and assess suicidal ideation. Suicidal ideation includes suicidal threats that have been expressed in overt behaviour or verbalised to someone (Beck et al, 1979). Suicide ideators are individuals who currently have plans and wishes to commit suicide but have not yet made any recent overt suicide attempt (Beck et al, 1972). The instrument is completed by a clinician in a semi-structured interview.

The internal consistency and construct validity of the SSI was determined on a group of 90 patients who were hospitalised for continuous self-destructive ideations. 59% of the study population was Caucasian, 35% were Negro and 6% were „other'. The majority of the 90 patients were diagnosed as depressed on admission (Beck et al, 1979). Each of the 90 patients completed the Hopelessness Scale (HS) and the BDI, and the SSI was used as the criterion measure. The SSI scores were compared to the „self-harm' items of the BDI and correlation between the two scores was .41 ($p < 0.001$). Both hopelessness and depression, correlated positively with the extent of suicidal ideation ($r = .47$; $p < 0.001$ and $r = .39$; $p < 0.001$, respectively), but correlation between the BDI and the SSI was non-significant when the HS was removed. The groups with high hopelessness scores had higher mean suicide ideation scores.

The SSI and BDI were used in Uganda in the refinement of the 100-item Response Inventory for Stressful Life Events (RISLE) into a shorter 36-item version (Ovugo et al, 2005). It was found that the 100-item and 36-item RISLE questionnaires were highly correlated with each other (Pearson $r = 0.918$) and moderately correlated with the BDI and the SSI. Also the 36-item RISLE was heavily biased toward the detection of suicide ideation. Hence, the 36-item RISLE can be used instead of the SSI in an African study population.

No evidence has been found of the SSI having been used in agricultural studies globally.

2.4.4 Confounders / Effect Modifiers for Depression and Suicidality

Depression has many causes and many forms of manifestation. In fact, depression is always caused by a combination of factors, which is different in complexity for every individual who develops the condition. Some of the factors causing depression are financial problems, poverty, instability, constant stress, low self-esteem, relationship problems, dependency needs and pessimistic patterns of thinking about oneself.

The low level of socioeconomic status and role of alcohol abuse as predisposing causes of depression and suicidality / suicide are being discussed in this section.

2.4.4.1 Socioeconomic Status (SES)

The association of low SES (determined by family income and level of education) with reduced central serotonergic responsitivity in a group of 270 adults in the USA was investigated by Matthews et al (2000). Participants were recruited through media advertisements and local brochures and posters and enrolled in the University of Pittsburgh Cholestrol and Risk Evaluation project. The study found that low SES was related to aggression (measured by the Angry Hostility subscale of the NEO Personality Inventory) and impulsivity (measured by the BIS-II), which in turn was related to reduced serotonergic responsitivity. Animal studies show that a stressful social environment can have long-lasting behavioural effects, which are associated with alterations in the brain serotonergic systems (Matthews et al, 2000). It can be speculated that individuals who are subjected to low levels of socioeconomic status for indefinite periods of time may be exposed to chronic stress, which may also be associated with reduced central serotonergic functioning of the brain. Low serotonin levels (see physiological causes of depression in section 2.4.1.1 on page 24), as well as aggression and impulsivity are associated with depressive disorders (Patton et al, 1995; Davies, 1995; Felsten and Hill, 1999; Oquendo & Mann, 2000).

However, the evidence of an association between low SES and depression or suicidality and suicide is equivocal.

Global studies have found that poverty or socioeconomic deprivation and increased financial debt, play a major role in suicide acts being perpetrated in agricultural and rural areas worldwide (Gregoire, 2002; Mudie, 2006; Newman, 2006; Mishra, 2006; Perry, 2006; Bhatia, 2008).

Contrary to these studies is a study conducted in Sri Lanka (Manuel et al, 2008), which found that low SES as indexed by poor housing quality ($p = 0.003$) and low levels of education ($p < 0.001$) were associated with low levels of pesticide self-poisoning, but this was significant for education only ($p = 0.015$). The findings of this study is supported by a case-control study of pesticide poisoning conducted by van der Hoek and Konradsen (2005) in the same study area in Sri Lanka, which reported no association between socioeconomic position or debt and self-poisoning. It could be speculated that the markers for socioeconomic status may differ in various contexts, and as suggested by Manuel et al (2008) the divergence of different measures of socioeconomic status in Sri Lanka (education and housing versus unemployment) may be what differentiates Sri Lanka from other countries.

Poverty and low educational standards are also rife in the agricultural sector in South Africa, as confirmed by a study conducted by Kruger et al (2006) to assess socioeconomic indicators, nutritional status and living conditions of farm workers and their families on farms in the North-West Province. They found that access to electricity, water and sanitation, as well as, monthly food rations or subsidies varied by farm and was dependent on the farm owners. Household food resources were compromised by a lack of financial resources. Most of the adults had an education level below or up to grade four. The paternalism still being perpetuated by farmers towards their farm workers, allowed the latter to remain dependent on the farm owner, kept them in abject poverty, robbed the farm workers of their self-esteem and retarded their development as individuals (Du Toit, 1992; Kruger et al, 2006). Abject poverty, a sense of hopelessness, alcohol dependence, lack of finances, low education levels, depression symptoms, and previous suicide attempts are some of the common experiences of farm workers living and working in the Worcester area of the Breede River Valley (Holtman et al, unpublished).

2.4.4.2 Alcohol Use

Alcohol acts primarily on the neurons (nerve cells) and neurotransmitters within the brain. It has the ability to enhance the effects of the inhibitory neurotransmitter gamma-aminobutyric acid (GABA) and weaken the effects of the excitatory neurotransmitter glutamine. Alcohol therefore relaxes inhibitions and makes it easier for thoughts to become actions. Alcohol affects the emotional centre in the limbic centre of the brain. Hence, alcohol abuse and dependence typically causes individuals to become angry, aggressive, depressed and sometimes suicidal, as well as, memory loss.

Findings from the South African Stress and Health (SASH) study reported that alcohol abuse in South Africa had a prevalence of 13.3%, and the rate of alcohol use disorders was the highest in the world after the Ukraine (Herman et al, 2009).

It was reported by the WHO (WHO, 1999b) that „a pattern of men drinking more frequently and to the point of intoxication is prevalent across Sub-Saharan Africa', and that „among black South Africans, more than twice th men drink more regularly than women'.

An example of the alcohol problem experienced in South Africa is the results of an exploratory study conducted in the Correctional Services (Brandvlei Prison), Boland Overberg Region, on 216 male juveniles between the ages of 14 to 20 years (79% Coloured; 19% African; 2% „other'), which found that 84% of the study population reported regular alcohol consumption starting from the age of 6 years. Of the participants who reported alcohol use, 26% reported consuming one or more alcohol drinks daily for 10 -19 days of the month (Matthews, 2004). Holtman et al (unpublished) also found that alcohol dependence was one of the common experiences of farm workers living and working in the Worcester area of the Breede River Valley.

2.4.4.2.1 Screening Alcohol Tests

Over the years, many diagnostic tools have been developed to screen for and evaluate problems associated with alcohol. The use of short screening tests has been encouraged in primary and emergency health-care settings. Should a screening test identify a problem, a more in-depth assessment should be carried out. (See Appendix D for more information on screening alcohol tests).

The **CAGE Test** is one of the most popular screening tools for alcohol abuse. It consists of four short questions that diagnose alcohol problems over a lifetime. Questions are asked about problems associated with alcohol use rather than the amount of alcohol consumed. A problem with alcohol is indicated by two „yes' responses.

- C – Have you ever felt you should **cut down** on your drinking?
- A – Have people **annoyed** you by criticizing your drinking?
- G – Have you ever felt bad or **guilty** about your drinking?
- **Eye-opener** – Have you ever had a drink first thing in the morning to steady your nerves or to get rid of a hangover?

The instrument can be used in a clinical setting using informal language and has been shown to be most effective when used as part of a general health history (Steinweg & Worth, 1993). Buchsbaum et al (1991) assessed the performance of the CAGE questionnaire in a cross-sectional survey of English-speaking patients aged 18 years and older, who were attending the Medical College of Virginia's ambulatory medicine clinic for a new or follow-up visit. The authors found that a CAGE score of 2 or more was associated with a sensitivity of 74% and specificity of 91% amongst the study population.

The CAGE questionnaire has been used in local studies in South Africa, as well. A study investigating the health status of 247 fruit farm workers in the Western Cape Province, South Africa, found that 87% of the sample was defined as potentially alcoholic on the basis of the CAGE questionnaire and the equivalent proportion for the MAST test was 65% (London et al, 1997; London et al, 1998; London, 2000). The same study found the CAGE score to be the only significant substance abuse related predictor of neurological symptoms (OR = 1.37; 95% CI 1.07-1.77). Similarly in 1995, the CAGE questionnaire was administered to 96 individuals in an Afrikaans speaking, primarily coloured community in Ammerville, North West province, South Africa (mean age 38 ± 11.95 years) (Claassen, 1999). The study found that 66% of the respondents reported a positive score (≥ 2), of which 46% were males.

The CAGE questionnaire has also been used in a South African study to determine alcohol use problems amongst prehospital emergency services personnel in the Western Cape Province (Ward et al, 2006).

2.5 References

Aaron, R; Joseph, A; Mullyll, J; George, K; Prasad, J; Minz, S; Abraham, VJ; Bose, A 2004, „Suicides in young people in rural southern India', *The Lancet,* vol. 363, pp. 1117 - 1118.

Abebe, MB & Mekonnen, Y 2005, „Health effects of chronic exposure to pesticides of farm workers in Ethiopia', *African Newsletter on Occupational Health and Safety,* vol. 15, no.3, pp. 71 - 73.

Abou Donia, Mohamed B. 2003, „Organophosphorus Ester-Induced Chronic Neurotoxicity', *Archives of Environmental Health,* vol. 5, no. 8.

Aertgeerts, B; Buntinx, F; Ansoms, S; J, Fevery 2006, „Screening properties of questionnaires and laboratory tests for the detection of alcohol abuse or dependence in a general practice population', *Br J Gen Pract.,* vol.51, no. 464, pp. 206 - 217.

Agricultural Information Services 1999, *The AIS World Pest Database*. Retrieved October 04, 2008, from http://www.aisglobal.net/worldpestdatabase.html

Ahmed, GM & Davies, DR 1997, „Chronic organophosphate exposure: toward the definition of a neuropsychiatric syndrome', *Journal of Nutritional and Environmental Medicine,* vol. 7, pp. 169 - 176.

Ajdacic-Gross, V; Weiss, MG; Ring, M; Hepp, U; Bopp, M; Gutzwiller, F; Rössler, W 2008, „Methods of suicide: International suicide patterns derived from the WHO mortality database', *Bulletin of the World Health Organization,* vol. 86, no. 9, pp. 726 – 732.

Aldridge, JE; Seidler, FJ; Meyer, A; Thillai, I; Slotkin, TA 2003, „Serotonergic systems targeted by developmental exposure to chlorpyrifos: effects during different critical periods', *Environmental Health Perspectives,* vol. 111, pp. 1736 - 1743.

Ali, SF; Hasan, M; Tariq, M 1979, „Levels of dopamine, norepinephrine and 5-hydroxytryptamine in different regions of rat brain and spinal cord following chronic administration of organophosphate pesticide diclorvos', *Indian J. Exp. Biol.,* vol. 17, pp. 424 - 426.

Ames, RG; Steenland, K; Jenkins, B; Chrislip, D; Russo, D 1995, „Chronic Neurologic Sequelae to Cholinesterase Inhibition among Agricultural Pesticide Applicators', *Archives of Environmental Health,* vol. 50, no.6, pp. 440 - 444.

Amr, MM; Halim, ZS; Moussa, SS 1997, „Psychiatric Disorders among Egyptian Pesticide Applicators and Formulators', *Environmental Research,* vol. 73, pp. 193 - 199. Article number ER73744.

Ang, RP 2007, „Factor structure of the 12-item aggression questionnaire: Further evidence from Asian adolescent samples', *Journal of Adolescence,* vol. 30, pp. 671-685.

Antonijevic, B & Stojiljkovic, MP 2007, „Unequal Efficacy of Pyridinium Oximes in Acute Organophosphate Poisoning', *Clinical Medicine and Research,* vol. 5, no.1, pp. 71 - 82.

Association of Veterinary and Crop Associations of South Africa. (2003). Guidelines for the Responsible Use of Crop Protection and Animal Health Products (revised ed.).

Baca-Garcia, E; Diaz-Sastre, C; Resa, EG; Blasco, H; Conesa, DB; Oquendo, MA; Saiz-Ruiz, J; de Leon, J 2005, „Suicide attempts and impulsivity'. *Eur Arch Psychiatry Clin Neurosci,* vol. 255, pp. 152 - 156.

Bardin, PG; Van Eeden, SF; Moolman, JA; Foden, A; Joubert, JR 1994, „Organophosphate and carbamate poisoning', *Arch Int Med,* vol. 154, pp.1433-1441.

Barratt, ES 1959, „Anxiety and impulsiveness related to psychomotor efficiency', *Perceptual and Motor Skills,* vol. 9, pp. 191 - 198.

Barrratt, ES 1985, „Impulsiveness subtraits: Arousal and information processing' in JT Spence and CE Izard (eds), *Motivation, Emotion and Personality,* Elsevier Science, North Holland, pp. 137 - 146.

Bartlett, C; Coles, E 1998, „Psychological health and well-being: why and how should public health specialists measure it? Part 1: rationale and methods of the investigation, and review of psychiatric epidemiology', *Journal of Public Health Medicine,* vol. 20, no. 3, pp. 281 - 287.

Bazylewicz-Walckzak, B; Majzakova, W; Szymczak, M 1999, „Behavioral effects of occupational exposure to organophosphorous pesticides in female greenhouse plantin workers', *Neurotoxicology*, vol. 20, no. 5, pp. 819 - 826.

Beck, AT; Ward, CH; Mendelson, M; Mock, J; Erbaugh, J 1961, „An Inventory for Measuring Depression', *American Medical Association,* vol. 4, pp. 561 - 571.

Beck, AT; Kovacs, M; Weissman, A 1979, „Assessment of Suicidal Ideation: The Scale for Suicide Ideation', *Journal of Consulting and Clinical Psychology,* vol. 47 no. 2, pp. 343 - 352.

Beck, AT; Steer, RA; Ball, R; Ranieri, WF 1996, „Comparison of Beck Depression Inventories – IA and – II in Psychiatric Outpatients', *Journal of Personality Assessment,* vol. 67, no. 3, pp. 588 - 597.

Béga, S 2008, „Boys grew breasts after crop spraying', *Cape Argus,* 12 July, p.7.

Bernstein, D; Roy, E; Srull, T; Wickens, Ch 1991, *Psychology*, Houghton Mifflin Company, Boston.

Bertolote, JM; Fleischmann, A 2003, „Suicide and mental disorders: do we know enough?', *The British Journal of Psychiatry,* vol. 183, pp. 382 - 383.

Bertolote, JM; Fleischmann, A; Eddlestone, M; Gunnell, D 2006, „Deaths from pesticide poisoning: a global response', *British Journal of Psychiatry,* vol. 189, pp. 201 - 203.

Bertolote, JM; Fleischmann, A; Butchart, A; Besbelli, N 2006, „Suicide, suicide attempts and pesticides: a major hidden public health problem', *Bulletin of the World Health Organization,* vol. 84, no. 4, pp. 257 - 336.

Beseler, C; Stallones, L; Hoppin, JA; Alavanja, MCR; Blair, A; Keefe, T; Kamel, F 2006, „Depression and Pesticide Exposures in Female Spouses of Licensed Pesticide Applicators in the Agricultural Health Study Cohort', *Journal of Occcupational and Environmental Medicine,* vol.48, no.10, pp. 1005 - 1013.

Beseler, C; Stallones, L; Hoppin, JA; Alavanja, MCR; Blair, A; Keefe, T; Kamel, F 2008, „Depression and Pesticide Exposures among Private Pesticide Applicators Enrolled in the Agricultural Health Study', *Environmental Health Perspectives,* vol. 116, no.2, pp. 1713 - 1719.

Bhatia, J 2008, *'East and South Asia: Suicide by Pesticide Ingestion Common'.* Retrieved January 19, 2009, from http://globalvoicesonline.org/2008/09/06/east-and-south-asia-suicide-by-pesticide-ingestion

Booth, N; Briscoe, M; Powell, R 2000, „Suicide in the farming community: methods used and contact with health services', *Occup Environ Med,* vol. 57, pp. 642 - 644.

Boxer, PA; Burnett, C; Swanson, N 1995, „Suicide and occupation: a review of the literature', *J Occup Environ Med,* vol. 37, pp. 442 - 452.

Brouwer, DH; Brouwer, EJ; Hemmen van, JJ 1994, „Estimation of long term exposure to Pesticides', *American Journal of Industrial Medicine,* vol. 25, pp. 573 - 588.

Bryant, FB; Smith, BD 2001, „Refining the Architecture of Aggression: A Measurement Model for the Buss-Perry aggression Questionnaire', *Journal of Research in Personality,* vol. 35, pp. 138 - 167.

Buddy, T 2007, *About.com: Short Alcohol Tests Ideal for Healthcare settings'.* Retrieved February 07, 2009 from http://www.Alcohol Screening Tests – Short Alcohol Tests.

Budhal, RS 2006, „Identification of Aggression of Junior Primary Learners', Masters of Education Thesis, University of South Africa, Pretoria.

Buss, AH; Perry, M 1992, „The Aggression Questionnaire', *Journal of Personality and Social Psychology,* vol. 63 no. 3, pp. 452 - 459.

Buchsbaum, DG; Buchanan, RG; Centor, RM; Schnoll, SH; Lawton, MJ 1991, „Screening for alcohol abuse using CAGE scores and likelihood ratios', *Annals of Internal Medicine,* vol. 115 no. 10, pp. 774 - 777.

Bwititi, T; Chikuni, O; Loewenson, R; Murambiwa, W; Nhachi, C; Nyazema, N 1987, „Health Hazards in Organophosphate Use among Farm Workers in the

Large-scale Farming Sector', *Central African Journal of Medicine,* vol. 33 no. 5, pp. 120 – 126

Casarett; Douell (3rd edition) 1986, *Toxicology: The basic Science of Poisons,* Macmillan Publishing Co.

Casey, P; Dunn, G; Kelly, B; Birkbeck, G; Dalgard, O; Lehtinen, V; Britta, S; Ayusa-Mateos, J; Dowrick, C 2006, „Factors associated with suicidal ideation in the general population: Five centre analysis from the ODIN study', *British Journal of Psychiatry,* vol. 189, pp. 410 - 415.

China Development Brief 2000, *'Impulsive' young women find pesticides offer a quick way out.* Retrieved January 12, 2009, from http://www.'Impulsive'

Cholinesterase Reference Laboratory (Radiologic, Classic and Clinical Chemistry Division) n.d. Retrieved August 19, 2002, from http://chppm-www.apgea.army.mil/dls/CHOLIN.HTM

Ciesielski, S; Loomis, DP; Mims, SR; Auer, A 1994, „Pesticide Exposures, Cholinesterase Depression, and Symptoms among North Carolina Migrant Farm workers', *American Journal of Public Health,* vol. 84 no.3, pp. 446 - 451.

Claassen, JN 1999, „The benefits of the CAGE as a screening tool for alcoholism in a closed rural South African community', *South African Medical Journal,* vol. 89 no.9, pp. 976 - 979.

Colosio, C; Tiramani, M; Maroni, M 2003, „Neurobehavioral effects of pesticides: State of the art', *Neurotoxicology,* vol. 25, pp. 577 - 591.

Coronado, GD; Thompson, B; Strong, L; Griffith, WC; Islas, I 2004, „Agricultural Task and Exposure to Organophosphate Pesticides among Farmworkers', *Environmental Health Perspectives,* vol. 112, no. 2, pp. 142 - 147.

Corrigan, FM; MacDonald, S; Brown, A; et al 1994, „Neurasthenic fatigue, chemical sensitivity and GABA receptor toxins', *Medical Hypotheses,* vol. 43, pp. 195 - 200.

Costa, LG; Giordano, G; Guizzetti, M; Vitalone, A 2008, 'Neurotoxicity of pesticides: a brief review', *Frontiers in Bioscience,* vol. 13, pp. 1240 - 1249.

Crow, T; Cross, A; et al 1984, „Neurotransmitter receptors and monoamine metabolites in the brains of patients with Alzheimer-type dementia and depression, and suicides', *Neuropharmacology,* vol. 12, pp. 1561 - 1569.

Dalvie, MA; London, L; Mbuli, S; Cairncross, E 2004, „Knowledge and attitudes in the rural Western Cape towards pesticides in water sources', *Water SA,* vol. 30 no.1, pp. 43 - 50.

Dalvie, MA; Africa, A; London, L, „Change in the quantity and toxicity of pesticides sold in South African crop sectors, 1994-1999, *Environment International,* vol. 35, no. 4, pp. 683 - 687.

Davies, JE 1990, „Neurotoxic Concerns of Human Pesticide Exposures', *American Journal of Industrial Medicine,* vol. 18, pp. 327 - 331.

Davies, DR 1995, „Organophosphates, affective disorders and suicide', *Journal of nutritional medicine,* vol. 5 no.4, pp. 367 - 374.

Davies, R; Ahmed, G; Freer, T 2000, „Chronic exposure to organophosphates: background and clinical picture', *Advances in Psychiatric Treatment,* vol.6, pp.187 - 192.

Davies, R; Ahmed, G; Freer, T 2000, „Psychiatric aspects of chronic exposure to organophosphates: diagnosis and management', *Advances in Psychiatric Treatment,* vol.6, pp. 356 – 361.

Delgado, E; McConnell, R; Miranda, J; Keifer, M; Lundberg, I; Partanen, T; Wesseling, C 2004, „Central nervous system effects of acute organophosphate poisoning in a two-year follow-up', *Scandinavian Journal Work Environmental Health,* vol. 30, no. 5, pp. 362 - 370.

Demyttenaere, K; Bruffaerts, R; Posada-Villa, J; et al (WHO World Mental Health Survey Consortium) 2004, „Prevalence, Severity, and Unmet need for Treatment of Mental Disorders in the World Health Organization World Mental Health Surveys', *Journal of the American Medical Association*, vol. 291, no. 21, pp. 2581 - 2590.

Derogatis, LR; Melisaratos, N 1983, „The Brief Symptom Inventory: An introductory report', *Psychological Medicine,* vol. 13, pp. 595 - 605.

Derogatis, L (3rd ed.) 1993, *Brief Symptom Inventory (BSI) Administration, Scoring and Procedures Manual,* National Computer Systems, Inc., Minneapolis, USA

Dervic, K; Oquendo, MA; Grunebaum, MF; Ellis, S; Burke, AK; Mann, JJ 2004, „Religious Affiliation and Suicide Attempt', *Am J Psychiatry,* vol. 161, pp. 2303-2308.

Diekstra, R & Gulbinat, W 1993, „The epidemiology of suicidal behaviour: a review of three continents', *World Health Statistics Quarterly,* vol. 46, pp. 52 - 68.

Dille, JR & Smith, PW 1964, „Central nervous system effects of chronic exposure to organophosphate poisoning', *Aerospace Medicine,* vol. 34, pp. 475 - 478.

Du Toit, A1992, *The Farm as Family: Paternalism, Management and Modernisation on Western Cape Wine and Fruit Farms,* Report on Fieldwork conducted for Centre for Rural Legal Studies, Stellenbosch.

Dyro, FM 2003, *eMedicine – Organophosphates.* Retrieved April 09, 2003, from http://www.emedicine.com/neuro/topic 286.htm

Eddlestone, M; Sheriff, MHR; et al 1998, „Deliberate self harm in Sri Lanka: an overlooked tragedy in the developing world', *British Medical Journal,* vol. 317 no. 7151, pp. 133 - 135.

Eddlestone, M, Phillips, MR 2004, „Self poisoning with pesticides', *BMJ,* vol. 328, pp. 42 - 44.

El Batawi, Mostafa A 2004, *Health of workers in agriculture,* World Health Organization Regional Publications, Eastern Mediterranean Series 25, Alexandria, Egypt.

Environmental Justice Foundation (EJF) 2003, *What's Your Poison? Health Threats Posed by Pesticides in Developing Countries,* Environmental Justice Foundation, London, UK.

Eto, K 2000, „Minimata Disease', *Neuropathology,* 20 Suppl., pp. S14 - 19.

Feightner, JW; Worrall, G 1990, „Early detection of depression by primary care physicians', *Can Med Assoc J,* vol. 142 no. 11, pp. 1215 - 1220.

Felsten, G; Hill, V 1999, „Aggression Questionnaire hostility scale predicts anger in response to mistreatment', *Behaviour Research and Therapy,* vol. 37, pp. 87 - 97.

Fiedler, N; Burger, J; Gochfeld, M 1995, „Neurobehavioural Toxicity and Testing' in Stuart Brooks et al (eds), *Environmental Medicine*, Mosby, pp. 189 – 200.

Fisha, S 2002, „Depression among African patients: three diagnostic approaches' PhD Thesis, University of Pretoria, viewed 2009, September 20. http://upetd.up.ac.za/thesis/available/etd-10202005-143145/

Flisher, AJ & Parry, CDH 1994, „Suicide in South Africa: An analysis of nationally registered mortality data for 1984 - 1986', *Acta Psychiatr Scand,* vol. 90, pp. 348-353.

Freudenthal, William 2003, *eMedicine – Toxicity, Organophosphates.* Retrieved April 09, 2003 from http://www.emedicine.com/ped/topic1660.htm

Goldberg, DP 1972, *The Detection of Psychiatric Illness by Questionnaire,* Oxford University Press: London.

Goldberg, DP; Hillier, VF 1979, „A scaled version of the General Health Questionnaire', *Psychological Medicine,* vol. 9, pp. 139 - 145.

Goldberg, D; Williams, P 1988, *A user's guide to the General Health Questionnaire,* NFER-Nelson: Windsor.

Goldberg, D; Gater, R; Sartorious, N; Ustun, T; Piccinelli, M; Gureje, O; Rutter, C 1997, „The Validity of Two Versions of the GHQ in the WHO study of mental illness in general health care', *Psychological Medicine,* vol. 27, pp. 191-197.

Gomes, J; Lloyd, O; Revitt, MD; Basha, M 1998, „Morbidity among farm workers in a desert country in relation to long-term exposure to pesticides', *Scand J Work Environ Health,* vol. 24 no. 3, pp. 213 - 219.

Green Left 1999, *Dirty Dozen pesticides: banned but still traded.* Retrieved December 19, 2008 from http://www.green left – dirty dozen pesticides ban

Gregoire, A 2002, „The mental health of farmers', *Occup. Med.,* vol. 52 no. 8, pp. 471 - 476.

Groth-Marnat, G (2nd ed.) 1990, *The handbook of psychological assessment,* John Wiley & Sons, New York

Grodner, Mary L 1996, *Why Use Pesticides,* Louisiana Cooperative Extension Service.

Grohol, JM 2005, *Research on Depression.* Retrieved on January 14, 2009 from http://psychcentral.com/disorders/depressionresearch.htm

Gunnell, D; Eddlestone, M 2003, „Suicide by intentional ingestion of pesticides: a continuing tragedy in developing countries, *Int J Epidemiology,* vol. 32, pp. 902 - 909.

Halgin, RP; Whitbourne, S 2006, *Abnormal psychology: clinical perspectives on psychological disorders,* McGraw-Hill, Boston. Pp. 267 - 272.

Hamilton, T; Schweitzer, R 2000, „The cost of being perfect: perfectionism and suicide ideation in university students', *Australian and New Zealand Journal of Psychiatry,* vol. 34, pp. 829 - 835.

Hammad, YY; Manocha Y 1995, „Principals of Exposure Assessment', in Stuart Brooks et al (eds), *Environmental Medicine*, Mosby, pp. 37 - 45.

Hammond, M 1999, „Organizing Against Pesticide Use in Suburbia' in Miriam Wyman et al, *Sweeping the Earth,* Gynergy Books, Canada.

Hanshi, JA 2001, „Use of pesticides and personal protective equipment by applicators in a Kenyan district', *African Newsletter on Occupational Health and Safety,* vol. 11, pp. 74 - 76.

Harp, P; Tanaka (Jr.), D; Pope, CN 1997, „Potentiation of Organophosphate-Induced Delayed Neurotoxicity following Phenyl Saligenin Phosphate Exposures in 2-, 5-, and 8-Week-Old Chickens', *Fundamental and Applied Toxicology,* vol. 37, pp. 64 - 70.

Harvey, D; Hogan, DJ 1995, „Common Environmental Dermatoses', in Stuart Brooks et al (eds), *Environmental Medicine*, Mosby, pp. 263 - 281.

Hawton, K; Fagg, J; Simkin, S; Hariss, L; Malmberg, A 1998, „Methods used for suicide by farmers in England and Wales: the contribution of availability and its relevance to prevention', *British Journal of Psychiatry,* vol. 173, pp. 320 - 324.

Hayes, AL; Wise, RA; Weir, FW 1980, „Assessment of occupational exposure to organophosphates in pest control operators', *American Industrial Hygiene Journal,* vol. 41, pp. 568 - 575.

Herman, AA; Williams, DR; Stein, DJ; Seedat, S; Heeringa, S; Moomal, H 2009, „The South African Stress and Health Study (SASH)', *South African Medical Journal,* vol. 99, no.5, pp. 339 - 344.

„History / Uses of Organophosphates' 2000, *Organophosphates: Toxicology.* Retrieved April 09, 2003 from http://www.ansci.cornell.edu/courses/as625/2000term/organophos/History.html

Holtman, Z; Shelmerdine, S; Flisher, AJ; London, L n.d., „Pesticides, Depression and Suicide: Perspectives of Five Suicide Survivors and their Families', unpublished manuscript, University of Cape Town, Cape Town.

„How sensitive is your brain to alcohol-induced damage' 2001, *Alcoholism: Clinical & Experimental Research,* Science Blog. Retrieved June 02, 2009, from http://www.scienceblog.com/community. Archives 2001 A.

Innes, DF; Fuller, BH; Berger, GMB 1990, „Low serum cholinesterase levels in rural workers exposed to organophosphate pesticide sprays', *SAMJ,* vol. 78, pp. 581 - 583.

Jamal, GA; Hansen, S; Apartopoulos, F; Peden, A; Aziz, MA; Ballantyne, JP 2001, „Peripheral nerve dysfunction in farmers using organophosphate sheep dip', *J Nutr. Environ. Med.,* vol. 11, pp. 9 - 22.

Jamal, GA; Hansen, S; Pilkington, A; Buchanan, D; Gillham, RA; Abdel-Azis, M; Julu, POO; Al-Rawas, SF; Hurley, F; Ballantyne, JP 2002, „A clinical neurological, neurophysiological, and neuropsychological study of sheep farmers and dippers exposed to organophosphate pesticides', *Occupational Environmental Medicine,* vol. 59, pp. 434 - 441.

Jamal, GA; Hansen, S; Julu, POO 2002, „Low level exposures to organophosphorus esters may cause neurotoxicity', *Toxicology 181 – 182,* pp. 23 – 33.

Janowsky, DS; Davis, JM; El-Yousef, MK; Sekerke, HJ 1972, „A Cholinergic-Adrenergic Hypothesis of Mania and Depression', *The Lancet,* pp. 632 - 635.

Joe, S; Stein DJ; Seedat, S; Herman, A; Williams, DR 2008, „Non-fatal suicide behavior among South Africans: Results from the South Africa Stress and Health Study', *Social Psychiatry and Psychiatric Epidemiology,* vol. 43, no. 6, pp. 454 - 461.

Johnstone, A; Goldberg D 1976, „Psychiatric Screening in General Practice: A Controlled Trial', *The Lancet,* vol. 307, no. 7960, pp. 605 - 608.

Kamel, F; Rowland, AS; Park, LP; Anger, WK; Baird, DD; Gladen, BC; Moreno, T; Stallone, L; Sandler, DP 2003, „Neurobehavioral Performance and Work Experience in Florida Farmworkers', *Environmental Health Perspectives,* vol. 111, no.14, pp. 1765-1772. doi:10.1289/ehp.6341 http://dx.doi.org/ or http://www.ehponline.org/members/2003/6341/6341.html

Kamel, F; Hoppin, JA 2004, „Association of Pesticide Exposure with Neurologic Dysfunction and Disease', *Environmental Health Perspectives,* vol. 112, no. 9, pp. 950 - 958.

Kamel, F; Engel, LS; Gladen, BC; Hoppin, JA; Alavanja, MCR; Sandler, DP 2005, „Neurologic Symptoms in Licensed Private pesticide Applicators in the Agricultural Health Study', *Environmental Health Perspectives,* vol. 113, no. 7, pp. 877 - 882.

Kaplan, JG; Kessler, J; Rosenberg, N; Pack, D; Schaumberg, HH 1993, „Sensory neuropathy associated with Dursban (chlorpyrifos) exposure', *Neurology,* vol. 43, pp. 2193 - 2196.

Kart, A 2005, „Neuropathic Aspect of Organophosphate Toxicity: A Review', *Journal of Animal and Veterinary Advances,* vol. 4, no.8, pp. 723 - 725.

Kerwin, R; Naylor, R; Travis, MJ; Simons, O; Moore, PK 1997, „Drugs and the Nervous System', in CP Page, MJ Curtis, MC Sutter, MJA Walker & BB Hoffman (eds), *Integrated Pharmacology,* Mosby, London, pp. 93 - 148.

Kessler, D; Lloyd, K; Lewis, G; Gray, D 1999, „Cross sectional study of symptom attribution and recognition of depression and anxiety in primary care', *British Medical Journal,* vol. 318, pp. 436 - 440.

Kessler 2002, „Alcohol fuels suicidal tendencies', WOR Health Centre, Bristol.

Klerman, GL 1980, „Overview of affective disorders', in Kaplan HI et al (eds), *Comprehensive Textbook of Psychiatry,* Williams & Wilkins, Baltimore, 3rd ed. Vol. 2, pp. 1305 - 1319.

Konradsen, F 2007, „Acute pesticide poisoning – a global public health problem', *Danish Medical Bulletin – No.1,* vol. 54, pp. 58 - 61.

Kruger, A; Lemke, S; Phometsi, M; van't Riet, H; Pienaar, AE; Kotze, G 2006, „Poverty and household food security of black South African farm workers: the legacy of social inequalities', *Public Health Nutrition,* vol. 9 no. 7, pp. 830 - 836.

Lee, WJ; Alavanja, MCR; Hoppin, JA; Rusiecki, JA; Kamel, F; Blair, A; Sandler, DP 2007, „Mortality among Pesticide Applicators exposed to Chlorpyrifos in the Agricultural Health Study', *Environ Health Perspect,* vol. 115 no.4, pp. 528 - 534.

Levin, HS; Rodnitzky, RL; Mick, DL 1976, „Anxiety associated with exposure to Organophosphate Compounds', *Arch Gen Psychiatry,* vol. 33, pp. 225 - 228.

London, L 1994, „Agrichemical safety practices on farms in the Western Cape', *SAMJ,* vol. 84, pp. 273 - 278.

London, L & Myers, J 1995, „Critical Issues for Agrichemical Safety in South Africa', *American Journal of Industrial Medicine,* vol. 27, pp. 1 - 14.

London, L; Myers, JE; Nell, V; Taylor, T; Thompson, M-L 1997, „An Investigation into Neurologic and Neurobehavioral Effects of Long-Term Agrichemical Use among Deciduous Fruit Farm Workers in the Western Cape, South Africa', *Environmental Research,* vol. 73, pp. 132 - 145.

London, L & Myers, JE 1998, „Use of a crop and job specific exposure matrix for retrospective assessment of long term exposure in studies of chronic neurotoxic effects of agrichemicals', *Occup Environ Med,* vol. 55, pp. 1 - 8.

London, L; Nell, V; Thompson, M-L; Myers, JE 1998, „Health status among farm workers in the Western Cape – collateral evidence from a study of occupational hazards', *SAMJ,* vol. 88 no. 9, pp. 1096 - 1101.

London L, Rother HA 2000, „People, Pesticides and the Environment: Who bears the brunt of backward policy in South Africa? New Solutions', vol. 10, no. 4, pp. 339 – 350.

London, L & Rother, A 1998, „Pesticides - time to take action', *SA Labour Bulletin,* vol. 22 no.5, pp.73 - 79.

London, L; Dalvie, MA; Cairncross, E; Solomons, A, The Quality of Surface and Groundwater in the Rural Western Cape with regard to Pesticides, *Final report to the Water Research Commission, WRC Report No: 795/1/00,* Cape Town, South Africa.

London, L 2000, „Alcohol consumption amongst South African farm workers: a challenge for post-apartheid health sector transformation', *Drug and Alcohol Dependence,* vol. 59, pp. 199 - 206.

London, L; Flisher, AJ; Wesseling, C; Mergler, D; Kromhout, H 2005, „Suicide and Exposure to Organophosphate Insecticides: Cause or Effect?', *American Journal of Industrial Medicine,* vol. 47, pp. 308 - 321.

London, L; Thompson, M-L; Myers, J 2006, „Measurement of alcohol consumption amongst South African farm workers', *Public Health and Human Rights APHA 134th Annual Meeting and Exposition,* Boston, MA.

Lotti, M 1992, „Central neurotoxicity and behavioural effects of anticholinesterases', in Ballantyne, B; Marrs, TM; Aldridge, WN (eds), *Clinical and experimental toxicology of organophosphates and carbamates,* Butterworth, Stoneham, MA, pp. 465 – 487.

Lotti, M 1995,'Cholinesterase inhibition: complexities in interpretation', *Clinical Chemistry,* vol. 41, pp. 1814 - 1818.

Lotti, M & Moretto, A 2005, „Organophosphate-Induced Delayed Polyneuropathy', *Toxicological Reviews,* vol. 24 no. 1, pp. 37 - 49.

Lund, C; Stein DJ; Corrigall, J; Bradshaw, D; Scheider, M; Flisher, AJ 2008, „Mental health is integral to public health: a call to scale up evidence-based services and develop mental health research', *South African Medical Journal.*

Makowska, Z; Merecz, D; Mościcka, A; Kolasa, W 2002, „THE VALIDITY OF GENERAL HEALTH QUESTIONNAIRES, GHQ-12 AND GHQ-28, IN MENTAL HEALTH STUDIES OF WORKING PEOPLE', *International Journal of Occupational Medicine and Environmental Health,* vol. 15 no. 4, pp. 353-362.

Malmberg, A; Hawton, K; Simkin, S 1997, „A study of suicide in farmers in England and Wales', *Journal of Psychosomatic Research,* vol. 43, pp. 107 - 111.

Malmberg, A; Simkin, S; Hawton, K 1999, „Suicide in farmers', *British Journal of Psychiatry,* vol. 175, pp.103 – 105.

Malone, KM; Oquendo, MA; Haas, GL; Ellis, SP; Li, S; Mann, JJ 2000, „Protective Factors Against Suicidal Acts in Major Depression: Reasons for Living', *Am J Psychiatry,* vol. 157, pp. 1084 - 1088.

Manuel, C; Gunnell, DJ; van der Hoek, W; Dawson, A; Wijeratne, IK; Konradsen, F 2008, „Self-poisoning in Rural Sri Lanka: small area variations in incidence', *BMC Public Health,* vol. 8 no.26.

Maruping, M; London, L; Flisher, AJ n.d.. „Organophosphate exposure and suicide amongst South African farm workers', unpublished manuscript, University of Cape Town, Cape Town.

Matthews, KA; Flory, JD; Muldoon, MF; Manuck, SB 2000, „Does Socioeconomic Status Relate to Central Serotonergic Responsivity in Healthy Adults?', *Psychosomatic Medicine,* vol. 62, pp. 231 - 237.

Matthews, 2004, „An Exploratory Study of aspects on Environmental Conditions associated with Alcohol and Drug Abuse and Criminal Behaviour', Mini-Thesis for the degree of M.A. (Child and Family Studies), University of Western Cape.-, South Africa.

McCall, K 2001, „An understanding of depression – experiences of doctors', *BMJ,* vol. 323, p.1011

Mearns, J; Dunn, J; Lees-Haley, PK 1994, „Psychological effects of organophosphate pesticides: A review and call for research by psychologists', *J Clin Psych,* vol. 50, pp. 286 - 293.

Meijster, T; Wendel de Joode, B; Major, V; Maruping, M; London, L; Kromhout, H n.d., „Dermal exposure assessment for an epidemiological study among wine – and table grape farm workers', unpublished.

Minton, Neil A. & Murray, Virginia SG 1988, „A Review of Organophosphate Poisoning', *Medical Toxicology,* vol.3, pp. 350 – 375.

Mishra, S 2006, *Suicide of Farmers in Maharashtra: Executive Summary,* Indira Gandhi Institute of Development Research, Mumbai.

Mitchell-Heggs, N 1971, „Aspects of natural history and clinical presentation of depression', *Proc R Soc Med,* vol. 64, pp. 1171 - 1178.

Mkize, LP; Nonkelela, F; Mkize, DL 1998, „Prevalence of depression in a university population', *Curationis,* vol. 21, no. 3, pp. 32 - 37.

Moschandreas, DJ; Karuchit, S; Kim, Y; Ari, H; Leibowitz, MD; O'Rourke, MK; Gordon, S; Robertson, G 2001, „On predicting multi-route and multimedia residential exposure to chlorpyrifos and diazinon', *Journal of Exposure Analysis and Environmental Epidemiology,* vol. 11, pp. 56 - 65.

Mudie, L 2006, *Suicide Rampant Among China's Rural Women, Urban Middle Class.* Retrieved January 23, 2009 from http://www.Suicide

Muller, JE; Ignatius, W; Nel, DG; Stein, DJ 2008, „Depression and Anxiety in multisomatoform disorder: prevalence and clinical predictors in primary care', *South African Medical Journal.*

Nair, M; Pillay S 1997, „Psychiatric disorder in a South African general hospital: Prevalence in medical, surgical, and gynecological wards', *General Hospital Psychiatry,* vol. 19, no. 2, pp. 144 - 148.

National Injury Mortality Surveillance System (NIMS) 2001 (eds.), *Second Annual Report: A profile of Fatal Injuries in South Africa 2000,* MRC, UNISA, CSIR

Newman, B 2006, „Indian Farmer Suicides', *Food First: Backgrounder,* vol. 12 no. 4.

O'Donoghue, JL 1983, „Neurotoxicology', in Homburger, F; Hayes, JA; Pelikan, EW; Karger (eds), *A guide to general toxicology,* Elsevier, Basel.

O'Malley, M 1997, „Clinical evaluation of pesticide exposure and poisonings', *The Lancet,* vol. 349, pp. 1161 – 1166.

Oquendo, MA; Mann, JJ 2000, „The biology of impulsivity and suicidality', *Psychiatr Clin North AM,* vol. 23, pp. 11 - 25.

Organic Emporium 2006, *'The health hazards of organophosphate use in South Africa'.* Retrieved April 12, 2008 from http://www.organicemporium.co.za/news.php

Organophosphates: Toxicology 2000, *„Effects/Symptoms of Toxicity'.* Retrieved April 09, 2003 from http://www.ansci.cornell.edu/courses/as625/2000term/organophos/EffectsSymptomsTreatment.html

Ovuga, E; Boardman, J; Wasserman, D 2005, „The Response Inventory for Stressful Life Events (RISLE) I.refinement of the 100-item version', *African Health Services,* vol. 5, no. 2, pp. 137 - 144.

Parrón, T; Hernández, AF; Villanueva, E 1996, „Increased risk of suicide with exposure to pesticides in an intensive agricultural area. A 12-year retrospective study', *Forensic Sci Int,* vol. 79 no.1, pp. 53 - 63.

Patel, V; Abas, M; Broadhead, J; Todd, C; Reeler, A 2001, „Depression in developing countries: lessons from Zimbabwe', *BMJ,* vol. 322, pp. 482 - 484.

Patton, JH; Stanford, MS; Barratt, ES 1995, „Factor structure of the Barratt Impulsiveness Scale', *Journal of Clinical Psychology,* vol. 51, pp. 768 – 774.

Peden, M; Butchart, A 1999, „Trauma and Injury' in Crisp, N & Ntuli, A (eds.), *South African Health Review 1999,* Health Systems Trust, Durban, pp. 331 - 344.

Penagos, H; Manuskiatti, W; Abrams, K; Hogan, DJ; Maibach, HI; O'Malley, M 2001, „The Reported Skin Effects of Pesticides by Use and Structural Category', in Penagos Homero et al (eds), *Pesticide Dermatoses,* CRC Press, Florida, p. 91.

Perry, M 2006, „Australian farmers commit suicide as hope evaporates', *Mail & Guardian online: Sydney, Australia,* 19 October 2006 07:39. Retrieved January 24, 2009 from Mail & Guardian online.

Pesticides and You 2000 - 2001, Global climate change and pesticides', *News from Beyond Pesticides/ National Coalition Against the Misuse of Pesticides (NCAMP),* vol. 20 no.4, p. 0-0.

Peters, M 2006, 'How pesticide poisoning is choking country life', *Weekend Argus,* 28 October, p. 4.

Pickett, W; King, WD; Lees, RE; Bienefeld, M; Morrison, HI, Brison, RJ 1998, „Suicide mortality and pesticide use among Canadian farmers', *Am J Ind Med,* vol. 34 no. 4, pp. 364 - 372.

Pickett, W; King, WD; Faelker, T; Lees, REM; Morrison, HI; Bienefeld, M 2000, „Suicides among Canadian Farm Operators', *Chronic Diseases in Canada,* vol. 20 no. 3.

Pilkington, A; Jamal, GA; Gilham, R; Hansen, S; Kidd, M; Hurley, JF; Soutar, CA 1999, „Epidemiological study of the relations between exposure to organophosphate pesticides and indices of chronic peripheral neuropathy and neuropsychological abnormalities in sheep farmers and dippers. Phase 3; Clinical neurological, neurophysiological and neuropsychological study', *Official report to British HSE, DoH and MAFF,* May, pp. 1 - 205.

Pilkington, A; Buchanan, D; Jamal, GA; Gilham, R; Hansen, S; Kidd, M; Hurley, JF; Soutar, CA 2001, „An epidemiological study of the relations between exposure to organophosphate pesticides and indices of chronic peripheral neuropathy and neuropsychological abnormalities in sheep farmers and dippers', *Occup Environ Med,* vol. 58, pp. 702 - 710.

Phillips, MR; Yang, G; Zhang, Y; Wang, L; Ji, H; Zhou, M 2002, „Risk factors for suicide in China: a national case-control psychological autopsy study', *Lancet,* vol. 360, pp. 1728 – 1736.

Poojara, L; Vasudevan, D; Arun Kumar, A; Kamat, V 2003, „Organophosphate poisoning: Diagnosis of intermediate syndrome', *Indian Journal of Critical Care Medicine,* vol. 7, no. 2, pp. 94 - 102.

Powell, TJ 2000, „Chronic neurobehavioural effects of mercury poisoning on a group of Zulu chemical workers', *Brain Injury,* vol. 14, no.9, pp. 797 - 814.

Reidy, TJ; Bowler, RM; Rauch, SS; Pedroza, GI 1992, „Pesticide Exposure and Neuropsychological Impairment in Migrant Farm Workers', *Archives of Clinical Neuropsychology,* vol. 7, pp. 85 - 95.

Renner, R 2004, „A new mechanism for chlorpyrifos? Implicating serotonin', *Environmental Health Perspectives.* Retrieved May 11, 2009 from http//:www.thefreelibrary.com/A ….-a0114559340.

Reutter, S 1999, „Hazards of chemical weapons release during war: new perspectives', *Environmental Health Perspectives,* vol. 107, no. 12, pp. 985–990.

Robson, MG; Hamilton, GC; Brachman, GO 2000, „Case Study on Chronic Organophosphate Poisoning', *Paper presented at the ECOHSE 2000 Symposium,* Kaunas, Lithuania.

Rosenstock, L; Keifer, M; Daniell, WE; McConnell, R; Claypoole, K; and the Pesticide Health Effects Group 1991, „Chronic central nervous system effects of acute organophosphate pesticide intoxication', *The Lancet,* vol. 338, pp.223 – 227.

Rothlein, J; Rohlman, D; Lasarev, M; Phillips, J; Muniz, J; McCauley, L 2006, „Organophosphate Pesticide Exposure and Neurobehavioral Performance in Agricultural and non-Agricultural Hispanic Workers', *Environmental Health Perspectives.* http://www.medscape.com/viewarticle/532161

Savage, EP; Keefe, TJ; Mounce, LM; Heaton, RK; Lewis, JA; Burcar, PJ 1988, „Chronic Neurological Sequelae of Acute Organophosphate Pesticide Poisoning', *Archives of Environmental Health,* vol. 43 no.1, pp.38 - 45.

Schulz, R; Peall, SKC; Dabrowski, JM; Reinecke, AJ 2001, „Spray Deposition of Two Insecticides into Surface Waters in a South African Orchard', *Journal of Environmental Quality,* vol. 30, pp. 814 - 822.

Schulz, R; Peall, SKC; Dabrowski, JM; Reinecke, AJ 2001, „Current-use insecticides, phosphates and suspended solids in the Lourens River, Western Cape, during the first rainfall event of the wet season', *Water SA,* vol. 27 no.1, pp. 65 - 70.

Screenivasan, B; Stephens, R 2004, „Neuropsychological effects of long-term low-level organophosphate exposure in orchard sprayers in England', *Archives of Environmental Health.*

Senanyake, N; Karalliedde, L 1987, „Neurotoxic effects of organophosphorous insecticides. An intermediate syndrome', *New England Journal of Medicine,* vol. 316, no. 13, pp. 761 - 763.

Singh, S & Sharma, N 2000, „Neurological Syndromes following organophosphate poisoning', *Neurology India,* vol. 48 no.4, pp. 308 - 313.

Slotkin, TA 2005,'Alterations in central nervous system serotonergic and dopaminergic synaptic activity in adulthood after prenatal or neonatal chlorpyrifos exposure', *Environmental Health Perspectives.* Retrieved May 11, 2009 from http//:www.thefreelibrary.com/Alterations...-a0135818143

Slotkin, TA; Tate, CA; Ryde, IT; Levin, ED; Seidler, FJ 2006, „Organophosphate Insecticides Target the Serotonergic System in Developing Rat Brain Regions: Disparate Effects of Diazinon and Parathion at Doses Spanning the Threshold for Cholinesterase Inhibition', *Environmental Health Perspectives,* vol. 114, no.10, pp. 1542 - 1546.

Smetherham, J-A 2007, 'Deadly haze drifts in from the vineyards', *Cape Times,* 13 November, pp. 4 - 5.

Smetherham, J-A 2007, 'Farmers' arsenal of toxins claims a human toll', *Cape Times,* 13 November, p. 5.

Smetherham, J-A 2008, 'Scrupulously obey the injunction, farmer told', *Cape Times,* 07 February, p. 6

Smit, LAM; van-Wendel-de-Joode, BN; Heederick, D; Peiris-John, RJ; van der Hoek, W 2003, „Neurological Symptoms Among Sri-Lankan Farmers Occupationally Exposed to Acetylcholinesterase-Inhibiting Insecticides', *American Journal of Occupational Medicine,* vol. 44, pp. 254 - 264.

Smits, NM 2000, „Suicide and depression resulting from exposure to pesticides among tobacco farmers in Paraná, Brazil' a pilot study, Science Shop, Liaison Office, Wageningen University, Netherlands.

So, YT 1995, „Nervous System' in Stuart Brooks et al (eds), *Environmental Medicine*, Mosby, pp. 318 – 325.

Solomon, C; Poole, J; Palmer, KT; Peveler, R; Coggan, D 2007, „Neuropsychiatric symptoms in past users of sheep dip and other pesticides', *Occup Environ Med,* vol. 64, pp. 259 - 266.

South African Standard, Code of practice (ed.2) 1993, „The safe handling of pesticides (SABS 072)', *South African Bureau of Standards,* Pretoria.

Spedding, A 2008, „Rural Stress Review: Depression and suicide among farmers', *RuSource, the rural information network (developed from the Arthur Rank Centre project: Farming Information for Rural Ministry (FIRM)),* briefing 181, Rural Solutions, United Kingdom. http://www.ruralsolutions.co.uk/

Spruit O & van Puijvelde M 1998, „Evaluation of the Protective Equipment used during Herbicide Application on Banana Plantations', *Internverslag 1998-304,* Landbouwuniversiteit Wagengingen.

Stallones, L & Beseler, C 2002, Pesticide Poisoning and Depressive Symptoms among Farm Residents', *Ann Epidemiol,* vol. 12 no. 6, pp. 389 - 394.

Steer, RA; Rissmiller, DJ; Beck, AT; Anderson, KG 2000, „Use of the Beck Depression Inventory-11 with depressed geriatric patients', *Behaviour Research Therapy,* vol. 38 no.3, pp. 311 - 318.

Steinweg, DL; Worth, H 1993,'Alcoholism: The Keys to the CAGE', *American Journal of Medicine,* vol. 94, pp. 520 - 523.

Stephens, R; Spurgeon, A; Calvert, IA; Beach, J; Levy, LS; Berry, H; Harrington, JM 1995, „Neuropsychological effects of long-term exposure to organophosphates in sheep dip', *Lancet,* vol. 345, pp. 1135 - 1139.

Studemire, A; Frank, R; Hedemark, N 1986, „The economic burden of depression', *Gen Hosp Psychiatry,* vol. 8, pp. 387 - 394.

Sultatos, L 1994, „Mammalian Toxicology of Organophosphorous Pesticides', *Journal Toxicology Environ Health,* vol. 43, pp. 271 - 289.

The Human Ecologist (THE) Supplement vol. 2 1998, *„Chlorpyrifos'.* Retrieved March 02, 2008 from http://members.aol.com/HEALNatnl/hs0202.html

The Toxic Chemicals Most Linked to Depression n.d. Retrieved January 12, 2009, from http://www.sixwise.com/

Tortora, GJ & Grabowski, SR (Tenth ed.) 2003, *Principles of Anatomy and Physiology,* John Wiley & Sons, Inc., USA

Van Wijngaarden, E 2003, „An Exploratory Investigation of Suicide and Occupational Exposure', *JOEM,* vol. 45 no.1, pp. 96 - 101.

Ward, C; Lombard, C; Gwebushe, N 2006, „Critical incident exposure in South African emergency services personnel: prevalence and associated mental health issues', *Emergency Medicine Journal,* vol. 23, no.3, pp. 226 – 231.

Willemse, M 2008, „Exploring the relationship between self-efficacy and aggression in a group of adolescents in the peri-urban town of Worcester', Masters in Psychology Thesis, University of Stellenbosch, South Africa.

World Health Organization 1962, *Occupational Health Problems in Agriculture: Fourth Report of the Joint ILO/WHO Committee on Occupational Health,* World Organization, Geneva.

World Health Organization (WHO) 1999, *Report on a Workshop on Suicide Prevention for countries in the African Region,* Department of Mental Health WHO, Geneva.

World Health Organization (WHO) 1999b, *Global Status Report on Alcohol,* WHO, Geneva

World Health Organization (WHO) 2008, „*WHO Statement: World Suicide Prevention Day 2008'.* Retrieved October 26, 2008 from http://www.who.int/entity/mentalhealth/prevention/suicide/wspd.2008. statement.

Yang, CC; Deng, JF 2007, „Intermediate syndrome following organophosphate insecticide poisoning', *Journal Chinese Medical Association,* vol. 70, no. 11, pp. 467 - 472.

Zhang, J; Stewart, R; Phillips, M; Shi, Q; Prince, M 2009, „Pesticide exposure and suicidal ideation in rural communities in Zhejiang province, China', *Bulletin of the World Health Organization,* vol. 8740, pp. 745 - 753.

Zung, VWK & King, RE 1983, „Identification and treatment of masked depression in a general medical practice', *J Clin Psychiatry,* vol. 44, pp. 365 - 368.

CHAPTER 3

METHODS USED IN THE STUDY

3.1 Description of the Research Area

The study was situated in the Breede Valley area of the Western Cape Province. The Breede Valley consists of five (5) main areas: Worcester, Rawsonville, HexRiver Valley, De Doorns, Touwsrivier and each area's surrounding farming areas (Schroeder, 2002). Worcester is the largest business and commercial center of the whole Breede Valley area and regarded as the gateway to the Hex River Valley, which lies north of the town. Altogether 20% of the South African national vineyards are in the Worcester district, which accounts for the Breede Valley's economy being largely based on agricultural development (Schroeder, 2002).

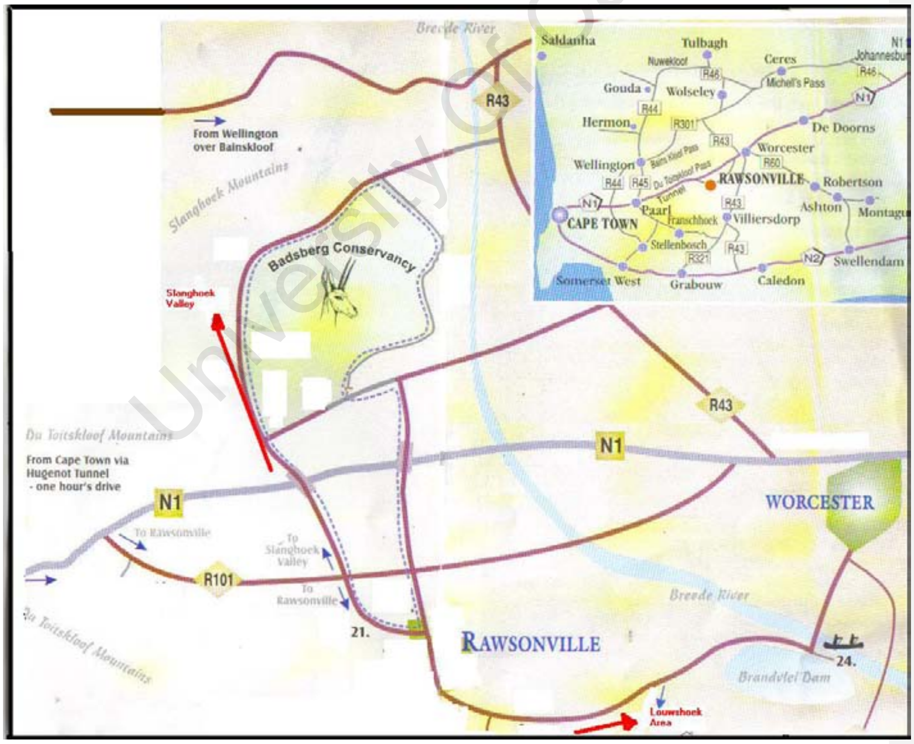
These areas are administered by the Breede Valley Local Municipality. The farming areas, which are the target areas for this research study, have been administered by the Cape Winelands District Municipality (CWDM) since 2000. Prior to 2000, the area was administered by the Winelands and Breede River District Councils.

The study was conducted in the farming areas of Rawsonville and Hex River Valley (which includes the town of De Doorns). Since all table grape farmers in the Hex River Valley and neighbouring areas are members of the Hex Valley Producers Association, the study population for table grape farms was randomly sampled from the 201 member farms of the Hex Valley Producers' Association in 2002, as a result of which, one farm in Brandwacht and one in Nuy were selected into the study, as well.

Rawsonville is a satellite town situated in the heart of the Breede River Valley, and is renowned for its wine-grape farming products. Approximately 90 km east of Cape Town and 15 km west of Worcester, Rawsonville consists of three (3) main areas, Du Toitskloof, Slanghoek Valley and Louwshoek. (figure 1.1)

- Du Toitskloof, placed at the foot of the Du Toitskloof mountain range, surrounded by the Breede and Molenaars rivers.
- Slanghoek Valley lies to the north-west of Rawsonville, surrounded by the Slanghoek mountains. Five (5) farms in this area were included in the study
- Louwshoek area, situated on the outskirts of Rawsonville, to the south-east of the village, close to the Brandvlei Dam. Four (4) farms in this area were included in the study.

Figure 3.1 Wine Grape Study Sites[5]



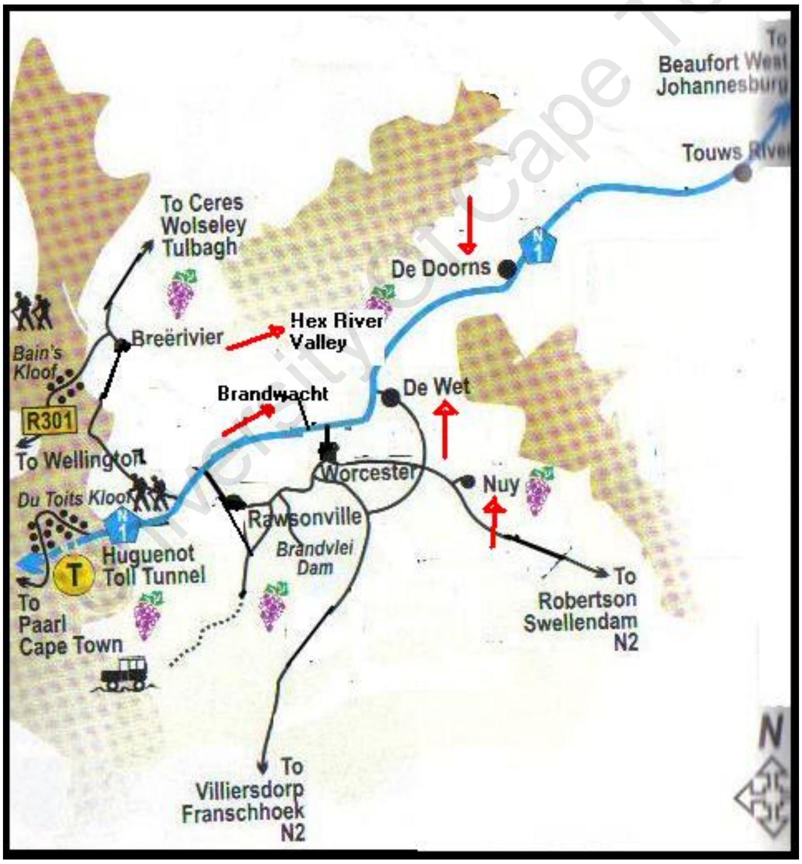
5 Source of map: Rawsonville Tourist Information and Wine Tasting Centre

The Hex River Valley is about 140 km east of Cape Town. It consists of four (4) main areas: Sandhills, Hex River, Orchard and De Doorns The farms of these areas lie nestled between the Hex and Quado mountains.

In 2006, the Hex River Valley had been recognized as the largest producer of export table-grapes in South Africa for the past century (Hex Valley Tourism Bureau, 2006).

For the purposes of this study, farms in Sandhills and the immediate vicinity of Hex River (De Wet, Kanetvlei, Over-Hex) were grouped into the Hex River area. Figure 1.2 illustrates the study sites for the table grape farms.

Figure 3.2 Table Grape Study Sites[6]



[6] Source of map: Hex Valley Tourism Bureau

3.2 Study Design, Population and Sampling

3.2.1 Study Design

A cross-sectional analytical study was conducted in June, July and August 2002, where dependent and independent variables were measured simultaneously. In a cross-sectional survey, a sample of the study population (farm workers on wine and table grape farms in the Worcester area) is investigated at a point in time. The descriptive component of the study allowed for the calculation of the prevalence of the risk factors (exposures) and the prevalence of disease (outcomes) during the stated time period. The analytical component of the study allowed for the cross-sectional comparison of exposed groups with respect to the presence of outcomes.

3.2.2 Population

According to the 2001 national population census, 146 029 people were living in the cities, towns and farming areas administered by the Breede Valley Municipality. Of the total population, the majority were living in Worcester, the main town of the Municipality while slightly over a quarter (27%) were farm residents (Statistics South Africa, Census 2001). The towns in the study site comprised about 7% of area's population (1765 people or < 2% resident in Rawsonville and 7272 people or 5% in De Doorns). These population figures are not static because of the continuous migration of work-seekers between farms and squatter residential areas. „The Breede Valley experiences a combination of oscillating migration and rural-to-urban movement due to the seasonal nature of farm labour' (Schroeder, 2002, p. 32).

The projected population figures for the Cape Winelands District Municipality indicated that there were 71657 persons living in the district in 2002 (population data from 1996 census projected to 2002; Report – DC2: March 2003).

The Hex Valley Producers' Association estimated a population figure of 12000 permanent farm workers on the 201 member table grape farms in 2001, with an additional 6000 seasonal workers during the months December to May (interview with Mrs. Elsa Jordaan, secretary of the Hex Valley Producers' Association, September 2001).

3.2.3 Sampling

Power calculations, using Epi Info Version 6.0 (Dean et al, 1996), were computed for sample size. Statistical calculations indicated that a sample size of 776 respondents was required, assuming a 3:1 ratio of exposed to non-exposed participants, a power of 80%, an alpha (α) of 0.05 and a priori estimate of the odds of pesticide exposure being 2.00 (Table 3.1). Hence, a study of this size would have the power to identify significant associations for a farm worker exposed to organophosphate pesticides who was twice as likely to be depressed or suicidal, than a worker who had not experienced any exposure.

Table 3.1 Sample size calculations: Epi Info version 6.0

Assumptions	**Estimated Odds Ratio a priori**	**Ratio Exposed: Non-exposed**	**Exposed Number**	**Non – Exposed**	**Total N**
$\alpha = 0.05$; Power = 0.8	2.00	3.1	582	194	776
$\alpha = 0.05$; Power = 0.8	2.50	3.1	315	105	420
$\alpha = 0.05$; Power = 0.8	3.00	3.1	210	70	280

Because of the uncertainty as to whether the sample of 776 participants would be obtained due to the reluctance of wine grape farmers to participate in the study and the initial inability to obtain the contact details of the members of the

Hex Valley Producers' Association, participation was initially requested from all farm workers on each farm, when access to these farms was obtained. Moreover, on some farms, particularly the wine grape farms, farm owners and managers preferred to have all their workers interviewed instead of the sample required from each farm. This resulted in a sample of 817 farm workers being included in the study (179 wine grape participants and 638 table grape participants). Overall, none of the farm workers on the selected farms, who were approached to participate in the study, refused to do so.

Sixty of the 201 member table grape farms were randomly selected for the study, using a table of random numbers (Vaughan & Morrow, 1989). Forty-eight farms (80%) participated in the study. On 14 (29%) of the selected table grape farms, 50% and more workers per farm were interviewed. On the rest of the table grape farms, only the pesticide applicators / handlers and 5 – 6 male and female general farm workers were interviewed. Participation therefore varied from three (3) to thirty (30) farm workers per farm for the table grape sample (Table 3.2).

Sampling in the Rawsonville area could not be done randomly. Therefore a convenience sample of wine grape farms, five (5) in Slanghoek and four (4) in Louwshoek participated in the study. Despite a large proportion of 2001 being spent networking and building relationships with the farmers in Slanghoek, most wine grape farm owners / managers in the Rawsonville area refused to participate in the study. As a result of the efforts of an environmental health officer for the Boland District Municipality, and a farm owner who was the chairman of the Goudini Farmers' Association at the time of the study, a convenience sample of wine grape farms, five (5) in Slanghoek and four (4) in Louwshoek was obtained. All the farm workers on the wine grape farms in the convenience sample were requested to participate in the study. Participation in this area varied from one (1) to thirty nine (39) worker per farm (Table 3.2). The one isolated farm worker was from an organic farm where the participant had been a tractor driver / head spray man prior to the change in the farm's agricultural practices.

Table 3.2 describes the farm worker participation per farm for wine and table grape areas.

Table 3.2 Summary of worker participation per farm

Number of participant farm workers	Number of Wine Grape farms	Number of Table Grape farms
1 – 10	1	28
11 – 20	4	11
21 – 30	2	9
31 – 40	2	
Total participant farms	9	48
No. of non-response farms	57	12
Total farms in study area	66	201
Total participant farm workers	179	638
Total farm workers in population	Unknown – no specific statistics available	± 12 000 permanent workers and ± 6000 annual seasonal workers

3.3 Pilot Studies

Prior to the main study in 2002, three (3) pilot studies were completed. Two pilot studies were completed during 2001 and one in 2002:

3.3.1 Three (3) of the depression outcome instruments, the General Health Questionnaire (GHQ), Beck Depression Inventory (BDI) and the Brief Symptom Inventory (BSI) were translated into Afrikaans, and in June 2001 field testing of the translated versions of these psychiatric questionnaires was carried out on a group of twelve (12) farm workers working on a wine grape farm in Stellenbosch (a farming area approximately 100km west of the study area), in the Western Cape. The field testing demonstrated that 20 minutes to one hour was required to administer the 3 questionnaires. Focus group discussions were held with all the workers who participated in the field testing to determine the participants' understanding of the questionnaires and the appropriateness of the language used for conveying the intent of the instruments. The questionnaires were revised and corrected based on the findings of the focus group discussions. These questionnaires were field tested again in 2002 prior to their administration in the main study.

3.3.2 An observational study was conducted in October 2001, on farm workers on three (3) farms in Slanghoek and six (6) farms in Hex River Valley to identify the main farming hazards and the jobs / tasks involving pesticide exposure. This study allowed for the acquisition of knowledge on farming practices on the two types of grape farms, and the specific tasks executed by grape farm workers, which assisted in refining the exposure questionnaire. The observational study included field testing of a semi-quantitative Dermal Exposure Assessment instrument (DREAM), derived from work of the Dutch collaborators in the study, to validate the work exposure questionnaire and assess dermal exposure to pesticides (van Wendel de Joode, 2004: chapter 3).

3.3.3 The exposure questionnaire and the six (6) standardized depression and suicidality outcome questionnaires for the main study were translated into Afrikaans. Field testing of the translated versions of these instruments was carried out on a group of ten (10) Afrikaans speaking farm workers on another wine grape farm in Stellenbosch, on 05 June 2002. The questionnaires were tested for language validity and administration time, and they were administered by the same research assistants who conducted the interviews for the main study. The field testing demonstrated good face validity with the farm workers, and reported that both instruments could be completed within 60 - 90 minutes depending on the work history of the individual participant. The measurement of the red blood cell (erythrocyte) acetylcholinesterase (AChE) levels was not included in the field testing.

3.4 Main Study Measurements

The main study was conducted during the period 19 June to 29 July 2002, with a further four (4) days of interviews on 05 and 26 August 2002, and 11 and 21 October 2002. In an attempt to increase the participation of more highly exposed farm workers (tractor drivers and pesticide spray operators) on table grape farms, interviews conducted on the latter 4 days included mainly these workers, and during this time three to ten participants per table grape farm were interviewed.

The exposure and outcome measurements were administered by 9 – 12 interviewers who spoke Afrikaans fluently, and were current or past environmental health students.

3.4.1 Exposure Questionnaire

The final study exposure questionnaire, which was translated into Afrikaans, was back-translated into English (Appendix B). Questions were designed to capture a mixture of quantitative and qualitative data. For the purposes of this study, only the quantitative data was analyzed.

The exposure questionnaire was structured to obtain the following information:

1. Demographics
2. Work / occupational history from the first job until the current employment
3. Frequency of exposure by days, weeks and months per job
4. Current / recent occupational exposure
5. Environmental exposure

The work history questions included: job tasks / activities that involved exposure to pesticides; and exposures to pesticides in non-farming activities like manufacturing and transporting pesticides. The job activities included tractor driving; being a head sprayer; applying pesticides using a handgun apparatus (hand sprayer) or a back pack apparatus (back pack sprayer); general farm work that included maintenance work in the vineyards, harvesting of grapes, dipping of sheep or cattle and gardening.

The exposure questionnaire included the following potential covariates for depression and suicidality:

1. Age of the participant
2. Type of farm (wine or table grape) the participant was employed on at the time of the interview
3. Provision of personal protective clothing (PPE) in their current jobs
4. Current socio economic status
5. Previous incidents of pesticide poisoning
6. Past and current general medical and psychiatric health history
7. History of alcohol consumption (C.A.G.E. score)

These are described in more detail in section 3.7.1.4 on pages 24 - 25.

The exposure questionnaire, including questions on the potential covariates, was based on previous local pesticide studies (London, 1995; Dalvie et al, 1999). The findings of the observational study (page 6, section 3.3.2) were used in the construction of the task based exposure assessment aspect of the questionnaire. The preliminary interviews held in 2001 and 2002, with farm workers, environmental health officers working in the relevant farming areas, the chairperson of the Goudini Farming Association, the chairman, secretary and other executive members of the Hex Valley Producers Association, played a large role in the acquisition of knowledge of grape farming activities, development of the task based and environmental exposure questions, and determination of the optimal period for conducting the main study.

The initial intent to use the DREAM instrument to measure potential and actual pesticide exposure from the data on „frequency of exposure by days, weeks and months per job' was abandoned because of the limited data obtained during the interviewing process.

3.4.2 Acetylcholinesterase Measurements

Erythrocyte / red blood cell (RBC) acetylcholinesterase (AChE) activity was measured, using the Test-mate ChE Cholinesterase Test System (Model 400). The Test-mate ChE is a field-kit used for „the quantative determination of cholinesterase in whole blood to monitor pesticide exposure' (EQM Research, Inc., Manual A – © 2001; London et al, 1995). The Test-mate ChE photometric analyzer is factory-calibrated and requires no further calibration when being used in the field (EQM Research, Inc., Manual A – © 2001).

RBC – AChE and not plasma cholinesterase (PChE) activity was measured because the former enzyme activity is specific to organophosphate or carbamate pesticide exposure, whereas PChE activity can be inhibited by conditions like chronic alcoholism, chronic liver disorders, malnutrition, early pregnancy and oral contraceptive pills (Reigart & Roberts 1999, p. 40) and is also a marker of exposure rather than biological effect following exposure (see section 2.3.3.1 in Chapter 2, page 38).

Capillary blood was obtained from the participants by means of a finger prick test that was administered by a qualified nurse, who had been trained in the use of the Test-mate ChE testing system. The Model 460 AChE Assay Kit was used for the measurement of RBC – AChE.

In addition to the questions on current / recent occupational exposure in the exposure questionnaire, the participants' RBC – AChE activity was also measured at the time of the cross-sectional study, as an assessment of recent OP exposure (measurement of AChE is an essential element in the medical surveillance of chemical agents and pesticide handlers). With recent overexposure to OP pesticides, RBC-AChE activity is inhibited or depressed. The tests determined participants' current RBC-AChE activity, which had never previously been measured in this group of workers. The wine grape farm workers were surveyed and their RBC-AChE enzyme activity measured, before any substantive pesticide exposure took place, but the table grape participants were surveyed and their RBC-AChE enzyme activity measured, during the pesticide spraying period.

The following recommended RBC-AChE criteria for surveillance practice was used:

- ≥ 31.4 U/g acceptable / normal levels of RBC-ChE
- 26.7 – 31.4 U/g participant should be retested immediately
- 22.0 – 26.7U/g participant should be investigated and retested immediately
- < 22.0 U/g participant should be withdrawn from the exposure situation and retested after six (6) weeks

Figure 3.3 Test-mate ChE Cholinesterase Test System (Model 400) field kit used for measuring AChE levels

3.4.3 Depression and Suicidality Outcome Questionnaires

Depressive and suicidal symptoms were assessed using eight (8) recognized instruments for measurement of depression and suicidal tendencies. In addition, suicidality / suicidal ideation was measured by four (4) specific questions assessing self-injury in the twelve (12) months prior to the interview. All the outcome questionnaires were translated into Afrikaans and then back-translated into English to ensure language validity (Appendix B). The final outcome questionnaires were field tested with the exposure questionnaire on 05 June 2002 (see section 3.3.4, page 6), and administered with the exposure questionnaire during the interviews for the main study.

3.4.3.1 Psychometric characteristics of the outcome instruments

- The **General Health Questionnaire** is a standardized 28 – item questionnaire **(GHQ – 28)** recommended for survey work where sub-scales are required, and is designed to assess persons in primary care and non-psychiatric clinical settings, for **psychiatric disorders in the past two (2) months**. It consists of four 7-item subscales assessing somatic symptoms, anxiety and insomnia, social dysfunction and severe depression. The questionnaire is scored such that the higher the score, the higher the levels of psychiatric morbidity. There are three (3 methods) whereby the instrument can be scored

1. The „GHQ scoring method (0, 0, 1, 1)' is recommended when the questionnaire is used as a screening test for case identification (Goldberg & Hiller, 1979; Goldberg & Williams, 1988). For this scoring method, the cut-off 5/6 (≤ 5 being low and ≥ 6 high) is used to determine cases.
2. The „CGHQ: scoring method of Goodchild and Duncan-Jones (0, 1, 1, 1 for negative items and 0, 0, 1, 1 for positive items) has been reported to provide a less skewed distribution of the total GHQ scores, which supposedly increases the sensitivity of the instrument (Goldberg & Williams, 1988)

3. The „Likert scoring method (0, 1, 2, 3)' is recommended in survey work where sub-scales are required, and it produces a less skewed score distribution than the GHQ scoring method (Swallow et al, 20.

   The GHQ – 28 Likert scoring method was used for the purposes of this study.

   The GHQ-28 has an overall score range of 0.0 – 84.0. The suggested cut-off score of 23/24 (≤ 23 being low and ≥ 24 high) for the Likert scoring method (Goldberg et al, 1997) was used for multivariate analysis to signify workers with high and low risks of psychiatric morbidity.

   The GHQ Severe Depression Subscale has a score range of 0.0 – 21.0. The 75th percentile measurement (< 2 and ≥ 2) was used for multivariate analysis as a cut-off to distinguish workers with high depression from those with low depression.

   The results of the **GHQ - 28 Total Score and GHQ - 28 Severe Depression Subscale** were analysed separately for this study.

- The 21-item **Beck Depression Inventory (BDI-IA)** is a standardised self – assessment instrument that measures the depth of depression in the past two (2) weeks. The standard cut-offs of the instrument's total score can be used to measure the individual's level of depression, viz. 0-9 indicates that the person is not depressed, 10-18 indicates mild – moderate depression, 19-29 indicates moderate-severe depression, and 30-63 signifies severe depression. The BDI is scored 0, 1, 2, 3 with an overall score range of 0.0 – 63.0 (the higher the score, the higher the levels of depression). An overall score of „less than 4' could possibly be a denial of depression and a score „greater than 40' could indicate a possible exaggeration of depression symptoms (Stinton, L. 2002). In this study, the overall BDI score and the cut-off point of ≥ 11 was used to measure the participants' level of depression (univariate and bivariate analyses). The median score (< 11 and ≥ 11) was used for multivariate analysis to distinguish workers with high depression from those with low depression.

- The **Brief Symptom Inventory (BSI)** is a 53-item self-report symptom inventory that assesses the level of physical, physiological and psychological distress (general distress) experienced by the participants in the last seven (7) days, including the day of the interview. The **BSI total raw score** is the sum of responses to the entire 53 questions. This includes the sum of the nine (9) primary symptom dimensions assessed in this inventory, viz. „somatization', „obsessive-compulsive' behaviour, „interpersonal sensitivity', „depression', „anxiety', „hostility', „phobic anxiety', paranoid ideation' and „psychotocism'. There are also four additional items that are not included in the individual scores for the 9 primary symptom dimensions. The items are each scored 0 – 4 with „4' being rated as the highest level of distress and the BSI has an overall score range of 0.0 – 212.0.

  In addition to the 9 primary symptom dimensions, three (3) global indices of distress are also measured, viz. the „Global Severity Index' (GSI), Positive Symptom Total (PST) and „Positive Symptom Distress Index (PSDI). Derogatis (1993) states that "the GSI is the most sensitive single indicator of the respondent's distress level"

  The **GSI raw score** is calculated by summing the scores for the 9 symptom dimensions and the 4 additional items (as with the BSI raw score). The total score is then divided by the total number of responses (53 if there are no missing items, or corrected for the number of missing values, e.g. 52 if there is one (1) missing item or 51 if there are two (2) missing items).

  Of the 9 primary symptom dimensions, only the Depression Symptom Dimension was analysed for this study. This dimension consists of six (6) items. The **raw score for the Depression Symptom Dimension** is calculated by summing the 6 depression items (total score of 0 – 24) and then dividing the total summed score by the number of actual responses (6 if there are no missing items, five (5) if there is one missing value, four (4) if there are two missing values, etc.).

After calculating the raw scores for the GSI and Depression Symptom Dimension, the scores were converted to standardized T scores for each participant using the Norm Group B (adult non patients) „gender-keyed' (separate norms for males and females) version (Derogatis, 1993).

A participant who had a GSI or / and Depression Symptom Dimension T score equal to or greater than sixty-three (≥ 63) was regarded as having high levels of „general distress' or / and „high levels of depression', respectively, and was recognised as a „positive case' for physical, physiological and psychological distress or / and depression.

In this study, the BSI GSI T score was used in univariate and bivariate analyses to assess the general distress levels of participants, the „case score' measurement (cut-off ≤ 62 and ≥ 63) was used in multivariate analysis to distinguish high symptom workers from low symptom workers. The BSI Depression Symptom Dimension T score was used in univariate and bivariate analyses to assess the participants' depression levels and the 75th percentile measurement (< 39 and ≥ 39) was used for multivariate analysis to distinguish workers with high depression from those with low depression.

- The refined **Four-Factor Measurement Model of the Aggression Questionnaire (12-item AQ)** assesses the four factors of global aggression, viz. physical and verbal aggression, anger and hostility (Buss & Perry, 1992). Participants are required to answer the individual questions on a scale of one to six (1 – 6) with 1 being „absolutely uncharacteristic of me' and 6 being „absolutely characteristic of me'. The score range is 12.0 – 72.0. In this study, the overall aggression score was used in univariate and bivariate analyses as a measurement of the participants' levels of aggression (the higher the score, the more aggressive the individual) and the median score (≤ 24 and > 24) was used in the multivariate models to distinguish workers with high aggression from those with low aggression.

- The **Barrat Impulsiveness Scale version 11 (BIS-11)** is a 30-item self-report questionnaire designed to assess generally impulsive behaviour. It allows for the assessment of six (6) first-order factors (attention, motor, self-control, cognitive complexity, perseverance and cognitive instability) and three (3) second-order factors (attentional impulsiveness, motor impulsiveness and nonplanning impulsiveness). The second-order factors incorporated the first-order factors: attentional impulsiveness (attention and cognitive instability); motor impulsiveness (motor and perseverance); nonplanning impulsiveness (self-control and cognitive complexity).

  The scoring method used is 1, 2, 3, 4 with score „4' indicating the most impulsive response. High scores therefore indicate high levels of impulsivity.

  During the piloting of the questionnaire, it was found that item 19 of the questionnaire „I act on the spur of the moment' could not be meaningfully translated into Afrikaans and also appeared to duplicate item 17 „I act on impulse'. Item 19 was therefore omitted from the finalised questionnaire and a 29-item questionnaire was administered to the participants of the study. Hence the overall score range for the BIS-11 was 29.0 – 116.0.

  In this study, the overall BIS score was used to measure the general impulsiveness of participants (univariate and bivariate analyses) and the median score (≤ 55 and > 55) was used in multivariate analysis to distinguish workers with high impulsivity from those with low impulsivity.

- The **Scale for Suicide Ideation (SSI)** is a 19-item clinical research instrument designed to assess and "quantify the intensity of current conscious suicidal intent" applicable to individuals with suicidal ideation (Beck, Kovacs & Weissman, 1979).

  The instrument mainly measures „active suicidal desire' with 3 questions addressing suicide „preparation' and 3 measuring „passive suicidal desire'. Each item of the questionnaire is scored 0, 1, 2 with a total score of 0.0 – 38.0. In this study, the overall SSI score was used in univariate and bivariate analyses to assess the current levels of suicidal ideation of participants (the higher the score, the greater the suicidal ideation). The median score (≤ 1 and > 2) was used in multivariate analysis to distinguish workers with high suicidality from those with low suidicality.

3.4.3.2 Application of the Outcome Instruments

The application of neuropsychiatric instruments in local and global studies, have been discussed in chapter 2 (section 2.4.3, „Neuropsychiatric Instruments used in the Detection of Depression and Suicidality'). It is only in the last four (4) decades that standardised methods of assessment in the form of international diagnostic systems with guides, structured interviews and operational definitions, and standardised research instruments (questionnaires), have been developed, tested and validated around the world, allowing for estimates of prevalence, incidence, outcome and examination of associated risk (Baingana et al, 2006). The neuropsychiatric instruments used in this study have been used quite extensively in non-agricultural studies in South Africa, but few have assessed validity in the South African context. Moreover, there appears to be a lack of application of these neuropsychiatric instruments in agricultural studies in South Africa. .

The original 60 question version of the GHQ has been abbreviated to versions of 30, 28, 20 and 12 items. The GHQ has been translated into 10 languages and the validity of the GHQ-28 and the GHQ-12 were applied in 15 countries, where no significant differences in validity results by age, sex, education or in contrast between developing and developed countries, were found (Goldberg et al, 1997). The authors of the GHQ also encourage the equivalent substitution of items that are not understood in the local language of the study population. The GHQ-12 and -28 compared well with the GHQ-60 and correlation between the 3 versions equals 0.85 - 0.97. Correlations between the 4 scales of the GHQ-28 range from 0.33 to 0.58, with a mean sensitivity of 79.7% and specificity of 79.2% (Goldberg et al, 1997). The overall sensitivity of the GHQ has been about 68% and the specificity 81% (Feightner et al, 1990). In a study conducted in South Africa by the Human Sciences Research Council (HSRC) (2008), the total score for the GHQ-60, -30 and -28 was used as a screening for non-psychotic psychiatric disorders. A reliability of 0.75 was found for the study (particular form of GHQ not reported). For the GHQ-28, median sensitivity was 0.86 and median specificity 0.82, while for the GHQ-30 median sensitivity was 0.81 and median specificity was 0.80, indicating that the GHQ-28 was more suitable for identifying actual positive cases (HSRC, 2008). Another study conducted in South Africa by Ward et al (2006) where the GHQ-28 was used to identify staff of emergency services suffering from anxiety or depression, did not address validity criteria.

The BDI has also been widely used in the mental health field for many years (Bartlett & Coles, 1998a) and has been used for measuring psychological well-being (Bartlett & Coles, 1998a), severity of depression (Feightner, 1990) and suicidal ideation (particularly item 9 of the questionnaire) (Casey et al, 2006). Studies have shown that the BDI has a specificity of 0.73 to 0.92 and a correlation of 0.60 to 0.74 with other measurement scales (Feightner et al, 1990). A study conducted in South Africa by Fisha (2002) reported that a low non-significant positive correlation was found between the BDI-II and the Depression Index (DE PI) of the Rorschach Inkblot Test, and both instruments correlated positively with the Depressed Suicidal Ideation Critical Item Scale of the Minnesota Multiphasic Personality Inventory (MMPI-2) (Fisha, 2002). Furthermore, the study found that the BDI-II was a reliable and valid instrument capable of diagnosing depression among African patients.

This finding is supported by a study conducted in Uganda, which reported that the BDI and Beck's Scale for Suicide Ideation (SSI) was moderately correlated with an indigenous mental health screening instrument developed in Uganda, the 100-item (BDI, Pearson r varied from 0.3 to 0.5; SSI, Pearson r varied from 0.3 to 0.4) and the shortened 36-item Response Inventory for Stressful Life Events (RISLE) (BDI, Pearson r = 0.4; SSI, Pearson r varied from 0.3 to 0.4) (Ovuga et al, 2005). The BDI-II was additionally used in a study of 250 students in Transkei, South Africa, who presented with somatic symptoms and were diagnosed with mild to severe depression (53%) and moderately to severe depression (14%) (Mkize et al,1998).

The BIS-II has been used in the Western Cape and Kwazulu-Natal provinces of South Africa, in a collaborative study on gambling conducted by the Universities of Kwazulu-Natal, Cape Town, Alabama (Birmingham) and Baylor College of

Medicine (Dellis et al, n.d.) No validity or reliability results for the BIS-II were reported.

The 29-item self-report Aggression Questionnaire (AQ) developed by Buss and Perry (1992) was refined to the 12-item four-factor measurement model of the AQ, reflecting the same underlying constructs (physical aggression, verbal aggression, anger and hostility) as the original 29-item model (Bryant & Smith, 2001). A comparison of the original 29-item Aggression Questionnaire and the 12-item refined measurement model, show that the pattern of correlations are very similar for all four factors (Physical Aggression = 0.85; Verbal Aggression = 0.72; Anger = 0.83; Hostility = 0.77). The Crohnbach alphas for the AQ 29-item total score is 0.89 (Buss & Perry, 1992). Additionally, (Bryant & Smith, 2001) found that the construct validity of the refined measurement model appeared to be as good as the original 29-item AQ. A study conducted on a group of adolescents in Worcester, South Africa (Willemse, 2008), reported an alpha coefficient of 0.81 for the total score of the 29-item AQ. Another study conducted on junior primary learners in South Africa (Budhal, 2006), reported an alpha coefficient of 0.89 for the 29-item AQ and a test-retest reliability coefficient of 0.80.

The BSI is a short alternative to the Symptom Checklist (SCL-90-R) and the correlation between the two instruments ranges from 0.92 (on Psychoticism) to 0.99 (on Hostility) for the primary symptom dimensions. The BSI can be used with clinical populations and with the general public, and has been normed on three United States of America (USA) populations (psychiatric outpatients; psychiatric in-patients and non-patient normals). For the purposes of this study, the adult non-patient norms were used.

The Internal Consistency Reliability Coefficient for the Depression primary symptom dimension is 0.85 and the test-retest Reliability Coefficient for the primary symptom dimensions range from 0.68 (on Somatization) to 0.91 on (Phobic Anxiety) and 0.90 (on the General Severity Index).(Derogatis & Melisaratos, 1983).

There is no evidence of the BSI having been used in agricultural studies in South Africa, but it has been used in a non-agricultural South African study that assessed the chronic neurobehavioural effects of mercury poisoning in a group of Zulu chemical workers employed by a mercury processing plant (Powell, 2000), but no validity or reliability results were reported.

The reliability and validity of the Scale for Suicidal Ideation (SSI) was determined on a group of 90 patients hospitalised for self-destructive ruminations. 59% of the study population was Caucasian, 35% were Negro and 6% were „other'. The internal consistency of the scale as determined by the alpha coefficient was 0.89. The interrater reliability coefficient (rated between 2 clinicians) was 0.83 ($p < 0.001$). Concurrent validity of the SSI was determined by the ideation scores correlation with the „self-harm' items of the BDI, which was 0.41 ($p < 0.001$).

There is no evidence of the SSI having been used in studies in South Africa, but it has been used in the validation of an Ugandan mental health screening instrument (RISLE) (Ovuga et al, 2005) as discussed earlier.

.

3.4.3.3 Field Work Management

Interviewers were trained in administration of the exposure and outcome questionnaires prior to the data being collected. In an effort to ensure that optimal quality data was collected, completed questionnaires were randomly checked periodically. Any problems encountered with the data being collected were brought to the attention of the interviewers immediately and the necessary corrective measures were implemented immediately. All the interviewers were included in the corrective training to promote standardisation of data collection methodology and information obtained. However, as pointed out in Sections 3.7.1 (Characteristics of the Exposure data), 3.7.1.1 (Cumulative Exposure) and 5.8 of Chapter 5 (Limitations of the Study), the poor quality of the pesticide exposure data collected resulted in an inability to calculate a Job Exposure Matrix (JEM) cumulative exposure metric, which may have improved the quality of the exposure characterisation.

3.5 Logistics

Interviews were conducted on the individual farms that had agreed to participate in the study. Interviewing facilities made available by the farm owner / manager were store rooms; packing sheds; farm crèches; open areas on the farm grounds; and in some cases interviews had to be conducted in the vineyards. A vehicle was hired to transport the interviewers to the participant farms on a daily basis. Interviews were carried out during work hours and the times varied from 07H30 to 08H30, depending on the starting time of the workers, until 16H00 to 17H00. Each interviewer interviewed about 4 workers per during the period 19 June to 29 July 2002, with a further four (4) days of interviews on 05 and 26 August 2002, and 11 and 21 October 2002.

The exposure questionnaire was completed first and then the depression / suicidality (outcome) questionnaire. Thereafter the professional nurse performed the cholinesterase measurements using the Test-mate ChE Cholinesterase Test System (Model 400). The whole process was completed in 75 – 105 minutes, initially. As the interviewers became more familiar with the questionnaires, the administration time was shortened to 60 – 90 minutes per participant.

The participants were given coffee / tea and sandwiches on completion of their interviews and measurement of their AChE levels.

Figure 3.4 Questionnaire interviewing scenarios

3.6 Ethics

The Research Ethics Committee of the University of Cape Town approved the study (Reference Number 104/99) and its amended protocols; the translated consent letter and translated exposure and outcome questionnaires.

A detailed explanation in Afrikaans (native language of the farm workers) of the purpose of the study, study protocols and the risks and benefits of the study was given to all participants on every participating farm as a group (Appendix A). Thereafter, written informed consent was obtained from each individual participant, prior to administration of the study measurements and any investigations being performed on any of them. Participation in the study was voluntary and confidentiality of the participants and results was maintained. Participants were advised they could refuse to have their AChE levels measured even if they were willing to participate in the other components of the study. About 20 participants refused to have their AChE levels measured.

Two professional nurses, registered with the South African Nursing Council, were available daily for the full duration of the field work. The one nurse measured the AChE blood levels, while the other was a Clinical Nurse Practitioner, who was available at all times to counsel and manage participants who reported depressive / suicidal symptoms.

Twelve farm workers (10 females and 2 males) reported a majority of positive responses to: depression questions in the BDI and BSI questionnaires and suicide ideation questions in the SSI. Additionally, they reported to their interviewers recent feelings of depression and / or suicidality. After being counseled by the Clinical Nurse Practitioner (CNP) in the field, these workers were referred to the social worker or health institution in the area. Two participants were referred to the Worcester Community Health Centre (day hospital) with general clinical complaints. The farm owners / managers agreed to transport these workers to the health institutions they were referred to.

Figure 3.5 Farm worker being counseled by the CNP prior to being referred to a social worker or health institution

3.7 Data Management

The data was encoded and captured onto the Statistical Package for the Social Sciences (SPSS) version 15.0. Every variable was given a name to describe its position in the dataset. The data was managed and analysed using the computer software (SPSS - SA, 2006).

The main area of interest was the investigation of relationships between the independent variables (exposure data); potential confounders for depression and suicidality; and the dependent variables (depression, suicidality, aggression and impulsivity outcomes).

The exposure and potentially confounding data was a mixture of continuous and categorical variables, while the scores for the outcome data were continuous variables. All categorical variables were coded Yes = “1” and No = “2”.

The distribution of the exposure and outcome data was skewed as indicated by the differences between the mean and median scores for both exposure and outcome variables, and confirmed by the Shapiro-Wilks test ($p < 0.01$). Log transformation of the exposure, covariate and neuropsychiatric outcome continuous variables failed to normalise the distribution in most cases, so re-categorisation into dichotomous variables, across the median values or the 75th percentile, was chosen for purposes of multivariate logistic analyses. Table 3.3 shows the categorised values for the continuous variables used for multivariate logistic regression analyses.

The data for this study were collected in mid- to late-2002 and the capturing of the data onto SPSS 15.0 was completed and checked for corrections by November 2003. Analysis of the data commenced in December 2003, but discrepancies within the data (such as duplication of questionnaires and incorrect responses entered) were found. As a result of this, the data were re-checked for corrections in 2004. Eventually it was decided to re-enter selected variables of the entire dataset onto SPSS, which commenced in mid 2005 and was completed by March 2007. Analysis of the revised dataset was completed by June 2008. Additionally, the completion of this study was also delayed because the researcher was a part-time student for the entire period of this study.

Table 3.3 Continuous variables transformed into Categorical Variables for Multivariate Logistic analysis

Continuous Variables	Median	Categorical Variables
Potential Covariates		
Age	33 years	≤ 33 (low) and > 33 (high) age
PPE	2 items	≤ 1 (low) and ≥ 2 (high) items of PPE
SES	4 items	< 4 (low) and ≥ 4 (high) SES status
Exposure Variables		
Agricultural years	11 years	≤ 11 (low) and > 11 (high) years
Years worked as a tractor driver	13 years	≤ 13 (low) and > 13 (high) years
Years worked as a head sprayer	13 years	≤ 13 (low) and > 13 (high) years
Neuropsychiatric Outcomes		
GHQ total score	23 / 24 cut-off	≤ 23 (low) and ≥ 24 (high) psychiatric morbidity score
GHQ Depression Subscale	2.0 (75th percentile)	< 2.0 (low) and ≥ 2.0 (high) depression score
BDI – IA	11.0 (median)	< 11.0 (low) and ≥ 11 (high) depression score
BSI GSI	T score = 63 (a positive case)	≤ 62 (non-case) and ≥ 63 (positive case) for general distress
BSI Depression Symptom Dimension	39.0 (75th percentile)	< 39.0 (low) and ≥ 39.0 (high) depression score
12-item AQ	24.0 (median)	≤ 24.0 (low) and > 24.0 (high) aggression
BIS-II	55.0 (median)	≤ 55.0 (low) and > 55.0 (high) impulsiveness
SSI	1.0 (median)	< 1.0 (low) and ≥ 1.0 (high) suicidal ideation

3.7.1 Characteristics of the Exposure Data

3.7.1.1 Cumulative Exposure

The primary measures of cumulative exposure were continuous in nature

- number of years worked in agriculture
- number of years worked as a tractor driver
- number of years worked as a head sprayer

Calculation of cumulative years worked in agriculture entailed differentiating between agricultural and non - agricultural jobs. The agricultural jobs were derived from Question 1.4 and included those in „forestry' and „pesticide manufacturing, processing and transport' (Appendix B). „Municipality' excluded agricultural tasks.

The years worked in agriculture was determined by adding the total years spent in each agricultural job for every participant. This information was obtained from the individual participant's occupational history. Total years worked in an agricultural environment was calculated for 796 (97.4%) of the participants.

The years worked as a tractor driver and / or head sprayer was selected as a measure of cumulative exposure as globally it has been recognised that workers involved in the handling (application and mixing) of pesticides are at greatest risk of exposure (London, 1994; Dalvie et al, 1999; Meijster et al, n.d.; El Batawi M, 2004; Costa et al, 2008).

Another measure of cumulative exposure was participants who had „ever worked as a head sprayer' in their occupational history (Appendix B, Question 4.1a). This was a categorical variable.

Despite the questionnaire including frequency of pesticide spraying, the data was not analyzed because of poor quality data collected by some of the research interviewers, which may have been due to interviewer naivety (despite the training given to them) as some of them may not have fully recognized the importance of obtaining specific and detailed exposure measurement data and the role that this data played in the assessment of cumulative pesticide exposure. Other factors that contributed to the quality of data collected was the daily administration of the large number of interviewers in the field at one time (9 – 12 interviewers daily), which interfered with the immediate checking of the quality of data obtained, and the cross-sectional design of the study that did not allow for revisits to farms or re-collection of data where necessary information was excluded or unclear. Additionally in some cases, insufficient information on frequency of pesticide spraying obtained from farm workers may have been due to some participants having difficulty with recall of specific aspects of farming tasks (like frequency of pesticide spraying where participants had had more than one spraying job), and possibly in participants who reported a history of alcohol abuse as it is known to play a causal role in neurological symptoms (London et al, 2006), brain damage / injury and memory loss (Anonymous, 2001). The lack of detailed exposure data is a significant limitation of the study, discussed later in Section 5.8 of Chapter 5.

3.7.1.2 Current Exposure

The measures of current exposure were all categorical variables. They were derived from Question 4 (Appendix B) that addressed the jobs / tasks occupied by the participants at the time of conducting the cross–sectional survey.

The current jobs / tasks included for analysis were those of „current head (lead) sprayer' and „worked in the vineyard while pesticides were being sprayed'. The variable „currently any spraying activity' was computed by identifying the participants who were pesticide spray operators (including work as either tractor sprayer, head (lead) sprayer, hand sprayer or backpack sprayer) in their current jobs, and then grouping them together on the basis that they executed one or more spraying activity in their current job (e.g. a backpack sprayer may perform hand spraying as well). Because of their involvement in dual or more spraying activities, and because these activities typically involve direct contact with pesticides, this group of workers were regarded as the „high exposure' group.

Table 3.4 shows that the cumulative and current exposure variables were significantly correlated (Spearman r's varied from 0.7 to 0.9). A moderately significant correlation was found between the variable „currently any spraying activity' and the rest of the current and cumulative job exposure variables (Spearman r's varied from 0.3 to 0.5), while a weak correlation was found between the exposure variables „currently any spraying activity' and „currently worked in the orchard or vineyard while spraying took place' (Spearman r = 0.14).

3.7.1.3 Environmental Exposure

Environmental exposure was measured as participants who reported „observation of pesticide spray drift reaching their house' and / or „noticed the smell of pesticides in their house' (Appendix B, Questions 7.8 and 7.9). Responses to these questions were coded Yes = "1"; No = "2"; Unsure = "3". A significant correlation was found between the two environmental exposure variables „observed spray mist reaching the house' and „smelled pesticides in the home' (Spearman r = 0.62)

Table 3.4 Spearman Rank Correlation of Cumulative and Current Job Exposure Variables

		Ever a head sprayer (n = 138)	Ever a tractor driver (n = 227)	Current head sprayer (n = 125)	Current tractor driver (n = 213)	Currently any spraying activity (n = 480)	Currently worked in orchard / vineyard during spraying (n = 374)
Ever a head sprayer	Correlation Coefficient	**1.000**					
Ever a tractor driver	Correlation Coefficient	.727**	**1.000**				
Current head sprayer	Correlation Coefficient	.943**	.685**	**1.000**			
Current tractor driver	Correlation Coefficient	.707**	.957**	.716**	**1.000**		
Current tractor driver / head sprayer / hand sprayer / backpack sprayer	Correlation Coefficient	.345**	.470**	.356**	.497**	**1.000**	
Currently worked in orchard/vineyard during spraying	Correlation Coefficient	.041	.046	.055	.055	.144**	**1.000**

** Correlation significant at the 0.01 level (2-tailed)

3.7.1.4 Potential Covariates

The potential covariates assessed in the study included the following variables:

- Age of participants. Data on age was available for 808 (98.9 %) of the 817 participants. Nine participants were unable to recall their dates of birth, or ages on the day of the cross-sectional survey. Where data on age was not available, it was recorded as missing data.

- Farm type – categorised as either wine or table grape

- Personal protective clothing (PPE) provided in the most recent job. The amount of PPE received by participants in their most recent job (Appendix B, Question 5.2) was calculated by summing the number of items received, based on one point per item. Participants were required to select from six (6) items of PPE, gloves; an overall; plastic covering; plastic overcoat with hood; „top boots' and masks.

- Current economic status of the participants. The current socio economic status of participants was assessed by whether they possessed or had access to a bath or shower; electricity in the home; refrigerator; television set; radio and telephone (Appendix B, Questions 11.5 and 11.6). These seven items were added together to generate a socioeconomic score, based on one point per item

- A history of previous pesticide poisoning was defined by the question: „Have you ever become sick from pesticides?' This question was qualified by the question „Did you visit a doctor?' The responses to both these questions were categorical variables

- History of current or / and past psychiatric illness. The categorical variable „psychiatric illness' was derived by merging the participants' responses to Question 10.2 on whether they had „ever been treated for depression, „nerves' or / and a psychiatric condition' (Appendix B). This variable therefore captured self-reported psychiatric illness and was a dichotomous variable.

- The total C.A.G.E. score was calculated by summing the responses to the four (4) questions, based on one point per item:

1. Have you ever felt that you should **Cut** down on your drinking?
2. Have people **Annoyed** you by criticizing your drinking habits?
3. Have you ever felt bad or **Guilty** about your drinking?
4. Have you ever had an **Eye-opener** (regmaker) first thing in the morning to steady your nerves or to get rid of a hangover?

A score equal to and greater than two (≥ 2) suggested that the participant was a „problem' drinker (Steinweg & Worth, 1993), which was used in the analysis as a categorical variable.

3.7.2 Characteristics of the Neuropsychiatric Outcome Data

The individual items for each of the respective six (6) neuropsychiatric outcome instruments were summed to compute individual total scores (e.g. GHQ-28 total score; BDI total score; BSI total score; etc.). The total score for the GHQ Depression Subscale was also computed. Missing values were replaced by the numerical value „0' to allow for the total scores to be computed.

When calculating the BSI GSI, the total BSI raw score is divided by the total number of responses, i.e. 53 if there are no missing items, or corrected for the number of missing values, e.g. 52 if there is one (1) missing item or 51 if there are two (2) missing items. Similarly, when calculating the raw score for the BSI Depression Symptom Dimension, the 6 depression items are summed (total score of 0 – 24) and then divided by the number of actual responses (6 if there are no missing items, five (5) if there is one missing value, four (4) if there are two missing values, etc.) (see section 3.4.3.1, page 117).

The outcome scores were used as continuous variables for univariate and bivariate analyses, and dichotomised across the median into categorical variables for the multivariate analyses (see Table 3.3).

Significant correlations of moderate strength (Spearman r's varied from 0.3 to 0.6) were found between all the neuropsychiatric outcome instruments (Tables 3.5 and 3.6). The GHQ (psychiatric morbidity) was most strongly correlated with the BDI (depression) (Spearman r's varied from 0.6 to 0.7), while general distress (BSI) was most strongly correlated with aggression, and suicide ideation was most strongly correlated with impulsivity and aggression (Spearman r = 0.4).

Table 3.5 Spearman Rank correlation of all Neuropsychiatric Outcome Instruments

N = 817		BDI Total Score	Aggression Total Score	BIS Total Score	Suicide Ideation Total Score	GHQ Total Score	BSI Total Raw Score
BDI Total Score	Correlation Coefficient	**1.000**					
Aggression Total Score	Correlation Coefficient	.362**	**1.000**				
BIS Total Score	Correlation Coefficient	.321**	.425**	**1.000**			
Suicide # Ideation Total Score	Correlation Coefficient	.293**	.389**	.433**	**1.000**		
GHQ Total Score	Correlation Coefficient	.605**	.327**	.149**	.163**	**1.000**	
BSI Total Raw Score	Correlation Coefficient	.586**	.556**	.379**	.341**	.562**	**1.000**

** Correlation significant at the 0.01 level (2-tailed)

missing data for one respondent

Table 3.6 Spearman Rank Correlation of the GHQ and GHQ Subscale: Severe Depression; the BSI Total Score, BSI Global Severity Index and BSI Depression Symptom Dimension

N = 817		GHQ Total Score	GHQ Subscale D - Severe depression	BSI Total Raw Score	T score for Global Severity Index	T score for BSI Depression
GHQ Total Score	Correlation Coefficient	**1.000**				
GHQ Subscale D - Severe depression	Correlation Coefficient	.617**	**1.000**			
BSI Total Raw Score	Correlation Coefficient	.562**	.410**	**1.000**		
T score for Global Severity Index	Correlation Coefficient	.542**	.400**	.978**	**1.000**	
T score for BSI Depression	Correlation Coefficient	.483**	.446**	.630**	.631**	**1.000**

** Correlation significant at the 0.01 level (2-tailed)

3.8 Data Analyses

Univariate, bivariate and multivariate analyses were conducted for the relevant exposure, covariate and outcome variables. Univariate analyses summarised the distribution of each measured variable.

Exploratory bivariate analyses were used to assess the types of relationships between outcomes, exposures and covariates. Continuous and categorical analyses were performed. The Wilcoxon rank-sum test was used to compare exposed and unexposed categories of workers for all the neuropsychiatric outcomes. Because the data was not normally distributed, Spearmans Correlation Coefficients were used to analyse the strength of relationships between exposure and covariate variables and the depression and suicidality continuous outcomes. In addition, tables 4.21a to 4.28a in Chapter 4 tabulate the Odds Ratios for the association of each neuropsychiatric outcome with all exposure, demographic and confounding variables.

All the statistical tests were performed at a 5% level of significance. Therefore an alpha of 0.05 was used as the criteria for determining significance of relationships between variables.

3.8.1 Variables included in multivariate models

Forced multiple logistic regression analysis was used to explore relationships between dichotomous outcomes and exposures, controlling for potential covariates. In the multivariate models, each outcome measurement dichotomised into high and low (section 3.4.3.1, pages 117-122), was adjusted for cumulative and current occupational exposure (section 3.7.1, pages 132-133), environmental exposure (page 134) and all potential covariates (section 3.7.1.4, page 136). (See Table 3.3, page 131, for a summary of the categorical variables used for the multivariate logistic regression analyses).

The base multivariate model (see Table 4.21b, page 192) developed to measure the possible association between an exposure variable (e.g. agricultural years worked) and a neuropsychiatric outcome (e.g. GHQ total score cut-off ≤ 23 and ≥ 24) controlling for relevant potential covariates, was then adjusted in the following way: The same model was used, substituting each of the eight (8) neuropsychiatric outcomes and each of the nine (9) exposure variables, keeping the other variables constant. The substituted multivariate models can be viewed in Appendix C, Tables C2 to C9. What is presented in the results is the base model (using agricultural years worked (dichotomised) as the cumulative exposure metric) for each outcome (Tables 4.21b to 4.28b) and a summary of the models substituting the other exposure metrics for each outcome (Tables 4.21c to Table 4.28c), as well as a listing of the measure of effect of the cumulative exposure metric on all the neuropsychiatric outcomes in one table, (Table 4.29).

The multivariate models which included the exposure variables, „years worked as a tractor driver'; „years worked as a head sprayer'; „ever a head sprayer' and „current head sprayer' could not be adjusted for the potential covariate „gender' as very few female participants (one female „ever head sprayer' and five female „ever tractor drivers') were engaged in these tasks at the time of the study.

Additionally, because of the significant association found between the potential covariate „age' and the variables, „years worked as a tractor driver' (Spearman r = 0.73) and „years worked as a head sprayer' (Spearman r = 0.56), these variables were not included together in the same multivariate model.

Although there was a significant correlation found between the two environmental exposure variables „observed spray drift reaching the home' and „observed the smell of pesticides in the home' (Spearman r = 0.621, p < 0.01), these two variables were analysed alternatively as individual measures of environmental exposure because correlation was less than 0.7.

3.9 REFERENCES

Baingana, FK; Alem, A; Jenkins, R 2006, „Mental Health and the Abuse of Alcohol and Controlled Substances', in Jamison et al (2nd edn), *Disease and Mortality in Sub-Saharan Africa,* World Bank, Washington, DC.

Bartlett, CJ ; Coles, EC 1998, „Psychological health and well-being: why and how should public health specialists measure it? Part 1: rationale and methods of the investigation, and review of psychiatric epidemiology', *Journal of Public Health Medicine,* vol. 20, no. 3, pp. 281 - 287.

Beck A, Kovacs M, Weissman A, 1979 „Assessment of Suicidal Ideation: The Scale for Suicide Ideation', *Journal of Consulting and Clinical Psychology,* vol. 47, No. 2, pp. 343-352.

Budhal, RS 2006, „Identification of Aggression of Junior Primary Learners', Masters of Education Thesis, University of South Africa, Pretoria.

Buss AH & Perry M, 1992 „The Aggression Questionnaire', *Journal of Personality and Social Psychology,* vol. 63, pp. 452-459.

Casey, PR; Dunn, G; Kelly, BD; Birkbeck, G; Delgard, OS; Lehtinen, V; Britta, S; Ayuso-Mateos, JL; Dowrick, C 2006, „Factors associated with suicidal ideation in the general population', *British Journal of Psychiatry,* vol. 189, pp. 410 - 415.

Dalvie MA, White N, Raine R, Myers JE, London L, Thompson M, Christiani DC, 1999 „Long-term respiratory health effects of the herbicide, paraquat, among workers in the Western Cape', *Occup Environ Med,* vol. 56, No.6, pp. 391-396.

Dean AG, Dean JA, Coulombier D, et al, 1996 „ Epi Info™, *Version 6.04a, a word processing, database, and statistics program for public health on IBM-*

compatible microcomputers', Centers for Disease Control and Prevention, Atlanta, USA.

Dellis, A; Hofmeyr, A; Schwardmann, P; Ross, D; Spurrett, D; Vuchinich, R; Barr, G; Rousseau, J; Sharp, C n.d., „The Criterion-Related and Construct Validity of the Canadian Problem Gampling Index in a sample of South African gamblers', *Centre for Ethics and Values in the Sciences.* http://www.SciFor.com

Derogatis, LR; Melisaratos, N 1983, „The Brief Symptom Inventory: An introductory report', *Psychological Medicine,* vol. 13, pp. 595 - 605.

Derogatis Leonard R, 1993. Brief Symptom Inventory (BSI). Administration, Scoring, and Procedures Manual. 3rd edition. Minneapolis, USA: National Computer Systems, Inc.

EQM Research, Inc. 2001. Test-mate ChE Cholinesterase Test System (Model 400), *Instruction Manual.* Cincinnati, Ohio USA.

Fisha, S 2002, „Depression among African patients: three diagnostic approaches' PhD Thesis, University of Pretoria, viewed 2009, September 20. http://upetd.up.ac.za/thesis/available/etd-10202005-143145/

Goldberg DP & Hiller VF, 1979, „A scaled version of the General Health Questionnaire', *Psychological Medicine,* vol.9, pp. 139-145.

Goldberg RJ & Williams P, 1988, „A user's guide to the General Health Questionnaire'. Windsor: NFER - Nelson

Goldberg DP, Gater R, Sartorius N, Ustun TB, Piccinelli M, Gureje O, 1997, „The validity of two versions of the GHQ in WHO study of mental illness in general health care', *Psychological Medicine,* vol. 27, pp.191-197

Human Sciences Research Council (HSRC) 2008, „The African Child Development Measures Resource', NFER-Nelson Publishing. http://www.hsrc.ac.za/ECD-Measure-154.phtml

London L, 1995, „An investigation into the neurological and neurobehavioural effects of long-term agrichemical exposure amongst deciduous fruit farm workers in the Western Cape, South Africa', PhD Thesis, University of Cape Town.

London, L; Thompson, ML; Sacks, S; Fuller, B; Bachmann, OM; Myers, JE 1995, „Repeatability and validity of a field kit for estimation of cholinesterase in whole blood', *Occupational and Environmental Medicine,* vol. 52, pp. 57 - 64.

London, L; Thompson, M-L; Myers, J 2006, „Measurement of alcohol consumption amongst South African farm workers', *Public Health and Human Rights APHA 134th Annual Meeting and Exposition,* Boston, MA.

Mkize, LP; Nonkelela, F; Mkize, DL 1998, „Prevalence of depression in a university population', *Curationis,* vol. 21, no. 3, pp. 32 - 37.

Ovuga, E; Boardman, J; Wasserman, D 2005, „The Response Inventory for Stressful Life Events (RISLE) I.refinement of the 100-item version', *African Health Services,* vol. 5, no. 2, pp. 137 - 144.

Patton JH, Stanford MS, Barrat ES, 1995, „Factor structure of the Barrat Impulsiveness Scale', *Journal of Clinical Psychology,* vol. 51, pp.768-774.

Reigart JR & Roberts JR, (5th ed.)1999. *Recognition and Management of Pesticide Poisonings.* United States Office of Pesticide Programs, Environmental Protection Agency, Washington, DC

Schroeder CV, 2002, *Breede Valley Municipality Final IDP Document 2002 - 2007* (p. 30)

SPSS – SA 2006, *SPSS for Windows: Version '150'.* Silvermine House, Steenberg. South Africa

Stinton L, (ed.) 2002. *'Beck Depression Inventory (BDI)'.* Retrieved April 17, 2003, from http://www.criminology.unimelb.edu.au/victims/resources/assessment/affect/bdi.html

Swallow BL, Lindow SW, Masson EA, Hay DM, 2003, „The use of the General Health Questionnaire (GHQ-28) to estimate prevalence of psychiatric disorder in early pregnancy', *Psychology Health & Medicine,* vol. 8, No.2. pp. 213 – 217.

van Wendel de Joode B, 2004. „An Occupational DREAM: Development, evaluation and application of a DeRmal Exposure Assessment Method'. Chapter 3*,* PhD Thesis, Utrecht University. PrintPartners Ipskamp B.V.

Vaughan JP & Morrow RH (ed.) 1989, *Manual of Epidemiology for District Health:* Geneva, World Health Organisation.

Ward, CL; Lombard, CJ; Gwebushe, N 2006, „Critical incident exposure in South African emergency services personnel: prevalence and associated mental health issues', *Emergency Medical Journal,* vol. 23, no. 3, pp. 226 - 231.

Western Cape Report, March 2003, *Adjustment of Powers and Functions. District Municipality Reports. Boland District Municipality (DC2)*

Willemse, M 2008, „Exploring the relationship between self-efficacy and aggression in a group of adolescents in the peri-urban town of Worcester', Masters in Psychology Thesis, University of Stellenbosch, South Africa

CHAPTER 4

RESULTS

4.1 Study participation

Table 4.1 summarises participation in the study. Eight hundred and seventeen (817) farm workers employed on nine (9) wine- and forty-eight (48) table-grape farms participated in the study. The wine grape farms were situated in Slanghoek and Louwshoek. The table grape farms were situated in Hex River, Orchard, De Doorns, Brandwacht and Nuy. The owners of the table grape farms were all members of the Hex Valley Producers' Association. (see table 4.1). All the participants completed structured exposure and outcome questionnaires. Red blood cell cholinesterase measurements were performed on seven hundred and eighty (780) participants.

The interviews with the farm workers were completed over a period of 24 days, from 19 June to 21 October 2002. Interviews were conducted by 9 to 12 interviewers per day and overall a range of 17 to 90 farm worker interviews were completed per interviewer. Participation in the study varied from 3 to 30 farm workers per farm for the table grape sample and one (1) to 39 worker per farm for the wine grape sample. The one isolated farm worker was from an organic farm where the participant had been a tractor driver / head spray man prior to the change in the farm's agricultural practices. On the selected farms, no selected workers refused to participate in the interviews, but 37 farm workers refused to have their RBC AChE activity measured, because of a fear for injections.

Table 4.1 Summary of participation in the study

Area	Number of farms in area	Number (%) of participating farms	Number of participants	Percentage of total study sample
WINE GRAPE FARMS				
Slanghoek	19	5 (26%)	98	12.0%
Louwshoek	47	4 (8.5%)	81	9.9%
TABLE GRAPE FARMS*				
Hex River	70	22 (31.4%)	284	34.8%
Orchard	17	9 (52.9%)	147	18.0%
De Doorns	107	15 (14.0%)	182	22.3%
Other farm areas:				
Brandwacht and Nuy	7	2 (28.6%)	25	3.0%

* The number of farms in the table grape areas are as reported in the Hex Valley Producers' Association membership list.

4.2 Demographic Characteristics

One hundred and seventy-nine (179) workers on wine grape farms and six hundred and thirty-eight (638) on table grape farms participated in the study. 59.4% were males and 40.5% females (Table 4.2).

Ten (10) of the 817 participants were unable to recall their dates of birth and nine (9) did not know their ages on the day of the cross-sectional survey. For participants who had data on age, their ages ranged from 17 to 79 years. The mean age of workers on wine grape farms was 34 years (SD 9.4) and 35 years (SD 10.6) on table grape farms. The median ages for workers on wine and table grape farms were 33 years (Table 4.2).

For participants who were able to recall their occupational history, the mean age of commencing their first job was 17 years (SD 4.8), and the median age was 18 years. The one hundred and eighty-five (23%) participants who reported being in the age group 8 – 15 years when they commenced their first job signifies the historical practice of child labour on grape farms in the Western Cape Province of South Africa.

Seven hundred and twenty-eight (89.1%) of the 817 participants were permanent workers in their current job and 49 (6.0%) were seasonal employees. There was no employment status data recorded for forty (4.9%) participants (18 males and 22 females).

Table 4.2 Demographic characteristics of wine and table grape farm workers participating in the study

Demographic Variable		Wine Grapes	Table Grapes	Total
Gender (n = 817)	**Males**	135 (75.0%)	351 (55.0%)	486 (59.5%)
	Females	44 (24.5%)	287 (44.9%)	331 (40.5%)
Age (n = 808)	**Males**	n = 131	n = 349	n = 480
	Mean (SD)	34.8 (9.8)	37.0 (11.7)	36.4 (11.3)
	Median (Range)	34.0 (18.0 - 64.0)	35.6 (17.0 -79.0)	35.0 (17.0 - 79.0)
	Females	n = 43	n = 285	n = 328
	Mean	31.4 (7.9)	33.0 (8.4)	32.8 (8.4)
	Median (Range)	30.4 (19.0 - 54.0)	32.0 (17.0 - 60.0)	32.0 (17.0 - 60.0)

4.3 Exposure characteristics

4.3.1 Cumulative Exposure

The work history of participants and their total number of years worked in an agricultural environment is an important indicator of exposure to pesticides. The average years worked in an agricultural environment was 14 (SD 10.4) years (Table 4.3a). Because of missing data on number of years spent in the first job in agriculture (n = 21), the number of years spent in an agricultural environment was calculated for seven hundred and ninety-six (796) participants only. The mean age derived for the sample as a whole of 17 years (see section 4.2) was used as the age of commencement of work for three (3) participants who reported only one job as occupational history and were unable to recall their ages on commencing work, but were able to provide their ages at the time of the study.

According to literature globally, farm workers who are most at risk of exposure are those involved with the direct handling of pesticides like tractor drivers and spray operators, including head sprayers, sprayers using hand held apparatus (handgun) and backpack apparatus.

Two hundred and twenty-seven (27.8%) participants were / had been a tractor driver (ever tractor driver) at some time during their cumulative years of working. Five of these tractor drivers were females working on table grape farms. Their cumulative years of work ranged from 4 months to 22 years. Of the 227 tractor drivers, 213 (93.8%) were still working as tractor drivers in their current jobs.

Because of missing data on age of commencement and completion of jobs in their work histories, the total years worked in agriculture could not be calculated for five of the tractor drivers. In the study, participants had worked an average of 15 years (SD 11.1) and a median of 13 years as „ever a tractor driver' during their cumulative years of working in agriculture (Table 4.3a).

One hundred and thirty-eight (16.9%) participants were / had been pesticide applicators (ever head sprayer) during their cumulative years of working in an agricultural environment. They had also worked an average of 15 years (SD 10.4) and a median of 13 years in agriculture (Table 4.3a). The 138 „ever head sprayers' were also tractor drivers at some time in their work history, or in their current job.

One of the 138 head sprayers was a female working on a table grape farm (Table 4.3b). She had worked as a head sprayer for two (2) years of her working life. Of the 138 head sprayers, 125 (91%) were still working as head sprayers in their current jobs.

The differences between the mean and median scores for all exposure variables showed skewness in the distribution of the exposure data confirmed by statistical tests (Shapiro-Wilks test p < 0.01).

Table 4.3a Continuous Exposure Variables by Gender and Farm Type

	Total years worked in agriculture (n = 796)		Total years worked as a tractor driver (n = 227)		Total years worked as a head sprayer (n = 138)	
	Mean (SD)	**Median (Range)**	**Mean (SD)**	**Median (Range)**	**Mean (SD)**	**Median (Range)**
Males	15.3 (11.3)	13.0 (0.3 - 53.0)	15.3 (11.1)	13.5 (0.0 - 50.0)	15.0 (10.4)	13.0 (0.0 - 43.0)
Females	12.1 (8.5)	10.0 (0.5 - 44.0)	10.1 (9.9)	7.0 (0.5 - 22.0)		
Wine Grapes	13.0 (10.3)	10.0 (0.3 - 47.0)	16.3 (11.6)	16.0 (0.3 - 43.0)	19.5 (11.2)	21.0 (1.0 - 43.0)
Table Grapes	14.3 (10.4)	12.0 (0.3 - 53.0)	14.9 (11.0)	13.0 (0.0 - 50.0)	14.2 (10.1)	13.0 (0.0 - 42.0)
Total	14.0 (10.4)	11.0 (0.3 - 53.0)	15.1 (11.1)	13.0 (0.0 - 50.0)	15.0 (10.4)	13.0 (0.0 - 43.0)

4.3.2 Current Exposure

Table 4.3b indicates the workers who were involved in „at risk' exposure tasks in their current jobs. 74% of participants, who were probably general farm workers currently working on wine and table grape farms, reported exposure to pesticides in the form of being in the vineyards while spraying took place.

Workers who were currently a tractor driver / head sprayer / handgun sprayer / backpack sprayer or more than one category of spray operator (n = 480; 79% males, 29% females depicted by the variable „currently any spraying activity'), were regarded as being the „high exposure' group in their current jobs. Pesticide spraying was highly gender specific, as there were no female head sprayers working on both wine and table grape farms at the time of doing the interviews, and only one female worker reported having ever been a head sprayer at some time in her work history (Table 4.3b).

Participants' experience of indirect or environmental exposure can also be viewed in Table 4.3b. 61% of farm workers on wine grape farms and 55% on table grape farms reported observing spray drift reaching their houses, and over 60% of male and female workers on wine and table grape farms reported smelling pesticides in their houses, on the days that spraying of the vineyards took place (Table 4.3b).

Table 4.3b Categorical Exposure Variables by Gender and Farm Type

	Ever a head sprayer	Current head sprayer	Currently any spraying activity	Currently working in vineyard while pesticides being sprayed	Observed spray drift reaching the house	Observed smell of pesticides in the house
Males (n = 486)	137 (28.2%)	125 (25.7%)	384 (79.0%)	374 (77.0%)	279 (57.4%)	305 (62.8%)
Females (n = 331)	1 (0.3%)	0 (0.0%)	96 (29.0%)	233 (70.4%)	180 (54.4%)	211 (63.7%)
Wine Grapes (n = 179)	20 (11.2%)	18 (13.3%)	130 (72.6%)	142 (79.3%)	109 (60.9%)	124 (69.3%)
Table Grapes (n = 638)	118 (18.5%)	107 (30.5%)	350 (54.9%)	465 (72.9%)	350 (54.9%)	392 (61.4%)
Total (n = 817)	138 (16.9%)	125 (15.3%)	480 (58.8%)	607 (74.3%)	459 (56.2%)	516 (63.2%)

4.3.3 Cholinesterase Measurements

Red blood cell acetylcholinesterase (RBC-AChE) activity was measured on seven hundred and seventy-eight (95.2%) participants as an additional assessment of recent exposure to OP pesticides (acetylcholinesterase (AChE) testing is an essential element in the medical surveillance of chemical agents and pesticide handlers). With exposure to OP pesticides, RBC-AChE activity is inhibited or depressed in proportion to the extent of exposure. Levels return to normal (baseline) over a period of approximately 2 months if no further exposures are experienced. The tests determined participants' current RBC-AChE activity, which had never been previously measured in this group. The following categorisation criteria were used (see chapter 3, section 3.4.2):

- ≥ 31.4 U/g — acceptable / normal levels of RBC-ChE
- 26.7 – 31.4 U/g — participant should be retested immediately
- 22.0 – 26.7U/g — participant should be investigated and retested immediately
- < 22.0 U/g — participant should be withdrawn from the exposure situation and retested after six (6) weeks

Table 4.4 shows that the mean and median cholinesterase measurements for the 778 participants were equal to or greater than 31.4 U/g (≥ 31.4 U/g). Eleven (1.3%) participants (2 wine grape workers, 9 table grape workers) reported RBC-ChE measurements of less than 22.0 U/g indicating severe OP exposure. 56.1% of the participants reported normal cholinesterase levels and 37.8% required investigation and retesting.

Table 4.4 Cholinesterase Measurements by Gender and Farm Type

	Males (n = 471)	**Females (n = 307)**	**Wine Grapes (n = 170)**	**Table Grapes (n = 608)**	**Total (n = 778)**
Mean (SD)	33.7 (6.0)	32.3 (6.0)	32.3 (6.3)	33.3 (5.9)	33.1 (6.0)
Median (Range)	33.1 (20.7 - 58.6)	31.4 (16.6 - 63.7)	32.2 (16.6 - 63.7)	32.7 (19.7 - 58.6)	32.6 (16.6 - 63.7)

4.4 Neuropsychiatric Outcomes

4.4.1 Scoring of Neuropsychiatric Outcomes

The psychometric characteristics of the depression / suicidality outcome instruments are described in Chapter 3, pages 117-122. The following are the neuropsychiatric outcome measurements used in the study and their score ranges

4.2.4.1.1 The General Health Questionnaire (GHQ 28). Score range 0.0 – 84.0.

4.2.4.1.2 The GHQ Subscale Depression. Score range 0.0 – 21.0.

4.2.4.1.3 The Beck Depression Inventory (BDI-1A). Score range 0.0 – 63.0.

4.2.4.1.4 The Brief Symptom Inventory (BSI). Raw score range 0.0 – 212.0.

4.2.4.1.5 The BSI Global Severity Index (GSI) T score. A score ≥ 63 is a „positive case'.

4.2.4.1.6 The BSI Depression Symptom Dimension T score. A score ≥ 63 is a „positive case'.

4.2.4.1.7 The Barrat Impulsiveness Scale (BIS – 11). Score range 29.0 – 116.0.

4.2.4.1.8 The Four-Factor Measurement Model of the Aggression Questionnaire (AQ). Score range 12.0 – 72.0.

4.2.4.1.9 The Scale for Suicide Ideation (SSI). Score range 0.0 – 38.0.

4.4.2 Neuropsychiatric Outcomes by Gender

The Wilcoxon test was used to compare groups of participants by gender and farm type in relation to all neuropsychiatric outcome instruments.

The outcome scores according to the gender of the participants are summarised in Table 4.5. The scores are interpreted as follows: the higher the overall score for the individual outcome measurement, the greater the severity of the presenting neuropsychiatric symptoms, for all instruments

One female lacked data for the Scale for Suicide Ideation measurement.

Generally, female participants reported being more depressed than males (BDI female median 3.0 compared to male median 2.0; $p < 0.01$), and had greater suicidal ideation (female median 1.0 versus male median 0.0; $p < 0.01$) than males. Similar patterns were evident for the GHQ Depression Subscale (female median 1.0 versus male median 0.0; $p < 0.01$).

Females were also slightly more aggressive than males (female median 26.0 versus male median 23.0; $p = 0.08$) and slightly more impulsive than males (female median 56.0 versus male median 54.0; $p = 0.49$), but these differences were not statistically significant.

There were no statistical gender differences for general distress (BSI GSI male and female median 55.0; $p = 0.27$) and the BSI Depression Symptom Dimension (male median 0.0 versus female median 33.0; $p = 0.70$).

Analysis of the subscales for the outcome instruments reinforced these findings:

- For the GHQ, females had significantly greater somatic symptoms (female median 4.0 versus male median 3.0; $p < 0.01$) and experienced more symptoms of anxiety and insomnia (female median 3.0 versus male median 2.0; $p < 0.01$) than males.

- For the BDI-IA, 85 (10.4%) participants scored equal to and above the median cut-off point (≥ 11) for depression.

- Analysis of the BIS-II showed that females scored significantly higher than males for the subfactor „Nonplanning Impulsiveness' (female median 21.0 versus male median 20.0; $p = 0.01$).

- For the BSI GSI T score, 18% of female and 25% of male participants were positive cases (score ≥ 63) for physical, physiological and psychological distress in the seven (7) days prior to and including the day of the interview. However, only one (1) of the females scored greater than 63 for the BSI Depression Symptom Dimension T score and there were no male „positive cases'.

Table 4.5 Neuropsychiatric Outcomes by Gender

Variables	Males (n = 486)		Females (n = 331)		Total (n = 817)	
	Mean (SD)	**Median (Range)**	**Mean (SD)**	**Median (Range)**	**Mean (SD)**	**Median (Range)**
General Health Questionnaire (GHQ) Total Score**	15.4 (8.7)	13.0 (0.0 - 69.0)	17.6 (9.6)	15.0 (1.0 -66.0)	16.3 (9.2)	14.0 (0.0-69.0)
GHQ Subscale D – Depression**	1.4 (2.7)	0.0 (0.0 - 17.0)	2.2 (2.5)	1.0 (0.0 - 18.0)	1.7 (3.1)	0.0 (0.0 -18.0)
Beck Depression Inventory (BDI) Total Score**	3.9 (5.8)	2.0 (0.0 - 43.0)	4.9 (6.2)	3.0 (0.0 - 38.0)	4.3 (6.0)	2.0 (0.0 - 43.0)
Brief Symptom Inventory (BSI) Total Score**	20.9 (21.0)	16.0 (0.0 -142.0)	26.2 (25.4)	19.0 (0.0-151.0)	23.0 (23.0)	18.0 (0.0-151.0)
BSI Global Severity Index T Score	51.5 (19.1)	55.0 (0.0 – 80.0)	52.3 (14.7)	55.0 (0.0 - 80.0)	52.0 (17.5)	55.0 (0.0 - 80.0)
BSI Symptom Dimension – Depression T Score	18.9 (20.4)	0.0 (0.0 - 56.0)	20.4 (19.8)	33.0 (0.0 - 67 0)	19.5 (20.2)	0.0 (0.0 - 67.0)
Aggression Questionnaire Total Score	26.1 (12.0)	23.0 (12.0 -65.0)	27.4 (12.0)	26.0 (12.0-65.0)	26.7 (12.0)	24.0 (12.0-65.0)
Barratt Impulsiveness Scale (BIS - 11) Total Score	54.7 (10.1)	54.0 (29.0-84.0)	55.0 (9.8)	56.0 (2.0 - 87.0)	54.8 (10.0)	55.0 (2.0 - 87.0)
Scale for Suicide Ideation Total Score**	1.4 (2.5)	0.0 (0.0 - 22.0)	1.8 # (3.4)	1.00 # (0.0 - 27.0)	1.5 (3.0)	1.0 (0.0 - 27.0)

**p< 0.01 (Wilcoxon test comparing males to females) # missing data for one respondent See chapter 3, section 3.4.3.1 for scores for outcome instruments.

4.4.3 Neuropsychiatric Outcomes by Farm Type

Analysis summarised in Table 4.6 indicate that the GHQ total score for participants working on wine grape farms was significantly greater than for those working on table grape farms (wine grape median 15.0 versus table grape median 14.0; $p < 0.01$).

Additionally, the score for the BSI GSI T score indicates that participants working on wine grape farms reported significantly higher levels of physical, physiological and psychological distress (general distress) during the seven (7) days prior to and including the day that they were interviewed for the research study, compared to those working on table grape farms (wine grape median 57.0 versus table grape median 55.0; $p < 0.01$). 24% of participants, 135 (21.2%) table- and 57 (31.8%) wine grape workers (Chi-square 8.875; $p = 0.003$) had a score equal to or greater than 63, which is an indication of a „positive case' of general distress.

Based on the GHQ Depression subscale (wine grape median 15.0 versus table grape median 14.0; $p < 0.01$), BDI total score (wine grape median 3.0 versus table grape median 2.0; $p < 0.01$) and the BSI Depression Symptom Dimension T score (wine grape median 36.0 versus table grape median 0.0; $p < 0.01$), participants working on wine grape farms were more depressed than those working on table grape farms. Wine grape participants were also more impulsive (wine grape median 59.0 versus table grape median 54.0; $p < 0.01$) and had greater tendencies to suicidal ideation (wine grape median 1.0 versus table grape median 0.0; $p < 0.01$) than participants working on table grape farms.

According to Table 4.6 there was no significant difference in aggression scores between participants on wine and table grape farms ($p < 0.05$).

Table 4.6 Neuropsychiatric Outcomes by Farm Type

Variables	Wine Grapes (n = 179)		Table Grapes (n = 638)		Total (n = 817)	
	Mean (SD)	**Median (Range)**	**Mean (SD)**	**Median (Range)**	**Mean (SD)**	**Median (Range)**
General Health Questionnaire (GHQ) Total Score**	18.1 (9.7)	15.0 (4.0 - 69.0)	15.8 (9.0)	14.0 (0.0 - 66.0)	16.3 (9.2)	14.0 (0.0 -69.0)
GHQ Subscale D – Depression**	2.7 (3.6)	1.0 (0.0 - 17.0)	1.5 (2.8)	0.0 (0.0 - 18.0)	1.7 (3.1)	0.0 (0.0 -18.0)
Beck Depression Inventory (BDI) Total Score**	6.8 (8.6)	3.0 (0.0 - 43.0)	3.6 (4.8)	2.0 (0.0 - 36.0)	4.3 (6.0)	2.0 (0.0 - 43.0)
Brief Symptom Inventory (BSI) Total Score	26.7 (26.0)	19.0 (0.0 -142.0)	22.0 (22.1)	18.0 (0.0 -151.0)	23.0 (23.0)	18.0 (0.0-151.0)
BSI Global Severity Index T Score**	55.5 (15.3)	57.0 (0.0 - 80.0)	50.8 (17.9)	55.0 (0.0 - 80.0)	51.9 (17.5)	55.0 (0.0 - 80.0)
BSI Depression Symptom Dimension T Score**	25.0 (20.5)	36.0 (0.0 - 56.0)	17.9 (19.8)	0.0 (0.0 - 67.0)	19.5 (20.2)	0.0 (0.0 - 67.0)
Aggression Questionnaire Total Score	26.9 (12.3)	24.0 (12.0 -65.0)	26.6 (12.0)	24.0 (12.0 - 65.0)	26.7 (12.0)	24.0 (12.0-65.0)
Barratt Impulsiveness Scale (BIS – 1A) Total Score**	58.0 (11.0)	59.0 (32.0 -82.0)	54.0 (10.0)	54.0 (2.0 - 87.0)	54.8 (10.0)	55.0 (2.0 - 87.0)
Scale for Suicide Ideation Total Score**	2.8 (4.0)	1.0 (0.0 - 22.0)	1.2 # (2.4)	0.0 # (0.0 - 27.0)	1.5 (3.0)	1.0 (0.0 - 27.0)

** p < 0.01 (Wilcoxon test comparing wine grape workers to table grape workers)
# missing data for one respondent

Suicidal ideation was also measured by the questions tabulated in Table 4.7. Of the participants who responded to these questions, it was more commonly female farm workers and participants working on table grape farms who reported engaging in thoughts of deliberate self-injury in the twelve (12) months prior to them being interviewed, but this was not consistently statistically significant (Table 4.7). Thirteen (5.2%) female participants compared to 7 (2.0%) males reported that they had informed someone of their plans to commit suicide (p = 0.03). Fifteen (2.3%) participants reported attempting to commit suicide in the 12 months prior to them being interviewed. Of the 15, only 6 participants were medically treated for self-injury (Table 4.7).

Table 4.7 Suicidality Outcomes by Gender and Farm Type

Variable	**N**	**Gender**		**N**	**Farm Type**		**Total**
		Males	**Females**		**Wine Grapes**	**Table Grapes**	
During the past 12 months have you ever seriously thought about hurting yourself in a manner that may cause you to die?	**M = 478** **F = 330**	9 (1.9%)	13 (3.9%)	**W =177** **T = 631**	8 (4.5%)	14 (2.2%)	22 (2.7%)
	Chi-square = 3.117 p = 0.077			Chi-square = 2.763 p = 0.096			
During the past 12 months, have you ever told someone that you plan to commit suicide?	**M = 355** **F = 249**	7 (2.0%)	13 (5.2%)	**W =128** **T = 476**	8 (6.3%)	12 (2.5%)	20 (3.3%)
	Chi-square = 4.825 p = 0.028			Chi-square = 4.381 P = 0.036			
During the past 12 months, have you ever tried to commit suicide?	**M = 382** **F = 272**	7 (1.8%)	8 (2.9%)	**W =156** **T = 498**	7 (4.5%)	8 (1.6%)	15 (2.3%)
	Chi-square = 0.871 p = 0.351			Chi-square = 4.399 p = 0.036			
Have any of your attempts to injure yourself caused you to be treated by a doctor or nurse?	**M = 379** **F = 271**	3 (0.8%)	3 (0.11%)	**W =137** **T = 513**	2 (1.5%)	4 (0.8%)	6 (0.9%)
	Chi-square = 0.172 p = 0.678			Chi-square = 0.547 p = 0.460			

4.5 Potential Covariates

The potential covariates for depression and suicidality assessed in the study were

- age of the participants
- type of farm - wine grapes or table grapes
- provision of personal protective clothing in their current jobs
- socio economic status of the participants
- past pesticide poisoning
- history of current and past psychiatric illness
- C.A.G.E. score equal to and greater than two (≥ 2), i.e. a score of 2, 3 or 4.

The ages of participants and types of farms have already been discussed in section 4.2.1 (demographic characteristics of study participants) and table 4.2.

4.5.1 Personal Protective Clothing (PPE)

There was a 100% response from all participants to the question, "What type of protective equipment do you receive in your current job?" Participants were required to select from gloves, overall, plastic covering, plastic overcoat with hood, „top boots' and masks.

Two hundred and eighty-two (35%) participants received two (2) items of protective clothing and one hundred and twenty-five (15%) received three (3) items. Table 4.8a shows that participants working on table grape farms received significantly more protective clothing than those on wine grape farms ($p < 0.01$), and females received significantly less clothing than males ($p < 0.01$). Generally, male farm workers were more involved in spraying activities, and therefore received more items of PPE. This finding was supported by further analysis, which showed that more male than female farm workers were included in the „high exposure' group of spray operators (384 (79%) males versus 96 (29%)

female workers). Furthermore, of the female „high exposure' workers 22% received one or no items of PPE, while 13% of the male „high exposure' workers received one or no items of PPE ($p < 0.01$), showing that overall male farm workers received more items of PPE than female workers for the same work performed. This was further demonstrated when the study showed that of the 337 non sprayers, more male than female non sprayers (males 78% versus females 57%) received 2 or more items of PPE for doing the same category of work.

4.5.2 Socio Economic Status (SES)

The socio economic status of participants was measured by whether they had a bath and/or shower and electricity in their home, and if they possessed a refrigerator, television set, radio and/or a telephone (total of 7 items) (see Chapter 3, Section 3.7.1.4).

Table 4.8a shows that workers on table grape farms possessed significantly more household items than wine grape workers ($p < 0.01$) (Table grape workers owned an average of 4 household items versus wine grape workers who had an average of 3 items). The range in SES in the sample was broad ranging from nil to seven items. Of the 18 (2.2%) participants who had access to all seven household items, 17 were table grape workers and one was a wine grape worker. Of the 8 participants who reported having no household items including a bath or shower, 7 were table grape workers and one was a wine grape worker.

4.5.3 Psychiatric History

For the purposes of this study, the focus was on participants who reported having been / being treated for a psychiatric illness at the time of their interview. Of the eighty-three (10.2%) participants who reported treatment for a psychiatric illness (Table 4.8b), females reported significantly more psychiatric illnesses than males (females, 15.7% versus males, 6.4%; $p < 0.01$). Additionally, workers on table grape farms had significantly more psychiatric illnesses than those on wine grape farms (table grape, 11.4% versus wine grape, 5.6%; $p < 0.05$).

Seventy-two workers (5.0% of wine grape and 9.9% of table grape workers) had been / were being treated for „nerves' at the time of their interview, and twenty-two (3.4%) table grape farm workers had been / were being treated for depression. None of the participants working on wine grape farms reported having been / were currently being treated for depression. Five of the 817 participants (2 wine grape and 3 table grape workers) in the study had been / currently were being treated for a psychiatric condition. (The variables „nerves', „depression' and psychiatric condition' were merged to compute the variable „current / past psychiatric illness' - see chapter 3 section 3.7.1.4).

4.5.4 Past Pesticide Poisoning

Of the 759 (92.9%) participants who responded to the question about past pesticide poisoning, 110 (14.5%) reported a history of past pesticide poisoning (Table 4.8b). Of the 110 participants, 106 (7.2% amongst wine grape and 4.5% amongst table grape workers) reported having been previously admitted to a hospital for pesticide poisoning.

Seventy-three (16.2%) male farm workers compared to 37 (12.0%) female workers reported having had an episode of past pesticide poisoning, but this was not statistically significant.

4.5.5 C.A.G.E. Score

A participant who scored equal to or greater than two (≥ 2) on the CAGE was identified as a possible problem drinker.

Table 4.8b shows that of the 770 (94.2%) farm workers who responded to the CAGE questions, 616 (80.0%) farm workers scored ≥ 2 on the CAGE score, indicating that they were possible problem drinkers. Of the participants who reported a CAGE score ≥ 2, 387 (82.0%) were male farm workers and 229 (76.8%) were female workers, indicating that male farm workers appeared to experience greater problems with alcohol than female workers, but this was not statistically significant (Table 4.8b).

Of the male farm workers who reported a CAGE score ≥ 2, 79.0% worked on table grape farms and 89.6% on wine grape farms, while of the female farm workers, 76.7% worked on table grape farms and 77.5 % on wine grape farms.

When comparing wine and table grape workers' CAGE scores, wine grape workers appeared to have a significantly greater problem with alcohol ($p = 0.01$) than table grape workers. Of the study sample of 179 wine grape and 638 table grape workers, 151 (84.4%) wine grape workers reported a CAGE score ≥ 2, while 465 (72.9%) table grape workers had a score ≥ 2 (Table 4.8b).

Table 4.8a Potential Covariates by Gender and Farm Type

	Age (n = 808)		PPE received in current job (n = 817)		Socio economic status (n = 817)	
	Mean (SD)	**Median (Range)**	**Mean (SD)**	**Median (Range)**	**Mean (SD)**	**Median (Range)**
Males	36.4 (11.3)	35.0 (17.0 - 79.0)	2.8 ** (1.5)	2.0 (0.0 - 6.0)	3.9 (1.5)	4.0 (0.0 - 7.0)
Females	32.8 (8.4)	32.0 (17.0 - 60.0)	2.1 ** (1.4)	2.0 (0.0 - 6.0)	4.0 (1.6)	4.0 (0.0 - 7.0)
Wine Grapes	33.9 (9.4)	33.0 (18.0 - 64.0)	1.8 ** (1.1)	2.0 (0.0 - 5.0)	3.2 ** (1.4)	3.0 (0.0 - 7.0)
Table Grapes	35.2 (10.6)	33.5 (17.0 - 79.0)	2.7 ** (1.6)	2.0 (0.0 - 6.0)	4.1 ** (1.5)	4.0 (0.0 - 7.0)
Total	35.0 (10.3)	33.1 (17.0 - 79.0)	2.5 (1.5)	2.0 (0.0 - 6.0)	3.9 (1.5)	4.0 (0.0 - 7.0)

** $p < 0.01$ (Wilcoxon test comparing gender and wine - to table grape workers

Table 4.8b Potential Covariates by Gender and Farm Type

	Farm type (n = 817)	Psychiatric sickness (n = 817)	Previous pesticide poisoning (n = 759)	C.A.G.E. Score ≥ 2 (n = 770)
Males	Wine = 135 (27.8%) Table = 351 (72.2%)	31 (6.4%)	73 (16.2%)	387 (82.0%)
Females	Wine = 44 (13.3%) Table = 287 (86.7%)	52 (15.7%)	37 (12.0%)	229 (76.8%)
		Chi-square=18.785 p = 0.000	Chi-square=2.572 p = 0.109	Chi-square=3.023 p = 0.082
Wine Grapes	179 (21.9%)	10 (5.6%)	26 (16.7%)	151 (84.4%)
Table Grapes	638 (78.1%)	73 (11.4%)	84 (13.9%)	465 (72.9%)
		Chi-square=5.251 p = 0.022	Chi-square=0.749 p = 0.387	Chi-square=6.462 p = 0.011
Total	817 (100%)	83 (10.2%)	110 (14.5%)	616 (80.0%)

4.6 Bivariate Comparisons

In the bivariate analyses, comparisons were made between participants who were „exposed' and „unexposed' to pesticides and associations were explored.

In section 4.6.1 the association of the neuropsychiatric outcomes with specific occupational exposure tasks was explored

Section 4.6.2 reports on the association of the neuropsychiatric outcomes with environmental or indirect pesticide exposure

Section 4.6.3 explored the association of the neuropsychiatric outcomes with cumulative occupational exposure tasks (tractor driving and head spraying) and recent exposure (erythrocyte AChE levels) stratified by gender

In section 4.6.4 the association of the neuropsychiatric outcomes with the potential covariates for depression stratified by gender, was explored

Both the dependent and independent variables were not normally distributed in most instances. Therefore, the Wilcoxon test was used to compare median scores by exposure category and Spearman Rank Correlation Coefficients were used to measure the strength of the relationships between scores and continuous exposure variables.

4.6.1 Association of Neuropsychiatric Outcomes with Categorical Occupational Exposure

The Wilcoxon test was used to compare the difference between participants who were exposed to pesticides because of the nature of their jobs and those who were unexposed, for all the neuropsychiatric outcome instruments. The categories of exposure explored were:

- Cumulative exposure represented by ever having been a head (lead) sprayer at some time in the occupational history of the worker
- Recent exposure by:
  - being a head sprayer in the current job

- being a tractor driver / head sprayer / handgun sprayer / backpack sprayer or more than one category of sprayer, regarded as the „high exposure' group in their current job
- being in the vineyards while pesticides were being sprayed in their current job

Table 4.9 shows that participants who were „never sprayers' (unexposed workers) scored higher on all the neuropsychiatric outcome measurements than those who had been / were „head sprayers' of pesticides at some time during their working lives. „Never sprayers' were found to be significantly more depressed (BSI Depression Symptom Dimension, unexposed median 33.0 versus exposed median 0.0; $p < 0.05$), more impulsive (BIS, unexposed median 55.0 versus exposed median 53.0; $p < 0.05$), had more psychiatric disorders (GHQ, unexposed median 14.0 versus exposed median 12.0; $p < 0.01$) and experienced greater levels of overall distress (BSI, unexposed median 19.0 versus exposed median 15.0; $p < 0.05$), than participants who were „ever sprayers'..

Analysis summarised in Table 4.10 shows that there were similar differences between participants who were current sprayers and „never sprayers' as shown for „ever head sprayers' and „never head sprayers' in Table 4.9.

Specifically, current „never sprayers' reported significantly greater levels of depression (BSI Depression Symptom Dimension, unexposed median 33.0 versus exposed median 0.0; $p < 0.05$) and impulsivity (BIS unexposed median 55.0 versus exposed median 53.0; $p < 0.05$) as well as more psychiatric disorders (GHQ unexposed median 14.0 versus exposed median 11.0; $p < 0.01$) than current sprayers (Table 4.10).

Four (4) categories of workers were involved in the spraying of pesticides. They were tractor drivers (26.1%), head sprayers (15.3%), sprayers using a hand spraying apparatus (hand sprayer; 42.9%) and those who used a backpack spraying apparatus (backpack sprayers; 22.9%). They were regarded as the „high exposure' group in their current jobs. Many of these workers were engaged in more than one form of spraying activity, for example all of the 138 „ever head sprayers' were also currently a tractor driver. The variable „current all spraying activities’ encompasses all the spraying activities of the „high exposure’ group (see chapter 3, section 3.7.1.2). Four hundred and eighty (58.8%) participants engaged in one or more type of spraying activity.

According to Table 4.11, participants who were unexposed (not currently participating in any spraying activities) had significantly more psychiatric disorders (GHQ, unexposed median 15.0 versus exposed median 13.5; $p < 0.01$) and greater suicidal ideation (unexposed median 1.0 versus exposed median 0.0; $p < 0.01$) than those who were currently engaged in the spraying activities of the „high exposure’ group.

Table 4.12 shows that there were no significant differences in the neuropsychiatric outcomes, when comparing the exposed group of participants who reported being currently in the vineyards when spraying took place, and those who were unexposed to this practice.

Table 4.9 Neuropsychiatric Outcomes by 'ever a head sprayer'

Variables	Exposed (n = 138)		Unexposed (n = 679)		P Value
	Mean (SD)	**Median (Range)**	**Mean (SD)**	**Median (Range)**	
General Health Questionnaire (GHQ) Total Score	14.6 (8.4)	12.0 (0.0 - 43.0)	16.7 (9.3)	14.0 (1.0 - 69.0)	0.002**
GHQ Subscale D – Depression	1.1 (2.2)	0.0 (0.0 - 11.0)	1.9 (3.2)	0.0 (0.0 - 18.0)	0.003**
Beck Depression Inventory (BDI) Total Score	3.2 (4.5)	2.0 (0.0 - 22.0)	4.5 (6.2)	2.0 (0.0 - 43.0)	0.016*
Brief Symptom Inventory (BSI) Total Score	18.2 (17.8)	15.0 (0.0 - 95.0)	24.0 (23.8)	19.0 (0.0 -151.0)	0.010*
BSI Global Severity Index T Score	49.3 (19.9)	55.0 (0.0 - 80.0)	52.4 (16.9)	55.0 (0.0 - 80.0)	0.301
BSI Symptom Dimension – Depression T Score	15.7 (19.5)	0.0 (0.0 - 53.0)	20.2 (20.2)	33.0 (0.0 - 67.0)	0.042*
Aggression Questionnaire Total Score	25.8 (11.7)	23.5 (12.0 - 58.0)	26.8 (12.0)	24.0 (12.0 - 65.0)	0.334
Barratt Impulsiveness Scale (BIS - 11) Total Score	53.2 (9.3)	53.0 (35.0 - 78.0)	55.2 (10.1)	55.0 (2.0 - 87.0)	0.026*
Scale for Suicide Ideation Total	1.1 (1.9)	0.0 (0.0 - 14.0)	1.6 (3.1) #	1.0 # (0.0 - 27.0)	0.147

** p < 0.01 (Wilcoxon); *p < 0.05 (Wilcoxon) # missing data for one respondent

Table 4.10 Neuropsychiatric Outcomes by 'current spray person'

Variables	Exposed (n = 125)		Unexposed (n = 692)		P Value
	Mean (SD)	**Median (Range)**	**Mean (SD)**	**Median (Range)**	
General Health Questionnaire (GHQ) Total Score	13.8 (8.0)	11.0 (0.0 - 43.0)	16.8 (9.3)	14.0 (1.0 - 69.0)	0.000**
GHQ Subscale D – Depression	0.9 (1.7)	0.0 (0.0 - 9.0)	1.9 (3.2)	0.0 (0.0 - 18.0)	0.001**
Beck Depression Inventory (BDI) Total Score	3.2 (4.6)	1.0 (0.0 - 22.0)	4.5 (6.2)	2.0 (0.0 - 43.0)	0.007**
Brief Symptom Inventory (BSI) Total Score	18.0 (18.2)	15 0 (0.0 - 95.0)	24.0 (23.7)	18.0 (0.0 - 151.0)	0.007**
BSI Global Severity Index T Score	48.6 (20.6)	55.0 (0.0 - 80.0)	52.4 (16.8)	55.0 (0.0 - 80.0)	0.193
BSI Symptom Dimension – Depression T Score	15.2 (19.4)	0.0 (0.0 - 53.0)	20.3 (20.2)	33.0 (0.0 - 67.0)	0.022*
Aggression Questionnaire Total Score	25.7 (11.4)	24.0 (12.0 - 57.0)	26.8 (12.1)	24.0 (12.0 - 65.0)	0.331
Barratt Impulsiveness Scale (BIS - 11) Total Score	52.9 (9.1)	53.0 (35.0 - 78.0)	55.2 (10.1)	55.0 (2.0 - 87.0)	0.018*
Scale for Suicide Ideation Total Score	1.0 (1.3)	0.0 (0.0 - 7.0)	1.6 (3.1) #	1.0 # (0.0 - 27.0)	0.093

** p < 0.01 (Wilcoxon); *p < 0.05 (Wilcoxon) # missing data for one respondent

Table 4.11 Neuropsychiatric Outcomes by 'current all spraying activities'

Variables	Exposed (n = 480)		Unexposed (n = 337)		P Value
	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)	
General Health Questionnaire (GHQ) Total Score	15.6 (8.4)	13.5 (0.0 - 55.0)	17.4 (10.1)	15.0 (3.0 - 69.0)	0.007**
GHQ Subscale D – Depression	1.6 (2.8)	0.0 (0.0 - 17.0)	1.9 (3.3)	0.0 (0.0 - 18.0)	0.418
Beck Depression Inventory (BDI) Total Score	4.1 (5.8)	2.0 (0.0 - 43.0)	4.7 (6.3)	3.0 (0.0 - 38.0)	0.094
Brief Symptom Inventory (BSI) Total Score	21.0 (20.4)	17.0 (0.0 -121.0)	26.0 (26.1)	19.0 (0.0 - 151.0)	0.013*
BSI Global Severity Index T Score	51.2 (18.5)	55.0 (0.0 - 80.0)	52.8 (15.8)	55.0 (0.0 - 80.0)	0.787
BSI Symptom Dimension – Depression T Score	19.7 (20.1)	0.0 (0.0 - 62.0)	19.2 (20.2)	0.0 (0.0 - 67.0)	0.407
Aggression Questionnaire Total Score	26.4 (12.2)	24.0 (12.0 - 65.0)	27.1 (11.7)	25.0 (12.0 - 63.0)	0.234
Barratt Impulsiveness Scale (BIS - 11) Total Score	54.7 (9.9)	54.0 (32.0 - 87.0)	55.0 (10.1)	56.0 (2.0 - 84.0)	0.349
Scale for Suicide Ideation Total	1.4 (2.6)	0.0 (0.0 - 23.0)	1.8 (3.3)#	1.0 # (0.0 - 27.0)	0.002**

** $p < 0.01$ (Wilcoxon); * $p < 0.05$ (Wilcoxon) # missing data for one respondent

Table 4.12 **Neuropsychiatric Outcomes by 'currently working in vineyard while pesticides being sprayed'**

Variables	Exposed (n = 607)		Unexposed (n = 210)		*P Value
	Mean (SD)	**Median (Range)**	**Mean (SD)**	**Median (Range)**	
General Health Questionnaire (GHQ) Total Score	16.3 (9.0)	14.0 (0.0 - 69.0)	16.4 (9.6)	14.0 (1.0 - 66.0)	0.852
GHQ Subscale D – Depression	1.7 (2.9)	0.0 (0.0 - 17.0)	1.9 (3.4)	0.0 (0.0 - 18.0)	0.897
Beck Depression Inventory (BDI) Total Score	4.3 (5.9)	2.0 (0.0-43.0)	4.4 (6.2)	2.0 (0.0-38.0)	0.943
Brief Symptom Inventory (BSI) Total Score	22.3 (22.5)	17.0 (0.0 -151.0)	25.1 (24.4)	19.0 (0.0 - 136.0)	0.086
BSI Global Severity Index T Score	51.1 (18.2)	55.0 (0.0 - 80.0)	54.1 (14.8)	57.0 (0.0 - 80.0)	0.151
BSI Symptom Dimension – Depression T Score	18.9 (20.1)	0.0 (0.0 - 67.0)	21.1 (20.4)	33.0 (0.0 - 62.0)	0.189
Aggression Questionnaire Total Score	26.6 (11.9)	24.0 (12.0 - 65.0)	26.9 (12.4)	23.0 (12.0 - 65.0)	0.806
Barratt Impulsiveness Scale (BIS - 11) Total Score	54.5 (10.1)	55.0 (2.0 - 87.0)	55.8 (9.7)	55.0 (37.0 - 84.0)	0.192
Scale for Suicide Ideation Total Score	1.4 (2.6)	1.0 (0.0 - 23.0)	1.9 (3.7) #	1.0 # (0.0 - 27.0)	0.189

missing data for one respondent

4.6.2 Association of Neuropsychiatric Outcomes with Environmental Exposure

Participants who reported seeing pesticide spray drift reaching their homes when spraying was taking place, were significantly more depressed (BSI Depression Symptom Dimension, exposed median 33.0 versus unexposed median 0.0; $p < 0.01$) and more aggressive (exposed median 25.0 versus unexposed median 22.0; $p < 0.05$) than those who did not observe any spray drift reaching their homes during periods of spraying (Table 4.13).

Based on the GHQ Total Score (exposed median 15.0 versus unexposed median 12.0; $p < 0.01$) participants who reported observing spray drift reaching their homes had more psychiatric disorders than those who did not report observing this phenomena (Table 4.13)

Table 4.14 shows that participants who reported smelling pesticides in their homes when spraying took place exhibited similar associations with psychiatric disorders to those of participants who reported observing pesticide spray drift reaching their homes, as displayed in Table 4.13.

As with the participants who reported observing pesticide spray drift reaching their homes, the „exposed' participants who reported smelling pesticides in their homes on the days that spraying took place, were significantly more depressed (BDI, exposed median 3.0 versus unexposed median 2.0; $p < 0.01$) and more aggressive (exposed median 25.0 versus unexposed median 22.0; $p < 0.01$) than the „unexposed' and „unsure' groups.

The similarity in the findings reported in Tables 4.11 and 4.12 are consistent with a significant correlation (Spearman $r = 0.621$, $p < 0.01$) between the two environmental exposure variables (see Chapter 3, section 3.7.1.3).

The similarity in the patterns of differences between the exposure and non-exposure scores for the BSI total score and BSI global severity index T score is expected because the two outcome instruments are highly correlated (Spearman $r = 0.978$, $p = 0.00$) (Chapter 3, Table 3.4).

Table 4.13 Neuropsychiatric Outcomes by 'observation of spray drift reaching the home'

Variables	Exposed (n = 459)		Unexposed (n = 335)		Unsure (n = 23)		P Value
	Mean (SD)	**Median (Range)**	**Mean (SD)**	**Median (Range)**	**Mean (SD)**	**Median (Range)**	
General Health Questionnaire (GHQ) Total Score	17.6 (9.7)	15.0 (2.0-66.0)	14.6 (8.2)	12.0 (0.0 - 69.0)	16.6 (7.9)	14.0 (7.0 - 39.0)	0.000**
GHQ Subscale D – Depression	2.0 (3.3)	0.0 (0.0 - 18.0)	1.4 (2.7)	0.0 (0.0 -17.0)	1.7 (2.6)	0.0 (0.0 - 9.0)	0.037*
Beck Depression Inventory (BDI) Total Score	4.6 (6.2)	2.0 (0.0 - 38.0)	3.9 (5.7)	2.0 (0.0 - 43.0)	5.0 (5.9)	3.0 (0.0 - 23.0)	0.048*
Brief Symptom Inventory (BSI) Total Score	25.4 (23.8)	20.0 (0.0 -151.0)	19.5 (21.0)	13.0 (0.0 -136.0)	29.0 (30.0)	23.0 (0.0 -142.0)	0.000**
BSI Global Severity Index T Score	54.0 (15.9)	57.0 (0.0 - 80.0)	48.6 (19.1)	52.0 (0.0 - 80.0)	55.6 (15.6)	59.0 (0.0 - 80.0)	0.004**
BSI Symptom Dimension – Depression T Score	20.9 (20.3)	33.0 (0.0 - 67.0)	17.1 (19.7)	0.0 (0.0 - 62.0)	25.5 (21.5)	38.0 (0.0 - 56.0)	0.000**
Aggression Questionnaire Total Score	28.0 (12.8)	25.0 (12.0 - 65.0)	25.0 (10.6)	22.0 (12.0 - 65.0)	25.8 (11.1)	25.0 (12.0 - 44.0)	0.013*
Barratt Impulsiveness Scale (BIS - 11) Total Score	54.3 (9.6)	54.0 (29.0 - 87.0)	55.4 (10.4)	55.0 (2.0 - 84.0)	57.1 (12.1	59.0 (35.0 - 82.0)	0.142
Scale for Suicide Ideation Total Score	1.5 # (3.0)	1.0 # (0.0 - 27.0)	1.6 (2.9)	1.0 (0.0 - 26.0)	1.9 (2.4)	2.0 (0.0 - 9.0)	0.283

** p < 0.01 (Kruskal-Wallis); * p < 0.05 (Kruskal-Wallis)
# missing data for one respondent

Table 4.14 Neuropsychiatric Outcomes by 'smell of pesticides in the home'

Variables	Exposed (n = 516)		Unexposed (n =292)		Unsure (n = 9)		P Value
	Mean (SD)	**Median (Range)**	**Mean (SD)**	**Median (Range)**	**Mean (SD)**	**Median (Range)**	
General Health Questionnaire (GHQ) Total Score	17.4 (9.6)	15.0 (1.0 -66.0)	14.4 (8.1)	12.0 (0.0 - 69.0)	15.2 (5.7)	14.0 (9.0 - 27.0)	0.000**
GHQ Subscale D – Depression	2.0 (3.3)	1.0 (0.0 - 18.0)	1.3 (2.6)	0.0 (0.0 - 15.0)	1.3 (1.7)	1.0 (0.0 - 4.0)	0.000**
Beck Depression Inventory (BDI) Total Score	4.8 (6.4)	3.0 (0.0 - 43.0)	3.5 (5.2)	2.0 (0.0 - 33.0)	3.9 (3.6)	3.0 (0.0-8.0)	0.003**
Brief Symptom Inventory (BSI) Total Score	25.6 (24.4)	20.0 (0.0 -151.0)	18.4 (19.9)	12.0 (0.0 - 136.0)	23.7 (15.8)	23.0 (1.0 - 53.0)	0.000**
BSI Global Severity Index T Score	54.0 (16.2)	57.0 (0.0 - 80.0)	48.0 (19.1)	52.0 (0.0 - 80.0)	56.8 (10.8)	60.0 (35.0 - 72.0)	0.000**
BSI Symptom Dimension – Depression T Score	21.0 (20.3)	33.0 (0.0-67.0)	16.4 (19.5)	0.0 (0.0 - 62.0)	31.1 (17.9)	39.0 (0.0 - 45.0)	0.000**
Aggression Questionnaire Total Score	27.8 (12.5)	25.0 (12.0 -65.0)	24.7 (10.8)	22.0 (12.0 - 60.0)	25.2 (7.5)	24.0 (14.0 - 35.0)	0.006**
Barratt Impulsiveness Scale (BIS - 11) Total Score	54.5 (10.1)	54.0 (2.0 - 87.0)	55.3 (9.8)	55.0 (29.0 - 84.0)	60.2 (10.1)	65.0 (35.0 - 67.0)	0.083
Scale for Suicide Ideation Total Score	1.5 # (3.0)	1.0 # (0.0 - 27.0)	1.6 (2.9)	1.0 (0.0 - 26.0)	1.6 (1.9)	1.0 (0.0 - 5.0)	0.776

** p < 0.01 (Kruskall-Wallis) # missing data for one respondent

4.6.3 Association of Neuropsychiatric Outcomes with Continuous Occupational Exposure stratified by Gender

The amount of years worked in an agricultural environment was calculated for 796 (97.4%) participants as discussed in section 4.2.2. Table 4.15 shows that the longer males and females worked in the agricultural sector, the less aggressive they appeared to be. Male farm workers also appeared to be less impulsive and suicidal, the longer they worked in an agricultural environment. For female farm workers, on the other hand, trends for suicidality and impulsivity were not significant but the decline in psychological distress was significant (BSI GSI T score, Spearman $r = -0.15$) the longer they worked in an agricultural environment

Limiting the analysis to high risk jobs only (Table 4.16), the longer tractor drivers worked in an agricultural environment, the less aggressive and impulsive they appeared to be ($p < 0.01$), whereas according to the BSI Depression Symptom Dimension T Score, head (lead) sprayers seemed to be significantly more depressed the longer they worked in the agricultural sector (Spearman $r = 0.17$, $p < 0.05$).

Depression or inhibition of the red blood cell cholinesterase levels (RBC ChE) is a measurement of recent exposure to organophosphate pesticides. Table 4.17, however, illustrates a positive association between higher RBC ChE levels and aggression for male farm workers (Spearman $r = 0.10$, $p < 0.05$).

Male farm workers with increased RBC ChE levels also reported significantly higher GHQ total scores ($p < 0.05$), and higher levels of physical, psychological and physiological distress according to the BSI raw score ($p < 0.01$).

Table 4.15 Spearman's Correlation of Neuropsychiatric Outcomes and Cumulative Years worked in Agriculture by Gender

OUTCOME VARIABLES	MALES (n = 476)	FEMALES (n = 320)	TOTAL (n = 796)
GHQ Total Score	0.08	0.07	0.06
GHQ sub scale D - Depression	-0.02	-0.002	-0.03
BSI Total Raw Score	0.01	0.03	0.001
BSI Global Severity Index - T Score	-0.05	-0.15**	-0.02
BSI symptom dimension Depression - T Score	-0.01	-0.001	-0.004
BDI Total Score	0.08	0.06	0.06
Aggression Total Score	-0.17**	-0.14*	-0.16**
BIS Total Score	-0.20**	-0.09	-0.15**
Suicide Ideation Total Score	-0.12**	-0.10 #	-0.13**

** Spearman Correlation significant at the 0.01 level (2-tailed).
* Spearman Correlation significant at the 0.05 level (2-tailed)
# missing data for one respondent

Table 4.16 Spearman's Correlation of Neuropsychiatric Outcomes and Cumulative Years worked as a Tractor Driver and/or Head Sprayer by Gender

OUTCOME VARIABLES	TRACTOR DRIVER			HEAD SPRAYER #	
	Males (n = 217)	**Females (n = 5)**	**Total (n = 222)**	**Males (n = 137)**	**TOTAL (n = 138)**
GHQ Total Score	0.08	0.00	0.07	0.09	0.07
GHQ sub scale D - Depression	0.08	0.00	0.07	0.07	0.05
BSI Total Raw Score	0.003	0.30	-0.01	0.04	0.02
BSI Global Severity Index (GSI) T Score	0.02	-0.70	0.00	0.15	0.15
BSI symptom dimension Depression - T Score	0.08	-0.22	0.06	0.17*	0.15
BDI Total Score	0.04	-0.05	0.03	0.09	0.07
Aggression Total Score	-0.20**	-0.40	-0.20**	-0.09	-0.11
BIS Total Score	-0.20**	0.00	-0.20**	-0.15	-0.17
Suicide Ideation Total Score	-0.11	-0.34	-0.12	-0.03	-0.06

** Spearman Correlation significant at the 0.01 level (2-tailed).
* Spearman Correlation significant at the 0.05 level (2-tailed)
# r not calculated for the one (1) female head sprayer

Table 4.17 Spearman's Correlation of Neuropsychiatric Outcomes and Erythrocyte Cholinesterase Measurements (U/g haemoglobin) by Gender

OUTCOME VARIABLE	MALES (n = 471)	FEMALES (n = 307)	TOTAL (n = 778)
GHQ Total Score	0.12*	-0.06	0.03
GHQ sub scale D - Depression	0.04	0.003	0.01
BSI Total Raw Score	0.15**	-0.02	0.07*
BSI Global Severity Index – T Score	-0.03	-0.04	0.02
BSI symptom dimension Depression - T Score	0.09	0.05	0.08*
BDI Total Score	0.08	-0.07	0.003
Aggression Total Score	0.10*	-0.004	0.06
BIS Total Score	0.07	0.02	0.05
Suicide Ideation Total Score	0.03	-0.05 #	-0.02 #

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
# missing data for one respondent

4.6.4 Association between Potential Covariates for Depression and Outcome Measurements stratified by Gender

Table 4.18 shows that according to the BDI, male farm workers appeared to be significantly more depressed ($p < 0.05$) as they grew older. On the other hand, male farm workers seemed to be less impulsive and have less suicidal ideation with increasing age ($p < 0.01$). Both male and female participants appeared to be less aggressive as they grew older ($p < 0.01$).

Male participants received significantly more items of personal protective clothing ($p < 0.01$) in their current jobs than females (see Table 4.8a).

Table 4.19 illustrates that the greater the number of items of personal protective clothing issued to / worn by the male participants, the less psychiatric disorders, depression, aggression, impulsiveness and suicide ideation symptoms reported by them ($p < 0.01$). Likewise, female participants, who were issued with greater amounts of protective clothing, also appeared to experience less depression, impulsiveness and suicidal ideation ($p < 0.01$).

Socio-economic status, as measured by ownership of household items, was inversely associated with most markers of neuropsychological morbidity. According to the BDI, GHQ Depression Subscale and the BSI Depression Symptom Dimension, male and female participants who owned more household items and had a shower or bath in their homes, appeared to be significantly less depressed than participants who had access to less household possessions ($p < 0.01$) (Table 4.20). Male and female farm workers, who had more household possessions, also seemed to be significantly less impulsive and have less psychiatric disorder ($p < 0.01$). Male farm workers, who had access to more household items, also reported significantly less suicidal ideation symptoms ($p < 0.05$) (Table 4.20). Of the 14 comparisons in Table 4.20, 10 were statistically significant.

Table 4.18 Spearman's Correlation of Neuropsychiatric Outcomes and Age by Gender

OUTCOME VARIABLE	MALES (n = 480)	FEMALES (n = 328)	TOTAL (n = 808)
GHQ Total Score	0.08	0.07	0.06
GHQ sub scale D - Depression	-0.05	0.02	-0.04
BSI Total Raw Score	0.02	0.08	0.03
BSI Global Severity Index – T Score	-0.01	-0.05	0.05
BSI symptom dimension Depression - T Score	-0.01	0.004	-0.001
BDI Total Score	0.112*	0.09	0.08*
Aggression Total Score	-0.15**	-0.11*	-0.15**
BIS Total Score	-0.14**	-0.04	-0.11**
Suicide Ideation Total Score	-0.12**	0.002 #	-0.09*

** Spearman Correlation significant at the 0.01 level (2-tailed).
* Spearman Correlation significant at the 0.05 level (2-tailed)
# missing data for one respondent

Table 4.19 Spearman's Correlation of Neuropsychiatric Outcomes and the Number of items of PPE received in Current Job by Gender

OUTCOME VARIABLE	MALES (n = 486)	FEMALES (n = 331)	TOTAL (n = 817)
GHQ Total Score	-0.15**	-0.001	-0.11**
GHQ sub scale D - Depression	-0.15**	-0.06	-0.14**
BSI Total Raw Score	-0.15**	-0.12*	-0.15**
BSI Global Severity Index - T Score	-0.07	-0.09	-0.05
BSI symptom dimension Depression - T Score	-0.24**	-0.10	-0.07*
BDI Total Score	-0.17**	-0.15**	0.19**
Aggression Total Score	-0.13**	-0.08	-0.11**
BIS Total Score	-0.21**	-0.22**	-0.21**
Suicide Ideation Total Score	-0.13**	-0.18** #	-0.15** #

** Spearman Correlation significant at the 0.01 level (2-tailed).
* Spearman Correlation significant at the 0.05 level (2-tailed).
# missing data for one respondent

Table 4.20 Spearman's Correlation of Neuropsychiatric Outcomes and Socio Economic Status by Gender

OUTCOME VARIABLE	MALES (n = 486)	FEMALES (n = 331)	TOTAL (n = 817)
GHQ Total Score	-0.15**	-0.12*	-0.12**
GHQ sub scale D - Depression	-0.16**	-0.16**	-0.15**
BSI Total Raw Score	-0.14**	-0.09	-0.12**
BSI Global Severity Index – T Score	-0.23**	0.02	-0.14**
BSI symptom dimension Depression - T Score	-0.20**	-0.16**	-0.19**
BDI Total Score	-0.18**	-0.14**	-0.16**
Aggression Total Score	-0.08	-0.17**	-0.12**
BIS Total Score	-0.20**	-0.11*	-0.16**
Suicide Ideation Total Score	-0.12*	-0.08 #	-0.10** #

** Spearman Correlation significant at the 0.01 level (2-tailed).
* Spearman Correlation significant at the 0.05 level (2-tailed).
# missing data for one respondent

4.7 Multivariate Analyses

Potential Covariates & Exposure Factors associated with the Outcome Measurements

Each outcome measurement was adjusted for cumulative and current occupational exposure, environmental exposure and the potential covariates. These results can be perused in the „unadjusted bivariate' models (Tables 4.21a, 4.22a, 4.23a until 4.28a).

Model Construction

The pesticide spraying tasks were highly gender specific in 2002 (see Table 4.3b, only one female „ever head sprayer' and five female „ever tractor drivers'). Hence the spraying exposure variables, „years worked as a tractor driver'; „years worked as a head sprayer'; „ever a head sprayer' and „current head sprayer' were not adjusted for the potential covariate „gender'.

There was also a significant association between the potential covariate „age' and the variables, „years worked as a tractor driver' (Spearman $r = 0.73$; $p < 0.01$) and „years worked as a head sprayer' (Spearman $r = 0.56$; $p < 0.01$) (Appendix C; Table C1). These variables were therefore not included in the same multivariate model.

A significant correlation existed between the two environmental exposure variables „observed spray drift reaching the home' and „observed the smell of pesticides in the home' (Spearman $r = 0.621$, $p < 0.01$), which accounted for the similar findings in the „unadjusted bivariate models' (Tables 4.21a, 4.22a, 4.23a until 4.28a). In the adjusted multivariate models, these two variables were analysed alternatively as individual measures of environmental exposure.

A base multivariate model was developed to measure the possible association between an exposure variable (e.g. agricultural years worked, see Table 4.21a) and a neuropsychiatric outcome (e.g. GHQ total score cut-off ≤ 23 and ≥ 24) adjusted for all the potential covariates (see Table 4.21a). Table 4.21b is an example of a base model.

This same base model was substituted to measure a possible association between each of the eight (8) neuropsychiatric outcomes (section 4.4) and each of the nine (9) exposure variables stated below, while controlling for the potential covariates (as stated in Table 4.21b). The exposure variables are:

- Years worked in agriculture
- Years worked as a tractor driver
- Years worked as a head sprayer
- Worked as a head sprayer at some time during his working life
- Current head sprayer
- Was currently working in the vineyard during spraying of pesticides
- Was currently engaged in one or more spraying activity
- Observed spray drift reaching the home
- Smelled pesticides in the home when spraying of pesticides took place

An extract of the Odds Ratio specific for the association between the individual outcome measurement (e.g. GHQ total score cut-off ≤ 23 and ≥ 24; GHQ Depression Subscale; etcetera) and each of the nine (9) exposure variables, adjusted for the potential covariates, is listed as a summary table for each outcome in turn (Tables 4.21c, 4.22c, 4.23c until Table 4.28c).

(See Appendix C, Tables C2 to C9, for the complete substituted multivariate models).

Table 4.29 is a summary table of the associations of each of the 8 neuropsychiatric outcomes with the exposure variable „years worked in agriculture' as a measure of cumulative exposure, adjusted for the common list of potential covariates as presented in Tables 4.21b, 4.22b, 4.23b, until Table 4.28

4.7.1 General Health Questionnaire-28 (cut-off score ≤ 23 and ≥ 24)

In the unadjusted model (Table 4.21a), significant associations were found between the measurement for psychiatric disorders (GHQ) and (1) potential covariates and (2) environmental exposure factors, listed below

(1) farm type (OR = 0.56; CI: 0.37 – 0.84); psychiatric illness (OR = 4.09; 95% CI: 2.51 - 6.65); low socio-economic status (OR = 1.53; CI: 1.06 - 2.23); previous pesticide poisoning (OR = 2.13; CI: 1.33 - 3.42)

(2) „observed pesticide spray drift reaching the home' (OR = 1.73; 95% CI: 1.16 - 2.57) and „observed smell of pesticides in the home' (OR = 1.67; 95% CI: 1.10 - 2.52).

After adjusting for all the potential covariates, and using „agricultural years worked' as a measure of cumulative exposure (Table 4.21b), current / past psychiatric illness (OR: 4.83; CI: 2.56 - 9.14), previous pesticide poisoning (OR: 2.17; CI: 1.26 - 3.72) and low socio economic status (OR: 1.62; CI: 1.01 - 2.58) remained significant predictors of psychiatric disorders in farm workers.

Cumulative exposure to pesticides, as represented by working for eleven (11) years and longer in an agricultural environment, was not associated with psychiatric disorders (OR: 1.13; 95% CI: 0.62 - 2.04) (Table 4.21b).

Table 4.21c shows that in the sequential models, after adjusting for all potential covariates, the only exposure variable associated with psychiatric disorders was „workers currently working in vineyard while spraying was taking place' (OR: 0.61; 95% CI: 0.38 - 0.98), but this was an inverse association.

Table 4.21a Unadjusted Bivariate Results

Potential Covariates & Exposure Factors associated with GHQ total score (cut-off ≤ 23 and ≥ 24) – measure of psychiatric disorder:

Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Potential Covariates				
Gender (Male =1, Female =0)	817	0.74	0.51 – 1.07	0.112
Age (> 33 = 1, ≤ 33 = 0)	808	1.32	0.91 – 1.92	0.146
Farm type (Table grapes = 1, Wine grapes = 0)	**817**	**0.56**	**0.37 – 0.84**	**0.005**
C.A.G.E. Score	692	1.09	0.91 – 1.31	0.348
Psychiatric Ilness (Yes =1, No =0)	**817**	**4.09**	**2.51 – 6.65**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	817	1.39	0.92 – 2.11	0.116
Low SES (< 4 = 1, ≥ 4 = 0)	**817**	**1.53**	**1.06 – 2.23**	**0.024**
Previous pesticide poisoning (Yes = 1, No = 0)	**759**	**2.13**	**1.33 – 3.42**	**0.002**
Exposure Variables				
Agricultural years worked (> 11 = 1, ≤ 11 = 0)	796	1.19	0.82 – 1.73	0.359
Years worked as tractor driver (> 13 = 1, ≤ 13 = 0)	227	0.93	0.42 – 2.08	0.857
Years worked as a head sprayer (> 13 = 1, ≤ 13 = 0)	138	0.64	0.25 – 1.69	0.372
A spray person at some time during their working life (Yes = 1; No = 0)	817	0.83	0.50 – 1.39	0.481
Current spray person (Yes = 1; No =0)	817	0.65	0.37 – 1.15	0.141
Currently working in vineyard while spraying taking place (Yes = 1; No = 0)	817	1.03	0.68 – 1.58	0.880
Currently doing one or more spraying activities (Yes = 1; No = 0)	817	0.74	0.51 – 1.07	0.112
Observed pesticide spray drift reaching the home (Yes = 1; No = 0)	**794**	**1.73**	**1.16 – 2.57**	**0.008**
Reported pesticide smell in home	**808**	**1.67**	**1.10 – 2.52**	**0.015**
Cholinesterase Levels (quartiles):	778			
○ > 36.3 U/g		1.00		
○ ≤ 28.9 U/g		1.00	0.59 – 1.69	0.995
○ > 28.9 U/g and ≤ 32.6 U/g		0.98	0.58 – 1.66	0.940
○ > 32.6 and ≤ 36.3		0.72	0.41 – 1.26	0.255

Table 4.21b Adjusted Multivariate Results

Psychiatric Disorders (GHQ total score cut-off ≤ 23 and ≥ 24) associated with Cumulative Years worked in Agriculture (Occupational Exposure), adjusted for all Potential Covariates (N = 609)

	Prevalence Odds Ratio	**Confidence Interval**	**p – value**
Agricultural years worked [> 11 = 1 (n = 316), ≤ 11 = 0 (n = 293)]	1.13	0.62 – 2.04	0.694
<u>Potential Covariates</u>			
Gender [Male =1 (n = 387), Female =0 (n = 222)]	0.82	0.50 – 1.34	0.422
Age [> 33 = 1 (n = 314), ≤ 33 = 0 (n = 295)]	1.52	0.84 – 2.73	0.166
Farm type [Table grapes = 1 (n = 474), Wine grapes = 0 (n = 135)]	0.67	0.39 – 1.14	0.137
C.A.G.E. Score	0.99	0.81 – 1.22	0.946
Psychiatric Ilness [Yes =1 (n = 53), No =0 (n = 556)]	**4.83**	**2.56 – 9.14**	**0.000**
PPE [≤ 1 = 1 (n = 139), ≥ 2 = 0 (n = 470)]	1.01	0.59 – 1.73	0.973
Low SES [< 4 = 1 (n = 237), ≥ 4 = 0 (n = 372)]	**1.62**	**1.01 – 2.58**	**0.045**
Previous pesticide poisoning [Yes = 1 (n = 93), No = 0 (516)]	**2.17**	**1.26 – 3.72**	**0.005**
Cholinesterase Levels (quartiles):			
○ > 36.0 U/g (n = 156)	1.00		
○ ≤ 28.9 U/g (n = 140)	1.07	0.56 – 2.03	0.844
○ > 28.9 U/g and ≤ 32.6 U/g (n = 158)	1.39	0.74 – 2.62	0.301
○ > 32.6 U/g and ≤ 36.3 U/g (n = 155)	0.88	0.46 – 1.69	0.696

Table 4.21c Adjusted Multivariate Results

Summary Table: Associations of GHQ scores & nine different Exposure Variables adjusted for a common list of potential covariates; ORs derived from sequential models using each exposure variable in turn (models from which these OR's are drawn are presented in full in Appendix C, Table C2)

Exposure Variables	**N**	**Prevalence Odds Ratio***	**Confidence Interval**	**p – value**
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	609	1.13	0.62 – 2.04	0.694
Years worked as tractor driver * [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	174	0.71	0.27 – 1.89	0.488
Years worked as a head sprayer * [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	110	0.48	0.15 – 1.49	0.202
A spray person at some time during their working life ** [Yes = 1 (n = 109); No = 0 (n = 510)]	619	1.15	0.63 – 2.09	0.657
Current spray person ** [Yes = 1 (n = 98); No =0 (n = 521)]	619	0.93	0.49 – 1.76	0.814
Currently working in vineyard while spraying taking place [Yes = 1 (n = 384); No = 0 (n = 235)]	619	**0.61**	**0.38 – 0.98**	**0.040**
Currently doing one or more spraying activity [Yes = 1 (n = 457); No =0 (n = 162)]	619	0.81	0.49 – 1.35	0.417
Observed pesticide spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	599	1.21	0.75 – 1.95	0.438
Reported pesticide smell in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	612	1.06	0.65 – 1.73	0.815

* Not adjusted for age and gender because there were only 5 female workers who had ever been a tractor driver, and 1female worker who had ever been a head sprayer. Age was also significantly correlated with „years worked as a tractor driver' and years worked as a head sprayer' (Table C1)

** Not adjusted for gender as there was only one female head sprayer

4.7.2 General Health Questionnaire (GHQ) Depression Subscale dichomotised across the 75th percentile

In the unadjusted model (Table 4.22a) significant positive associations were found between depression and (1) potential covariates and (2) environmental exposure factors, listed below

(1) current / past psychiatric illness (OR: 2.57; 95% CI: 1.63 - 4.07), minimal or no protective clothing (OR: 1.48; 95% CI: 1.05 - 1.08), low socio economic status (OR:1.52; 95% CI: 1.12 - 2.06) and previous / past pesticide poisoning (OR: 1.59; 95% CI: 1.05 - 2.41).

(2) „observed spray drift reaching the home' (OR: 1.41; 95% CI: 1.03 - 1.92) and „observed the smell of pesticides in the home' (OR: 1.87; 95% CI: 1.34 – 2.59).

Inverse associations were found between depression and male farm workers (OR: 0.71; 95% CI: 0.53 - 0.96) and depression and table grape farm workers (OR: 0.38; 95% CI: 0.27 - 0.53). In these instances, male and table grape farm workers were less likely to report depression.

In the unadjusted models, workers who had ever been a head sprayer and those who were current sprayers, were also less likely to be depressed (Table 4.22a).

After adjusting for all the potential covariates, and using agricultural years worked as a measure of cumulative exposure, current / past psychiatric illness (OR: 2.90; CI: 1.58 - 5.32), previous pesticide poisoning (OR: 1.62; CI: 1.00 - 2.63) and low socio economic status of less than 4 household items (OR: 1.53; CI: 1.05 - 2.23) remained significant predictors of depression in farm workers (Table 4.22b).

Table 4.22c shows that in the sequential models, after adjusting for all potential covariates, the only exposure variable associated with depression was „smelled pesticides in their homes' (OR: 1.66; 95% CI: 1.11 - 2.47).

Of the 516 (63.2%) participants who reported smelling pesticides in their homes on spraying days, 72 (14.0%) were „ever head sprayers', 136 (26.4%) were „ever tractor drivers' and 308 (59.7%) were the „high exposure' group in their current jobs, in that they „were currently doing one or more spraying activity'. Also, of the 227 „ever tractor drivers', 138 (60.8%) were „ever head sprayers'. Since these exposure groups were part of the participants who were environmentally exposed by smelling pesticides in their homes, further multivariate logistic regression models were run to control for these exposure activities.

Table 4.22c shows that, even after including the exposure variable „ever a tractor driver', and then the exposure variable „currently doing one or more spraying activity (last two rows of Table 4.22c), in the adjustment for potential covariates, the positive association between depression and the environmental exposure variable „smelled pesticides in the home' remained essentially unchanged (OR: 1.66; 95% CI: 1.11 - 2.47 and OR: 1.65; 95% CI: 1.11 - 2.46, respectively).

Table 4.22a Unadjusted Bivariate Results

Potential Covariates & Exposure Factors associated with GHQ Depression Subscale (75th percentile)

Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Potential Covariates				
Gender (Male =1, Female =0)	817	**0.71**	**0.53 – 0.96**	**0.027**
Age (> 33 = 1, ≤ 33 = 0)	808	0.87	0.64 – 1.17	0.357
Farm type (Table grapes = 1, Wine grapes = 0)	817	**0.38**	**0.27 – 0.53**	**0.000**
C.A.G.E. Score	692	0.93	0.80 – 1.07	0.303
Psychiatric Ilness (Yes =1, No =0)	817	**2.57**	**1.63 – 4.07**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	817	**1.48**	**1.05 – 1.08**	**0.024**
Low SES (< 4 = 1, ≥ 4 = 0)	817	**1.52**	**1.12 – 2.06**	**0.007**
Previous pesticide poisoning (Yes = 1, No = 0)	759	**1.59**	**1.05 – 2.41**	**0.030**
Exposure Variables				
Agricultural years worked (> 11 = 1, ≤ 11 = 0)	796	0.79	0.59 – 1.07	0.130
Years worked as tractor driver (> 13 = 1, ≤ 13 = 0)	227	1.35	0.73 – 2.47	0.337
Years worked as a head sprayer (> 13 = 1, ≤ 13 = 0)	138	1.04	0.47 – 2.29	0.925
A spray person at some time during their working life (Yes = 1; No = 0)	817	**0.63**	**0.41 – 0.97**	**0.036**
Current spray person (Yes = 1; No =0)	817	**0.55**	**0.34 – 0.86**	**0.010**
Currently working in vineyard while spraying taking place (Yes = 1; No = 0)	817	0.96	0.68 – 1.34	0.797
Currently doing one or more spraying activities (Yes = 1; No = 0)	817	0.97	0.71 – 1.31	0.821
Observed pesticide spray drift reaching the home (Yes = 1; No = 0)	794	**1.41**	**1.03 – 1.92**	**0.030**
Reported pesticide smell in the home	808	**1.87**	**1.34 – 2.59**	**0.000**
Cholinesterase Levels (quartiles):				
○ > 36.3 U/g	189	1.00		0.249
○ ≤ 28.9 U/g	195	0.79	0.79 – 1.87	0.375
○ > 28.9 U/g and ≤ 32.6 U/g	198	0.77	0.77 – 1.83	0.433
○ > 32.6 and ≤ 36.3	196	0.520	0.52 – 1.27	0.366

Table 4.22b Adjusted Multivariate Results

Depression (GHQ Subscale D) associated with Cumulative Years worked in Agriculture (Occupational Exposure), adjusted for all Potential Covariates (N = 609)

	Prevalence Odds Ratio	**Confidence Interval**	**p – value**
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	0.86	0.53 – 1.38	0.527
<u>Potential Covariates</u>			
Gender [Male =1 (n = 387); Female =0 (n = 222)]	**0.64**	**0.43 – 0.94**	**0.024**
Age [> 33 = 1 (n = 314); ≤ 33 = 0 (n = 295)]	1.16	0.72 – 1.86	0.547
Farm type [Table grapes = 1 (n = 474); Wine grapes = 0 (n = 135)]	**0.39**	**0.25 – 0.60**	**0.000**
C.A.G.E. Score	0.90	0.76 – 1.05	0.185
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 556)]	**2.90**	**1.58 – 5.32**	**0.001**
PPE [≤ 1 = 1 (n = 139); ≥ 2 = 0 (n = 470)]	1.13	0.73 – 1.73	0.591
Low SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 372)]	**1.53**	**1.05 – 2.23**	**0.027**
Previous pesticide poisoning [Yes = 1 (n = 93; No = 0 (n = 516)]	**1.62**	**1.00 – 2.63**	**0.049**
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 156)	1.00		
○ ≤ 28.9 U/g (n = 140)	1.01	0.60 – 1.70	0.980
○ > 28.9 U/g and ≤ 32.6 U/g (n = 158)	1.27	0.76 – 2.12	0.354
○ > 32.6 U/g and ≤ 36.3 U/g (n = 155)	0.78	0.46 – 1.32	0.359

Table 4.22c Adjusted Multivariate Results

Summary Table: Associations of GHQ Depression scores & nine different Exposure Variables adjusted for a common list of potential covariates; ORs derived from sequential models using each exposure variable in turn (models from which these OR's are drawn are presented in full in Appendix C, Table C3)

Exposure Variables	**N**	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	609	0.86	0.53 – 1.38	0.527
Years worked as tractor driver * [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	174	1.16	0.53 – 2.54	0.717
Years worked as a head sprayer * [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	110	1.00	0.35– 2.87	0.995
A spray person at some time during their working life ** [Yes = 1 (n = 109); No = 0 (n = 510)]	619	0.74	0.44 – 1.24	0.248
Current spray person ** [Yes = 1 (n = 98); No =0, (n = 521)]	619	0.67	0.39 – 1.16	0.152
Currently working in vineyard while spraying taking place [Yes = 1 (n = 457); No =0 (n = 162)]	619	1.01	0.67 – 1.54	0.947
Currently doing one or more spraying activity [Yes = 1 (n = 384); No =0 (n = 235)]	619	1.16	0.76 – 1.78	0.491
Observed pesticide spray drift reaching the home [Yes =1 (n = 352); No =0 (n = 247)]	599	1.31	0.89 – 1.91	0.170
Reported pesticide smell in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	612	**1.66** **1.66 #** **1.65 ##**	**1.11 – 2.47** **1.11 – 2.47** **1.11 – 2.46**	**0.013** **0.013** **0.014**

* Not adjusted for age and gender because only 5 female workers had ever been a tractor driver and 1 female worker a head sprayer. Age was also significantly correlated with „years worked as a tractor driver' and years worked as a head sprayer' (Table C1)
** Not adjusted for gender as there was only one female head sprayer
# Adjusted for all potential covariates and exposure variable „ever a tractor driver'
Adjusted for all potential covariates and „currently doing one or more spraying activity'

4.7.3 Beck Depression Inventory (BDI-IA)

In the unadjusted logistic regression model, all the potential covariates (other than gender and the C.A.G.E score) and environmental exposure assessed by „observed smell of pesticides in the home' on spraying days, were significantly associated with depression as measured by the BDI (Table 4.23a).

Table 4.23a shows that farm workers older than 33 years, were 60% more likely to be depressed than those who were 33 years of age and younger (OR: 1.62; CI: 1.02 - 2.56). Also, farm workers who had experienced past pesticide poisoning were 90% more likely to be depressed than workers who had not had that experience (OR: 1.89; CI: 1.07 - 1.33). Additionally, farm workers who received one or no items of PPE were twofold more likely to be depressed than workers who received 2 or more items of PPE (OR: 2.14; 95% CI: 1.34 - 3.43); and workers with a history of current / past psychiatric illness were four times more likely to be depressed than those without such a history (OR: 4.16; 95% CI: 2.41 – 7.18).

In the adjusted model, using agricultural years worked as a measure of cumulative exposure, age greater than 33 years, current / past psychiatric illness and low use of protective clothing (≤1 PPE), remained significant predictors of depression ($p < 0.05$) (Table 4.23b). Farm workers who were older than 33 years were twofold more depressed (CI: 2.41; OR: 1.16 - 5.00), and those with a history of current/past psychiatric illness were six fold more depressed (OR: 6.02; CI: 2.87 - 12.66) than their counterparts.

The adjusted model also illustrates an inverse association between depression and table grape farms (OR: 0.22; 95% CI: 0.12 - 0.41) indicating that farm workers on table grape farms were less likely to be depressed than those on wine grape farms.

Table 4.23c shows that in the sequential models, after adjusting for the potential covariates, none of the cumulative exposure variables were significantly associated with depression, as measured by the BDI

Table 4.23a Unadjusted Bivariate Results

Potential Covariates & Exposure Factors associated with the BDI-IA

Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Potential Covariates				
Gender (Male =1, Female =0)	817	0.78	0.50 – 1.23	0.288
Age (> 33 = 1, ≤ 33 = 0)	808	**1.62**	**1.02 – 2.56**	**0.041**
Farm type (Table grapes = 1, Wine grapes = 0)	817	**0.26**	**0.17 – 0.42**	**0.000**
C.A.G.E. Score	692	1.06	0.85 – 1.32	0.599
Psychiatric Sickness (Yes =1, No =0)	817	**4.16**	**2.41 – 7.18**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	817	**2.14**	**1.34 – 3.43**	**0.002**
Low SES (< 4 = 1, ≥ 4 = 0)	817	**1.94**	**1.23 – 3.04**	**0.004**
Previous pesticide poisoning (Yes = 1, No = 0)	759	**1.89**	**1.07 – 3.33**	**0.029**
Exposure Variables				
Agricultural years worked (> 11 = 1, ≤ 11 = 0)	796	1.16	0.73 – 1.82	0.530
Years worked as tractor driver (> 13 = 1, ≤ 13 = 0)	227	1.15	0.43 – 3.09	0.786
Years worked as a head sprayer (> 13 = 1, ≤ 13 = 0)	138	0.49	0.12 – 2.05	0.331
A spray person at some time during their working life (Yes = 1; No = 0)	817	0.55	0.27 – 1.13	0.106
Current spray person (Yes = 1; No =0)	817	0.55	0.26 – 1.16	0.116
Currently working in vineyard while spraying taking place (Yes = 1; No = 0)	817	0.99	0.59 – 1.65	0.968
Currently doing one or more spraying activities (Yes = 1; No = 0)	817	0.77	0.49 – 1.21	0.251
Observed pesticide spray drift reaching the house (Yes = 1; No = 0)	794	1.35	0.84 – 2.17	0.220
Reported pesticide smell in the home	808	**1.96**	**1.16 – 3.31**	**0.012**
Cholinesterase quartiles	778			
○ > 36.3 U/g (n = 189)		1.00		
○ ≤ 28.9 U/g (n = 195)		1.30	0.70 – 2.42	0.407
○ > 28.9 U/g and ≤ 32.6 U/g (n = 198)		0.85	0.43 – 1.65	0.622
○ > 32.6 U/g and ≤ 36.3 U/g (n = 196)		0.70	0.35 – 1.41	0.320

Table 4.23b Adjusted Multivariate Results

Depression (BDI-IA) associated with Cumulative Years worked in Agriculture (Occupational Exposure), Adjusted for all Potential Covariates (N = 609)

	Prevalence Odds Ratio	Confidence Interval	p – value
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	0.86	0.42 – 1.78	0.686
Potential Covariates			
Gender [Male = 1 (n = 387); Female = 222)]	0.77	0.42 – 1.42	0.405
Age [> 33 = 1 (n = 314) ≤ 33 = 0 (n = 295)]	**2.41**	**1.16 – 5.00**	**0.019**
Farm type [Table grapes =1 (n = 474); Wine grapes =0 (n = 135)]	**0.22**	**0.12 – 0.41**	**0.000**
C.A.G.E. Score	1.01	0.78 – 1.32	0.927
Psychiatric Sickness [Yes =1 (n = 53); No = 0 (n = 556)]	**6.02**	**2.87 – 12.66**	**0.000**
PPE [≤ 1 = 1 (n = 139); ≥ 2 = 0 (n = 470)]	**1.84**	**1.01 – 3.37**	**0.048**
Low SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 372)]	1.68	0.94 – 2.98	0.079
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 516)]	1.67	0.84 – 3.29	0.142
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 156)	1.00		
○ ≤ 28.9 U/g (n = 140)	1.29	0.62 – 2.69	0.504
○ > 28.9 U/g and ≤ 32.6 U/g (n = 158)	1.18	0.54 – 2.58	0.681
○ > 32.6 U/g and ≤ 36.3 U/g (n = 155)	0.51	0.21 – 1.23	0.132

Table 4.23c Adjusted Multivariate Results

Summary Table: Associations of BDI-IA scores & nine different Exposure Variables adjusted for a common list of potential covariates; ORs derived from sequential models using each exposure variable in turn (models from which these OR's are drawn are presented in full in Appendix C, Table C4)

Exposure Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	609	0.86	0.42 – 1.78	0.686
Years worked as tractor driver [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	109	0.92	0.26 – 3.29	0.898
Years worked as a head sprayer [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	110	0.41	0.06 – 2.68	0.351
A spray person at some time during their working life [Yes = 1 (n = 109); No = 0 (n = 510)]	619	0.64	0.27 – 1.55	0.323
Current spray person [Yes = 1 (n = 98); No = 0 (n = 521)]	619	0.77	0.32 – 1.88	0.571
Currently working in vineyard while spraying taking place [Yes = 1 (n = 457); No =0 (n = 162)]	619	0.73	0.39 – 1.36	0.325
Currently doing one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 235)]	619	0.63	0.33 – 1.19	0.153
Observed pesticide spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	599	0.90	0.51 – 1.61	0.733
Reported pesticide smell in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	612	1.06	0.58 – 1.93	0.861

* Not adjusted for age and gender because there were only 5 female workers who had ever been a tractor driver and 1female worker who had ever been a head sprayer. Age was also significantly correlated with „years worked as a tractor driver' and „years worked as a head sprayer' (Table C1)
** Not adjusted for gender as there was only one female head sprayer.

4.4.4 *Brief Symptom Inventory Global Severity Index (BSI GSI) – Measurement of General Distress Levels*

In the unadjusted logistic regression model (Table 4.24a), both environmental exposure measurements „reported the smell of pesticides in the home' and „observation of spray drift reaching the house' when spraying occurred, as well as, the potential covariates, „age', „farm type', „current/past psychiatric illness', low socio economic status (≤ 4)' and „past pesticide poisoning' were significantly associated with general distress levels as measured by the BSI GSI.

The following significant associations are exhibited in the unadjusted model in Table 4.24a:

- Farm workers older than 33 years experienced significantly more general distress than younger workers (OR: 1.43; CI: 1.03 – 1.99)
- Farm workers who had experienced one or more episodes of pesticide poisoning in the past, had higher levels of general distress (OR: 1.80; CI: 1.17 – 2.78)
- Farm workers with a history of current / past psychiatric illness had twofold higher levels of general distress (OR: 2.53; CI: 1.58 – 4.05)
- Farm workers who had less than 4 household items experienced higher levels of general distress (OR: 1.88; CI: 1.36 – 2.61)

Table 4.24b shows that after adjustment for all the potential covariates, and using agricultural years worked as a proxy for cumulative exposure, „age greater than 33 years' (OR: 1.72; 95% CI: 1.05 - 2.82), „current / past psychiatric illness' (OR: 3.55; 95% CI: 1.93 - 6.54) and „low socio economic status' (OR: 1.79; 95% CI: 1.20 - 2.65) remained significant predictors of general distress in farm workers.

Table 4.24c shows that in the sequential models, after adjusting for the potential covariates, none of the cumulative exposure variables were significantly associated with any forms of physical, physiological and psychological distress (general distress), as measured by the BSI GSI.

Table 4.24a Unadjusted Bivariate Results

Potential Covariates & Exposure Factors associated with BSI Global Severity Index (GSI) – measurement of general distress levels

Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Potential Covariates				
Gender (Male =1, Female =0)	817	1.21	0.87 – 1.69	0.254
Age (> 33 = 1, ≤ 33 = 0)	808	**1.43**	**1.03 – 1.99**	**0.033**
Farm type (Table grapes = 1, Wine grapes = 0)	817	**0.57**	**0.40 – 0.83**	**0.003**
C.A.G.E. Score	692	1.13	0.96 – 1.32	0.147
Psychiatric Sickness (Yes =1, No =0)	817	**2.53**	**1.58 – 4.05**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	817	1.19	0.82 – 1.72	0.367
Low SES (< 4 = 1, ≥ 4 = 0)	817	**1.88**	**1.36 – 2.61**	**0.000**
Previous pesticide poisoning (Yes = 1, No = 0)	759	**1.80**	**1.17 – 2.78**	**0.008**
Exposure Variables				
Agricultural years worked (> 11 = 1, ≤ 11 = 0)	796	1.06	0.76 – 1.47	0.742
Years worked as tractor driver (> 13 = 1, ≤ 13 = 0)	227	1.34	0.69 – 2.57	0.388
Years worked as a head sprayer (> 13 = 1, ≤ 13 = 0)	138	1.23	0.55 – 2.77	0.616
A spray person at some time during their working life (Yes = 1; No = 0)	817	0.89	0.57 – 1.38	0.593
Current spray person (Yes = 1; No =0)	817	0.83	0.52 – 1.33	0.440
Currently working in vineyard while spraying taking place (Yes = 1; No = 0)	817	0.94	0.65 – 1.36	0.756
Currently doing one or more spraying activities	817	1.01	0.72 – 1.40	0.974
Observed pesticide spray drift reaching the house (Yes = 1; No = 0)	794	**1.47**	**1.05 – 2.07**	**0.027**
Reported pesticide smell in the home	808	**1.53**	**1.07 – 2.17**	**0.019**
Cholinesterase quartiles				
○ > 36.3 U/g (n = 189)	778	1.00		
○ ≤ 28.9 U/g (n = 195)		0.73	0.44 – 1.19	0.200
○ > 28.9 U/g and ≤ 32.6 U/g (n = 198)		0.97	0.61 – 1.55	0.894
○ > 32.6 U/g and ≤ 36.3 U/g (n = 196)		1.28	0.81 – 2.02	0.289

Table 4.24b Adjusted Multivariate Results

General distress (BSI GSI) associated with Cumulative years worked in Agriculture (Occupational Exposure), Adjusted for all Potential Covariates

Exposure variable adjusted for all Potential Covariates (N = 609)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	0.82	0.50 – 1.35	0.437
Potential Covariates			
Gender [Male = 1 (n = 387); Female = 222)]	1.17	0.77 – 1.79	0.458
Age [> 33 = 1 (n = 314) ≤ 33 = 0 (n = 295)]	**1.72**	**1.05 – 2.82**	**0.033**
Farm type [Table grapes =1 (n = 474); Wine grapes =0 (n = 135)]	0.70	0.44 – 1.11	0.127
C.A.G.E. Score	1.11	0.93 – 1.32	0.257
Psychiatric Sickness [Yes =1 (n = 53); No = 0 (n = 556)]	**3.55**	**1.93 – 6.54**	**0.000**
PPE [≤ 1 = 1 (n = 139); ≥ 2 = 0 (n = 470)]	1.05	0.66 – 1.66	0.843
Low SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 372)]	**1.79**	**1.20 – 2.65**	**0.004**
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 516)]	1.46	0.89 – 2.40	0.134
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 156)	1.00		
○ ≤ 28.9 U/g (n = 140)	0.83	0.46 – 1.47	0.514
○ > 28.9 U/g and ≤ 32.6 U/g (n = 158)	1.54	0.90 – 2.65	0.118
○ > 32.6 U/g and ≤ 36.3 U/g (n = 155)	1.57	0.93 – 2.63	0.093

Table 4.24c Adjusted Multivariate Results

Summary Table: Associations of BSI GSI scores & nine different Exposure Variables adjusted for a common list of potential covariates; ORs derived from sequential models using each exposure variable in turn (models from which these OR's are drawn are presented in full in Appendix C, Table C5)

Exposure Variables	**N**	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	609	0.82	0.50 – 1.35	0.437
Years worked as tractor driver * [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	174	1.09	0.50 – 2.34	0.833
Years worked as a head sprayer * [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	110	1.18	0.45 – 3.08	0.738
A spray person at some time during their working life ** [Yes = 1 (n = 109); No = 0 (n = 510)]	619	0.96	0.57 – 1.60	0.866
Current spray person ** [Yes = 1 (n = 98); No = 0 (n = 521)]	619	0.97	0.57 – 1.65	0.899
Currently working in vineyard while spraying taking place [Yes = 1 (n = 457); No =0 (n = 162)]	619	0.85	0.55 – 1.30	0.454
Currently doing one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 235)]	619	0.79	0.51 – 1.23	0.296
Observed spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 274)]	599	1.10	0.73 – 1.63	0.656
Reported pesticide smell in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	612	1.08	0.72 – 1.62	0.711

* Not adjusted for age and gender because there were only 5 female workers who had ever been a tractor driver and 1 female worker who had ever been a head sprayer. Age was also significantly correlated with „years worked as a tractor driver' and „years worked as a head sprayer' (Table C1)
** Not adjusted for gender as there was only one female head sprayer.

4.7.4 Brief Symptom Inventory (BSI) - Depression Symptom Dimension dichomotised across the 75th percentile

In the unadjusted logistic regression model, significant associations with BSI outcomes were found for „gender', „farm type', „low socio economic status' and „past pesticide poisoning' (Table 4.25a). Males were two fold more depressed than females (OR: 2.11; CI: 1.51 - 2.95). A history of a previous episode(s) of pesticide poisoning was another significant predictor of depression for farm workers on both wine and table grape farms (OR: 1.66; CI: 1.09 - 2.55). Farm workers on table grape farms, however, were significantly less depressed than those working on wine grape farms (OR: 0.36; CI: 0.26 - 0.51) (Table 4.25a)

In the unadjusted model (Table 4.25a), significant associations with BSI outcomes were also found for environmental exposure ($p < 0.01$), and occupational exposure by currently performing one or more spraying activity (OR: 1.57; CI: 1.14 - 2.17).

In the adjusted model, using agricultural years worked as a measure of cumulative exposure (Table 4.25b), male farm workers (OR: 1.78; 05% CI: 1.16 - 2.71), workers with a low socio economic status (OR: 1.90; 95% CI: 1.30 - 2.79), and workers with a history of current / past psychiatric illness (OR: 2.36 CI: 1.26 – 4.41) were significantly more depressed ($p < 0.01$).

The adjusted model also illustrates an inverse association between depression and table grape farms (OR: 0.51; 95% CI: 0.33 - 0.78) indicating that farm workers on table grape farms were about half as likely to be depressed than those on wine grape farms.

Table 4.25c shows that in the sequential models, after adjusting for the potential covariates, none of the cumulative exposure variables were significantly associated with depression as measured by the BSI Depression Symptom Dimension.

Table 4.25a Unadjusted Bivariate Results

Potential Covariates & Exposure Factors associated with BSI Depression Symptom Dimension (75th percentile)

Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Potential Covariates				
Gender (Male =1, Female =0)	817	**2.11**	**1.51 – 2.95**	**0.000**
Age (> 33 = 1, ≤ 33 = 0)	808	1.15	0.85 – 1.58	0.368
Farm type (Table grapes = 1, Wine grapes = 0)	817	**0.36**	**0.26 – 0.51**	**0.000**
C.A.G.E. Score	692	1.09	0.94 – 1.27	0.247
Psychiatric Ilness (Yes =1, No =0)	817	1.52	0.94 – 2.45	0.090
PPE (≤ 1 = 1, ≥ 2 = 0)	817	1.06	0.74 – 1.53	0.740
Low SES (< 4 = 1, ≥ 4 = 0)	817	**2.26**	**1.65 – 3.10**	**0.000**
Previous pesticide poisoning (Yes = 1, No = 0)	759	**1.66**	**1.09 – 2.55**	**0.020**
Exposure Variables				
Agricultural years worked (> 11 = 1, ≤ 11 = 0)	796	1.03	0.75 – 1.40	0.868
Years worked as tractor driver (> 13 = 1, ≤ 13 = 0)	227	1.60	0.88 – 2.90	0.124
Years worked as a head sprayer (> 13 = 1, ≤ 13 = 0)	138	1.32	0.60 – 2.89	0.488
A spray person at some time during their working life (Yes = 1; No = 0)	817	0.82	0.54 – 1.26	0.363
Current spray person (Yes = 1; No =0)	817	0.75	0.48 – 1.17	0.205
Currently working in vineyard while spraying taking place (Yes = 1; No = 0)	817	0.85	0.60 – 1.20	1.349
Currently doing one or more spraying activities (Yes = 1; No = 0)	817	**1.57**	**1.14 – 2.17**	**0.006**
Observed pesticide spray drift reaching the home (Yes = 1; No = 0)	794	**1.62**	**1.16 – 2.25**	**0.004**
Reported pesticide smell in the home	808	**1.73**	**1.23 – 2.43**	**0.002**
Cholinesterase Levels (quartiles):				
○ > 36.3 U/g	189	1.00		
○ ≤ 28.9 U/g	195	0.68	0.43 – 1.07	0.093
○ > 28.9 U/g and ≤ 32.6 U/g	198	0.80	0.52 – 1.25	0.335
○ > 32.6 and ≤ 36.3	196	0.88	0.57 – 1.37	0.572

Table 4.25b Adjusted Multivariate Results

Depression (BSI Symptom Dimension) associated with Cumulative Years worked in Agriculture (Occupational Exposure), adjusted for all Potential Covariates (N = 609)

Exposure variable adjusted for all Potential Covariates	Prevalence Odds Ratio	Confidence Interval	p – value
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	0.86	0.53 – 1.41	0.553
<u>Potential Covariates</u>			
Gender [Male =1 (n = 387); Female =0 (n = 222)]	**1.78**	**1.16 – 2.71**	**0.008**
Age [> 33 = 1 (n = 314); ≤ 33 = 0 (n = 295)]	1.25	0.77 – 2.02	0.369
Farm type [Table grapes = 1 (n = 474); Wine grapes = 0 (n = 135)]	**0.51**	**0.33 – 0.78**	**0.002**
C.A.G.E. Score	1.10	0.93 – 1.30	0.283
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 556)]	**2.36**	**1.26 – 4.41**	**0.007**
PPE [≤ 1 = 1 (n = 139); ≥ 2 = 0 (n = 470)]	0.98	0.62 – 1.54	0.916
Low SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 372)]	**1.90**	**1.30 – 2.79**	**0.001**
Previous pesticide poisoning [Yes = 1 (n = 93; No = 0 (n = 516)]	1.30	0.80 – 2.13	0.291
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 156)	1.00		
○ ≤ 28.9 U/g (n = 140)	1.07	0.62 – 1.84	0.811
○ > 28.9 U/g and ≤ 32.6 U/g (n = 158)	1.41	0.83 – 2.39	0.205
○ > 32.6 U/g and ≤ 36.3 U/g (n = 155)	1.09	0.65 – 1.84	0.745

Table 4.25c **Adjusted Multivariate Results**

Summary Table: Associations of BSI Depression scores & nine different Exposure Variables adjusted for a common list of potential covariates; ORs derived from sequential models using each exposure variable in turn (models from which these OR's are drawn are presented in full in Appendix C, Table C6)

Exposure Variables	**N**	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	609	0.86	0.53 – 1.41	0.553
Years worked as tractor driver * [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	174	1.34	0.62 – 2.87	0.457
Years worked as a head sprayer * [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	110	1.12	0.40 – 3.13	0.823
A spray person at some time during their working life ** [Yes = 1 (n = 109); No = 0 (n = 510)]	619	0.74	0.44 – 1.25	0.260
Current spray person ** [Yes = 1 (n = 98); No = 0 (n = 521)]	619	0.73	0.42 – 1.26	0.261
Currently working in vineyard while spraying taking place [Yes = 1 (n = 457); No =0 (n = 162)]	619	0.68	0.45 – 1.03	0.070
Currently doing one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 235)]	619	0.86	0.56 – 1.32	0.481
Observed spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	599	1.10	0.74 – 1.62	0.647
Reported pesticide smell in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	612	1.18	0.79 – 1.76	0.422

* Not adjusted for age and gender because there were only 5 female workers who had ever been a tractor driver and 1 female worker who had ever been a head sprayer. Age was also significantly correlated with „years worked as a tractor driver' and „years worked as a head sprayer' (Table C1)
** Not adjusted for gender as there was only one female head sprayer

4.7.6 The Four-Factor Measurement Model of the Aggression Questionnaire (12-item AQ)

In the unadjusted logistic regression model (table 4.26a), significant positive associations were found between aggression and (1) potential covariates and (2) environmental exposure factors, as stated below

(1) CAGE score (OR: 1.24; CI: 1.08 - 1.42) and low socio economic status of (OR: 1.51; CI: 1.13 - 2.00)

(2) „observed pesticide spray drift reaching the home' (OR: 1.33; CI: 1.00 - 1.76) and „reported pesticide smell in the home' (OR: 1.39; CI: 1.04 - 1.86).

Farm workers were significantly more aggressive if they consumed alcohol (as indicated by the CAGE score) and if they owned or had access to less than 4 household items (low socio economic status).

After adjusting for all the potential covariates using agricultural years worked as proxy for cumulative exposure, the CAGE score (OR: 1.29; 95% CI: 1.11 - 1.50) and a low socio economic status (OR: 1.45; 95% CI: 1.03 - 2.06) remained significant predictors of aggression for farm workers working on wine and table grape farms in the Western Cape, in 2002 (Table 4.26b)

Table 4.26c shows that in the sequential models, after adjusting for all potential covariates, the only exposure variable positively associated with aggression was „reported pesticide smell in the home' (OR: 1.41; 95% CI: 1.00 - 2.00),

Table 4.26c shows that, even after including the exposure variable „ever a tractor driver', and then the exposure variable „currently doing one or more spraying activity (last two rows of Table 4.26c), in the adjustment for potential covariates, the positive association between aggression and the environmental exposure variable „smelled pesticides in the home' remained essentially unchanged (OR: 1.43; 95% CI: 1.01 - 2.03 and OR: 1.42; 95% CI: 1.00 - 2.01, respectively).

The exposure variable „years worked as a tractor driver' was also significantly associated with aggression (OR: 0.23; 95% CI: 0.15 - 0.60), but this was an inverse association.

Table 4.26a Unadjusted Bivariate Results

Potential Covariates & Exposure Factors associated with Aggression

Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Potential Covariates				
Gender (Male =1, Female =0)	817	0.78	0.59 – 1.04	0.088
Age (> 33 = 1, ≤ 33 = 0)	808	**0.66**	**0.50 – 0.87**	**0.003**
Farm type (Table grapes = 1, Wine grapes = 0)	817	0.93	0.67 – 1.30	0.677
C.A.G.E. Score	692	**1.24**	**1.08 – 1.42**	**0.002**
Psychiatric Ilness (Yes =1, No =0)	817	1.05	0.67 – 1.65	0.840
PPE (≤ 1 = 1, ≥ 2 = 0)	817	1.30	0.94 – 1.80	0.111
Low SES (< 4 = 1, ≥ 4 = 0)	817	**1.51**	**1.13 – 2.00**	**0.005**
Previous pesticide poisoning (Yes = 1, No = 0)	759	1.08	0.72 – 1 62	0.706
Exposure variables				
Agricultural years worked (> 11 = 1, ≤ 11 = 0)	796	**0.64**	**0.48 – 0 85**	**0.002**
Years worked as tractor driver (> 13 = 1, ≤ 13 = 0)	227	**0.50**	**0.29 – 0.84**	**0.010**
Years worked as a head sprayer (> 13 = 1, ≤ 13 = 0)	138	0.74	0.38 – 1.46	0.387
A spray person at some time during their working life (Yes = 1; No = 0)	817	0.91	0.63 – 1.31	0.611
Current spray person (Yes = 1; No =0)	817	0.98	0.67 – 1.44	0.933
Currently working in vineyard while spraying taking place (Yes = 1; No = 0)	817	1.15	0.84 – 1.58	0.376
Currently doing one or more spraying activities (Yes = 1; No = 0)	817	0.88	0.67 – 1.17	0.388
Observed pesticide spray drift reaching the home (Yes = 1; No = 0)	794	**1.33**	**1.00 – 1.76**	**0.051**
Reported pesticide smell in the home	808	**1.39**	**1.04 – 1.86**	**0.025**
Cholinesterase Levels (quartiles):				
o > 36.3 U/g	189	1.00		
o ≤ 28.9 U/g	195	0.76	0.51 – 1.14	0.188
o > 28.9 U/g and ≤ 32.6 U/g	198	0.82	0.55 – 1.23	0.337
o > 32.6 and ≤ 36.3	196	0.89	0.60 – 1.33	0.573

Table 4.26b Adjusted Multivariate Results

Aggression associated with Cumulative years worked in Agriculture (Occupational Exposure), adjusted for all Potential Covariates (N=609)

Exposure variable	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	0.70	0.46 – 1.08	0.109
<u>Potential Covariates</u>			
Gender [Male =1 (n = 387); Female =0 (n = 222)]	0.85	0.59 – 1.22	0.384
Age [> 33 = 1 (n = 314); ≤ 33 = 0 (n = 295)]	0.83	0.54 – 1.28	0.408
Farm type [Table grapes = 1 (n = 474); Wine grapes = 0 (n = 135)]	1.00	0.66 – 1.51	0.983
C.A.G.E. Score	**1.29**	**1.11 – 1.50**	**0.001**
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 556)]	1.20	0.67 – 2.15	0.547
PPE [≤ 1 = 1 (n = 139); ≥ 2 = 0 (n = 470)]	1.20	0.80 – 1.80	0.388
Low SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 372)]	**1.45**	**1.03 – 2.06**	**0.034**
Previous pesticide poisoning [Yes = 1 (n = 93; No = 0 (n = 516)]	1.14	0.72 – 1.80	0.580
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 156)	1.00		
○ ≤ 28.9 U/g (n = 140)	0.72	0.44 – 1.17	0.182
○ > 28.9 U/g and ≤ 32.6 U/g (n = 158)	0.97	0.61 – 1.55	0.901
○ > 32.6 U/g and ≤ 36.3 U/g (n = 155)	1.01	0.64 – 1.60	0.959

Table 4.26c Adjusted Multivariate Results

Summary Table: Associations of Aggression scores & nine different Exposure Variables adjusted for a common list of potential covariates; ORs derived from sequential models using each exposure variable in turn (models from which these OR's are drawn are presented in full in Appendix C, Table C7)

Exposure Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	609	0.70	0.46 – 1.08	0.109
Years worked as tractor driver * [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	174	**0.23**	**0.15 – 0.60**	**0.001**
Years worked as a head sprayer * [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	110	0.71	0.31 – 1.66	0.430
A spray person at some time during their working life ** [Yes = 1 (n = 109); No = 0 (n = 510)]	619	1.06	0.69 – 1.68	0.736
Current spray person ** [Yes = 1 (n = 98); No = 0 (n = 521)]	619	1.25	0.79 – 1.98	0.343
Currently working in vineyard while spraying taking place [Yes = 1 (n = 457); No =0 (n = 162)]	619	1.14	0.79 – 1.66	0.482
Currently doing one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 235)]	619	0.89	0.61 – 1.31	0.545
Observed spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	599	1.22	0.86 – 1.71	0.264
Reported pesticide smell in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	612	**1.41** **1.43 #** **1.42 ##**	**1.00 – 2.00** **1.01 – 2.03** **1.00 – 2.01**	**0.053** **0.045** **0.051**

* Not adjusted for age and gender because only 5 female workers had ever been a tractor driver and 1 a head sprayer. Age was also significantly correlated with „years worked as a tractor driver' and years worked as a head sprayer' (Table C1)
** Not adjusted for gender as there was only one female head sprayer
# Adjusted for all potential covariates and exposure variable „ever a tractor driver'
Adjusted for all potential covariates and „currently doing one or more spraying activity'

4.7.7 The Barratt Impulsiveness Scale (BIS – 11)

In the unadjusted model (Table 4.27a), it was found that low protective clothing (≤1 PPE) (OR: 1.69; CI: 1.22 – 2.34) and low socio economic status (OR: 1.82; CI: 1.36-2.42) were significant predictors of impulsivity, indicating that farm workers who received one or no item(s) of personal protective clothing and had access to less than 4 household items, were significantly more impulsive than workers who received more personal protective clothing or possessed more than 4 household items.

Also, in the unadjusted model, inverse associations were found between impulsivity and „age greater than 33 years' (OR: 0.72; CI: 0.55 – 0.95); farm type (OR: 0.58; CI: 0.41 – 0.81) and cumulative exposure by having worked more than 11 years in agriculture (OR: 0.58; CI: 0.44 – 0.77). Therefore workers who worked on table grape farms were less impulsive than those who worked on wine grape farms, and the longer they worked in the agricultural sector the less impulsive workers were likely to be (Table 4.27a).

After adjusting for all the potential covariates using agricultural years worked as a proxy for cumulative exposure, low socio economic status (< 4 household items) remained a significant predictor of impulsivity for farm workers on wine and table grape farms in the Western Cape (OR: 1.48; CI: 1.04 - 2.09) (Table 4.27b). Farm workers who had worked for more than 11 years in agriculture were significantly less impulsive than those who had worked for less than 33 years (OR: 0.54; CI: 0.35 – 0.83) (Table 4.27b), a finding which was made even when age was adjusted for, as age was one of the potential covariates included in the modelling.

Table 4.27c shows that in the sequential models, after adjusting for all potential covariates, the only exposure variable significantly associated with impulsivity was „agricultural years worked' (OR: 0.54; CI: 0.35 - 0.83), but this was an inverse association.

Table 4.27a Unadjusted Bivariate Results

Potential Covariates & Exposure Factors associated with Impulsivity

Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Potential Covariates				
Gender (Male =1, Female =0)	817	0.85	0.65 – 1.13	0.267
Age (> 33 = 1, ≤ 33 = 0)	808	**0.72**	**0.55 – 0.95**	**0.021**
Farm type (Table grapes = 1, Wine grapes = 0)	817	**0.58**	**0.41 – 0.81**	**0.001**
C.A.G.E. Score	692	0.99	0.86 – 1.13	0.848
Psychiatric Ilness (Yes =1, No =0)	817	1.12	0.71 – 1.76	0.631
PPE (≤ 1 = 1, ≥ 2 = 0)	817	**1.69**	**1.22 – 2.34**	**0.002**
Low SES (< 4 = 1, ≥ 4 = 0)	817	**1.82**	**1.36 – 2.42**	**0.000**
Previous pesticide poisoning (Yes = 1, No = 0)	759	0.90	0.60 – 1.35	0.614
Exposure Variables				
Agricultural years worked (> 11 = 1, ≤ 11 = 0)	796	**0.58**	**0.44 – 0.77**	**0.000**
Years worked as tractor driver (> 13 = 1, ≤ 13 = 0)	227	0.62	0.36 – 1.04	0.071
Years worked as a head sprayer (> 13 = 1, ≤ 13 = 0)	138	0.83	0.42 – 1.63	0.586
A spray person at some time during their working life (Yes = 1; No = 0)	817	0.74	0.51 – 1.08	0.118
Current spray person (Yes = 1; No =0)	817	0.73	0.50 – 1.08	0.115
Currently working in vineyard while spraying taking place (Yes = 1; No = 0)	817	0.93	0.68 – 1.27	0.633
Currently doing one or more spraying activities (Yes = 1; No = 0)	817	0.85	0.65 – 1.13	0.262
Observed pesticide spray drift reaching the home (Yes = 1; No = 0)	794	0.86	0.65 – 1.15	0.308
Reported smell of pesticides in home	808	0.90	0.68 – 1.20	0.476
Cholinesterase Levels (quartiles):	778			
○ > 36.3 U/g	189	1.00		
○ ≤ 28.9 U/g	195	0.85	0.57 – 1.27	0.419
○ > 28.9 U/g and ≤ 32.6 U/g	198	0.74	0.50 – 1.11	0.147
○ > 32.6 and ≤ 36.3	196	0.97	0.65 – 1.45	0.876

Table 4.27b Adjusted Multivariate Results

Impulsivity associated with Cumulative years worked in Agriculture (Occupational Exposure), adjusted for all Potential Covariates (N = 609)

Exposure Variable	Prevalence Odds Ratio	Confidence Interval	p – value
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	**0.54**	**0.35 – 0.83**	**0.005**
<u>Potential Covariates</u>			
Gender [Male =1 (n = 387); Female =0 (n = 222)]	1.01	0.71 – 1.46	0.941
Age [> 33 = 1 (n = 314); ≤ 33 = 0 (n = 295)]	1.12	0.72 – 1.73	0.609
Farm type [Table grapes =1 (n =474); Wine grapes =0 (n =135)]	0.72	0.48 – 1.09	0.123
C.A.G.E. Score	1.04	0.90 – 1.21	0.606
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n =556)]	1.60	0.89 – 2.90	0.118
PPE [≤ 1 = 1 (n = 139); ≥ 2 = 0 (n = 470)]	1.35	0.90 – 2.02	0.150
Low SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 372)]	**1.48**	**1.04 – 2.09**	**0.027**
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 516)]	0.87	0.55 – 1.39	0.565
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 156)	1.00		
○ ≤ 28.9 U/g (n = 140)	0.73	0.45 – 1.19	0.204
○ > 28.9 U/g and ≤ 32.6 U/g (n = 158)	0.73	0.46 – 1.18	0.196
○ > 32.6 U/g and ≤ 36.3 U/g (n = 155)	0.96	0.61 – 1.53	0.871

Table 4.27c Adjusted Multivariate Results

Summary Table: Associations of Impulsivity scores & nine different Exposure Variables adjusted for a common list of potential covariates; ORs derived from sequential models using each exposure variable in turn (models from which these OR's are drawn are presented in full in Appendix C, Table C8)

Exposure Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 293)]	609	**0.54**	**0.35 – 0.83**	**0.005**
Years worked as tractor driver * [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	174	0.57	0.29 – 1.11	0.098
Years worked as a head sprayer * [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	110	0.68	0.29 – 1.59	0.376
A spray person at some time during their working life ** [Yes = 1 (n = 109); No = 0 (n = 510)]	619	1.02	0.65 – 1.59	0.940
Current spray person ** [Yes = 1 (n = 98); No = 0 (n = 521)]	619	1.01	0.64 – 1.61	0.954
Currently working in vineyard while spraying taking place [Yes = 1 (n = 457); No =0 (n = 162)]	619	0.85	0.59 – 1.23	0.391
Currently doing one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 235)]	619	0.77	0.53 – 1.14	0.191
Observed spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	599	0.75	0.53 – 1.05	0.095
Reported pesticide smell in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	612	0.95	0.67 – 1.34	0.759

* Not adjusted for age and gender because only 5 female workers had ever been a tractor driver and 1 had ever been a head sprayer. Age was also significantly correlated with „years worked as a tractor driver' and years worked as a head sprayer' (Table C1)
** Not adjusted for gender as there was only one female head spraye

4.7.8 Scale for Suicide Ideation (SSI)

In the unadjusted logistic regression model (Table 4.28a), significant associations were found between the following occupational exposure tasks and suicide ideation:

- Cumulative years of working in an agricultural environment (> 11 years) (OR: 0.63; CI: 0.47 – 0.85)
- Current exposure by doing one or more pesticide spraying tasks (OR: 0.73; CI: 0.55 – 0.96)

Significant associations were also found between suicide ideation and the following potential covariates:

- Age greater than 33 years (OR: 0.72; CI: 0.54 – 0.96)
- Farm type – table grapes (OR: 0.46; CI: 0.33 – 0.65)

However, the above were all inverse associations.

After adjusting for all the potential covariates using agricultural years worked as a proxy for cumulative exposure, it was found that farm workers, working on table grape farms at the time of the interview, were 41% less likely to be suicidal than those working on wine grapes (OR: 0.59; CI: 0.39 – 0.90) (Table 4.28b).

Table 4.28c shows that in the sequential models, after adjusting for all potential covariates, none of the exposure variables were significantly associated with suicide ideation

Table 4.28a Unadjusted Bivariate Results

Potential Covariates & Exposure Factors associated with Suicide Ideation

Variables	N	Prevalence Odds Ratio	Confidence Interval	p – value
Potential Covariates				
Gender (Male =1, Female =0)	816	0.85	0.64 – 1.15	0.293
Age (> 33 = 1, ≤ 33 = 0)	807	**0.72**	**0.54 – 0.96**	**0.026**
Farm type (Table grapes = 1, Wine grapes = 0)	816	**0.46**	**0.33 – 0.65**	**0.000**
C.A.G.E. Score	691	0.95	0.83 – 1.10	0.512
Psychiatric Ilness (Yes =1, No =0)	816	1.11	0.69 – 1.79	0.656
PPE (≤ 1 = 1, ≥ 2 = 0)	816	1.36	0.98 – 1.91	0.069
Low SES (< 4 = 1, ≥ 4 = 0)	816	1.33	0.99 – 1.80	0.057
Previous pesticide poisoning (Yes = 1, No = 0)	758	0.80	0.51 – 1.24	0.316
Exposure Variables				
Agricultural years worked (> 11 = 1, ≤ 11 = 0)	795	**0.63**	**0.47 – 0.85**	**0.003**
Years worked as tractor driver (> 13 = 1, ≤ 13 = 0)	227	0.58	0.33 – 1.04	0.066
Years worked as a head sprayer (> 13 = 1, ≤ 13 = 0)	138	0.92	0.45 – 1.86	0.810
A spray person at some time during their working life (Yes = 1; No = 0)	816	0.97	0.66 – 1.43	0.868
Current spray person (Yes = 1; No =0)	816	0.94	0.63 – 1.41	0.769
Currently working in vineyard while spraying taking place (Yes = 1; No = 0)	816	0.87	0.62 – 1.20	0.392
Currently doing one or more spraying activities (Yes = 1; No = 0)	816	**0.73**	**0.55 – 0.98**	**0.037**
Observed pesticide spray drift reaching the home (Yes = 1; No = 0)	793	0.99	0.73 – 1.33	0.942
Reported smell of pesticides in home	807	1.00	0.73 – 1.35	0.973
Cholinesterase Levels (quartiles):	777			
o > 36.3 U/g	189	1.00		
o ≤ 28.9 U/g	195	0.93	0.61 – 1.42	0.745
o > 28.9 U/g and ≤ 32.6 U/g	198	0.91	0.60 – 1.39	0.911
o > 32.6 and ≤ 36.3	195	0.98	0.64 – 1.49	0.910

Table 4.28b Adjusted Multivariate Results

Suicide Ideation associated with Cumulative years worked in Agriculture (Occupational Exposure), adjusted for all Potential Covariates (N = 608)

Exposure variable		Prevalence Odds Ratio	Confidence Interval	p – value
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 292)]		0.72	0.46 – 1.14	0.162
<u>Potential Covariates</u>				
Gender [Male =1 (n = 387); Female =0 (n = 221)]		1.00	0.69 – 1.47	0.985
Age [> 33 = 1 (n = 313); ≤ 33 = 0 (n = 295)]		0.88	0.56 – 1.39	0.587
Farm type [Table grapes = 1 (n = 473); Wine grapes = 0 (n = 135)]		**0.59**	**0.39 – 0.90**	**0.015**
C.A.G.E. Score		1.01	0.86 – 1.18	0.897
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 555)]		1.09	0.58 – 2.03	0.793
PPE [≤ 1 = 1 (n = 139); ≥ 2 = 0 (n = 469)]		0.95	0.62 – 1.45	0.815
Low SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 371)]		1.05	0.73 – 1.51	0.791
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 515)]		0.78	0.47 – 1.28	0.320
Cholinesterase Levels (quartiles):				
○ > 36.3 U/g	(n = 156)	1.00		
○ ≤ 28.9 U/g	(n = 140)	0.82	0.49 – 1.36	0.429
○ > 28.9 U/g and ≤ 32.6 U/g	(n = 158)	0.91	0.56 – 1.50	0.719
○ > 32.6 U/g and ≤ 36.3 U/g	(n = 154)	0.92	0.57 – 1.49	0.727

Table 4.28c Adjusted Multivariate Results

Summary Table: Associations of Suicide Ideation scores & nine different Exposure Variables adjusted for a common list of potential covariates; ORs derived from sequential models using each exposure variable in turn (models from which these OR's are drawn are presented in full in Appendix C, Table C9)

Exposure Variables	**N**	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 292)]	608	0.72	0.46 – 1.14	0.162
Years worked as tractor driver * [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	174	0.52	0.26 – 1.04	0.065
Years worked as a head sprayer * [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	110	0.75	0.32 – 1.78	0.502
A spray person at some time during their working life ** [Yes = 1 (n = 109); No = 0 (n = 509)]	807	1.54	0.97 – 2.44	0.066
Current spray person ** [Yes = 1 (n = 98); No = 0 (n = 520)]	618	1.53	0.95 – 2.47	0.079
Currently working in vineyard while spraying taking place [Yes = 1 (n = 457); No =0 (n = 161)]	807	0.75	0.51 – 1.11	0.151
Currently doing one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 234)]	618	0.68	0.46 – 1.01	0.058
Observed spray drift reaching the home [Yes = 1 (n = 351); No = 0 (n = 247)]	598	0.94	0.66 – 1.35	0.748
Reported pesticide smell in the home [Yes = 1 (n = 395); No = 0 (n = 216)]	611	1.14	0.79 – 1.65	0.483

* Not adjusted for age and gender because only 5 female workers had ever been a tractor driver and 1 had ever been a head sprayer. Age was also significantly correlated with „years worked as a tractor driver' and years worked as a head sprayer' (Table C1)

** Not adjusted for gender as there was only one female head sprayer

4.7.9 *Summary of Adjusted Multivariate Results*

In summary Table 4.29 shows the associations of all 8 neuropsychiatric outcomes adjusted for all the potential covariates using agricultural years worked as a proxy for cumulative exposure. The significant findings were:

- Age older than 33 years was a predictor for depression (BDI) and general distress (BSI GSI)

- The CAGE score was a predictor for aggression

- Psychiatric illness was a predictor for psychiatric disorders (GHQ), general distress (BSI GSI) and depression (GHQ Depression Subscale, BDI, BSI Depression Symptom Dimension)

- Low SES was a predictor for psychiatric disorders (GHQ); general distress (BSI GSI); depression (GHQ Depression Subscale, BSI Depression Symptom Dimension); aggression and impulsivity

- Past pesticide poisoning was a predictor for psychiatric disorders (GHQ) and depression (GHQ Depression Subscale)

- Farm workers on table grape farms reported less symptoms of depression than the wine grape workers (GHQ Depression Subscale, BDI, BSI Depression Symptom Dimension).

Table 4.29 Adjusted Multivariate Results

Comment [LL1]:

Summary Table: Associations of all 8 Neuropsychiatric Outcomes with Cumulative years worked in Agriculture (Occupational Exposure), adjusted for a common list of potential covariates: OR's only (N = 609)

Variables	**GHQ Total Score**	**GHQ Depression**	**BDI-IA**	**BSI GSI**	**BSI Depression**	**Aggression**	**BIS-II**	**SSI**
Agricultural years worked [> 11 = 1 (n = 316); ≤ 11 = 0 (n = 292)]	1.13	0.86	0.86	0.82	0.86	0.70	**0.54 p = 0.01**	0.72
Gender [Male =1 (n = 387); Female =0 (n = 221)]	0.82	**0.64 p = 0.02**	0.77	1.17	**1.78 p = 0.01**	0.85	1.01	1.00
Age [> 33 = 1 (n = 313); ≤ 33 = 0 (n = 295)]	1.52	1.16	**2.41 p = 0.02**	**1.72 p = 0.03**	1.25	0.83	1.12	0.88
Farm type [Table grapes = 1 (n = 473); Wine grapes = 0 (n = 135)]	0.67	**0.39 p = 0.00**	**0.22 p = 0.00**	0.70	**0.51 p = 0.00**	1.00	0.72	**0.59 p = 0.02**
C.A.G.E. Score	0.99	0.90	1.01	1.11	1.10	**1.29 p = 0.00**	1.04	1.01
Psychiatric Ilness [Yes =1 (n = 53); [No =0 (n = 555)	**4.83 p = 0.00**	**2.90 p = 0.00**	**6.02 p = 0.00**	**3.55 p = 0.00**	**2.36 p = 0.01**	1.20	1.60	1.09
PPE [≤ 1 = 1 (n = 139); ≥ 2 = 0 (n = 469)]	1.01	1.13	**1.84 p = 0.05**	1.05	0.98	1.20	1.35	0.95
Low SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 371)]	**1.62 p = 0.05**	**1.53 p = 0.03**	1.68	**1.79 p = 0.00**	**1.90 p = 0.00**	**1.45 p = 0.03**	**1.48 p = 0.03**	1.05
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 515)]	**2.17 p = 0.01**	**1.62 p = 0.05**	1.67	1.46	1.30	1.14	0.87	0.78
Cholinesterase Levels (quartiles): * > 36.3 U/g ≤ 28.9 U/g > 28.9 and ≤ 32.6 U/g > 32.6 and ≤ 36.3 U/g	 1.00 1.07 1.39 0.88	 1.00 1.01 1.27 0.78	 1.00 1.29 1.18 0.51	 1.00 0.83 1.54 1.57	 1.00 1.07 1.41 1.09	 1.00 0.72 0.97 1.01	 1.00 0.73 0.73 0.96	 1.00 0.82 0.91 0.92

* (n) same as (n) for cholesterol levels (quartiles) in Tables 21b to 28b.
Statistically significant associations are in bold font

CHAPTER 5

DISCUSSION

Organophosphate pesticides (OP's) and their neurotoxic effects have, for decades, been the subject of clinical, ecological and epidemiological studies world-wide. These studies have reported on a range of acute and chronic neurological effects on farm workers' mental and physical health and function following OP exposure. Yet the provision of an optimal hazard-controlled working and living environment for farm workers remains an ongoing challenge.

The aim of this study was to investigate whether long-term exposure to organophosphate pesticides (OP's) was associated with psychological factors or conditions that predispose to suicide, specifically depression, amongst farm workers on grape farms in the Western Cape Province of South Africa.

The findings of the study will be discussed in the following sections :

5.1 discusses the current levels depression, impulsiveness and suicidal ideation for farm workers on wine and table grape farms

5.2 discusses the association between cumulative and recent occupational exposure to OP's and the neuropsychiatric outcomes, for all categories of farm workers

5.3 discusses the association between past pesticide poisoning, as measure of occupational exposure, and the neuropsychiatric outcomes

5.4 discusses the association between environmental exposure and the neuropsychiatric outcomes

5.5 discusses the association between the potential covariates (psychiatric illness, socioeconomic status, age, personal protective clothing and alcohol consumption) and the neuropsychiatric outcomes

5.6 discusses the gendered nature of pesticide exposure

5.7 discusses the validity of the measurements used in the study

5.8 discusses the limitations of the study

5.9 gives a summary of the study findings

5.1 Current Levels of Neuropsychiatric Outcomes of Farm Workers

In this study, female farm workers reported significantly higher levels of depression and suicidal ideation than male workers ($p < 0.01$), which is not surprising since the lifetime prevalence of depression is usually twofold higher for women than for men with the peak prevalence for women occurring between 35 and 45 years of age (Winokur 1979; Klerman 1980; Grimsrud et al 2009), and the mean age for women in this study was 33 (SD 8.4) years. Additionally, depression, especially in women, is common in developing countries (Patel et al 2001; Mkize et al, 1998). Moreover, it has been suggested by Studemire et al (1986) that depression was causally related to 60% of suicides and Goldney et al (2000) found that 46.9% of suicidal ideation was associated with clinical depression, placing female farm workers with elevated levels of depression in this study, in a high risk category for suicide.

Furthermore, the study also found that more female workers (13 females versus 7 males, $p = 0.03$) reported higher levels of suicidal ideation, including informing someone of their intention to commit suicide, in the 12 months prior to them being interviewed. This finding is consistent with a South African study (Joe et al, 2008), which found that the risk for attempted suicide was highest amongst Coloured females in the age group of 18 – 34 years with a lower level of education as the study population for the current study included Coloured females with a low education as well . Other research (Ajdacic-Gross et al, 2008) found that females had a tendency to attempt suicide more often than males (even though mortality from suicide was higher in males), which corresponds with the elevated levels of suicidal ideation found in female farm workers in this study. Additionally, a recent study conducted in China found that suicidal ideation was significantly associated with females and occurred more commonly in two rural areas in China (Zhang et al, 2009).

This study also found that female farm workers were significantly more impulsive than males ($p = 0.01$) in the „Nonplanning Impulsiveness' subfactor of the BIS-IA, which is consistent with the higher levels of suicidal ideation found in female farm workers. This finding is supported by a study of rural Chinese women who had attempted suicide and reported that the suicidal act had been contemplated for less than 2 hours before the attempt was made (Gunnell & Eddlestone, 2003; Bertolote et al, 2006; Mudie, 2006). The link between impulsivity, depression and suicidality is also supported by a study carried out by Swann et al (2008), who found that nonplanning impulsivity correlated with depression scores in subjects who had no history of substance abuse disorder, and among the depressive symptoms, suicidality correlated most strongly with the Barrat Impulsiveness Scale (BIS) scores.

In addition to the compounding influence that all these aforementioned factors may have contributed to the increased levels of depression in female workers, this study also found that female workers (who were predominantly vineyard maintenance workers) received significantly less PPE than males ($p < 0.01$). In fact, 78% of male „never sprayers' compared to 57% of female „never sprayers' (1.4:1) received 2 or more items of PPE. It has been speculated elsewhere that being provided with more items of PPE may be associated with a lower risk of pesticide exposure, particularly since PPE appears to have had a protective effect for tractor drivers and spray operators (Meijster et al, n.d.; London et al, 1998; van Wendel de Joode et al, 2004; Coronado et al, 2004; Dalvie et al, in press). This speculation on the protective effects of PPE finds credence in this study in the finding that after controlling for all potential covariates, and using more than eleven years worked in agriculture as a measure of cumulative exposure, workers who received one or no items of PPE were more likely to have higher levels of depression according to the BDI (OR: 1.84; 95% CI: 1.01-3.37) compared to those who received two or more PPE items. However, reverse causation should also be considered where depressed workers may have been provided with the PPE, but not reported it to the interviewers. Alternatively, workers who were less depressed may have been more aware of their health and safety and insisted on receiving more items of PPE.

When comparing the two groups of workers, farm workers on wine grape farms were significantly more depressed, impulsive and had more suicidal ideation ($p < 0.01$) than table grape workers, which may be an indication that table grape farms are significantly different in socio-economic profile and work organisation (see Table 4.29, page 224). Evidence of this is present in the fact that workers on table grape farms were provided with significantly more items of PPE than wine grape workers (3:2; $p < 0.01$) and had a higher socio-economic status, as judged by the median number of household items (4:3; $p < 0.01$), both of which were associated with a reduced likelihood of developing depression (see Table 4.29) (Matthews et al, 2000; Patton et al, 1995; Davies, 1995; Felsten and Hill, 1999; Oquendo & Mann, 2000).

.Even though the multivariate models of analysis adjusted for these covariates, there may still have been residual confounding present because of aspects which differed between table and wine grape farms which were not adequately captured by SES and increased PPE.

In particular, table grape workers may have been protected from the impact of risks for depression, since the table grape farming industry was already part of the export market in 2002 and farm owners and managers were obliged to comply with the requirements of [7]EurepGap concerning the welfare of their workers. In the multivariate model, after controlling for all the potential covariates, inverse associations were found between all the depression outcomes and work on a table grape farm (OR of the order of 0.2 to 0.5) and suicidal ideation and table grape farms (OR: 0.6). Thus at the time of the cross-sectional survey, for neuropsychological health, it appeared to be more advantageous to be employed on table grape farms.

The validity of the measurements used to assess the levels of neuropsychiatric outcomes of farm workers in this study coincides with the findings of other research studies, as discussed later in section 5.7 of this chapter.

5.2 Occupational Exposure – Outcome Relationships

In this study, no evidence was found for a positive association between long-term (cumulative) years of working in agriculture (a measure of cumulative OP exposure) and depression, psychiatric disorders, aggression, impulsivity, suicidal

[7] EUREPGAP is a set of global standards and procedures, developed by the Certification of Environmental Standards 2009 (CERES). Co-operatives and farms supplying the different supermarkets in Europe, the United Kingdom and USA, are required to be certified and compliant with EUREPGAP.

ideation and general distress (encompassing physical, physiological and psychological distress).

The amount of years that participants had worked in agriculture was broad and ranged from 3 months to 53 years (median 11 years). In this study, a participant's cumulative years of exposure was categorized into high and low using a cut-off of more than 11 years (> 11 versus ≤ 11 years) in an agricultural environment. The extent of participants' cumulative OP exposure was therefore dependent on their work history and the type(s) of job(s) they had occupied in agriculture. In this study, 396 (48.5%) of the study population had worked for >11 years in agriculture.

Farm workers regarded as having high exposure to pesticides were tractor drivers, spray operators (head, handgun and backpack sprayers) and workers responsible for the mixing and distribution of pesticides (London, 1994; London & Myers, 1998; Dalvie et al, 1999; Environmental Justice Foundation, 2003; Smit et al, 2003; Coronado et al, 2004; El Batawi, 2004; Meijster et al, n.d.), while general farm work was regarded as having minimal or no pesticide exposure. Besides duration of work in agriculture, cumulative exposure was also measured by duration of work as a tractor driver and / or head (lead) sprayer using 13 years as cut-off (≤ 13 versus > 13 years). Of the 227 (28%) workers who had ever been a tractor driver, 113 (49.8%) had worked for > 13 years, and of the 138 (17%) workers who had ever been a head (lead) sprayer, 68 (49.3%) had worked for > 13 years. This meant that for cumulative years worked in agriculture, there was a considerable gradient of exposure, whereas amongst those in high risk jobs, there tended to be a concentration of workers in the high end of the exposure spectrum.

The cross-sectional design of the study may have allowed for the participation of only healthy workers in the study, which implies the possibility of selection bias as it can be speculated that the workers available for participation in the study were those who had avoided any form of work-related illness and were therefore still in the employment of the individual farmers, whereas those workers who had suffered illness due to exposure may either have stopped working or been dismissed by their employers before the study commenced (a component of the Healthy Worker Effect). The large numbers of tractor drivers and head sprayers with long cumulative exposure (> 13 years) is consistent with a Healthy Worker

Effect and could account for a failure to demonstrate an association between cumulative years of pesticide exposure and the neuropsychiatric outcomes

Another factor that may have played a role in the overall finding of no association between cumulative OP exposure and the neuropsychiatric outcomes are the nature of cumulative exposure metrics used (job history recall and frequency of spraying tasks were the main sources of past exposure information), which may have affected the reliabitity and validity of the data obtained (Miligi et al, 1993), resulting in misclassification of exposure. According to Kromhout and Vermeulen (n.d.), the dependence on workers' ability to recall their job histories as a method of collecting occupational information, may be prone to recall bias. It has also been suggested that long-term exposure to OP's can itself result in difficulties with memory and concentration (Savage et al, 1988; Gerchon & Shaw, 1961, cited by Rosenstock et al, 1991; Sereda & Gromov, 1994, cited by Gomes et al, 1998). In this study, approximately 3% of the study population could not recall their age on starting their first job or the number of years they had spent in that job, resulting in the number of years worked in agriculture being calculated for 796 (97%) participants. Additionally, some workers had changed jobs quite frequently during their working life (eight workers were already employed in their seventh job at the time of the cross-sectional survey). Hence, taking cognisance of all these factors, it can be speculated that the accuracy and reliability of some workers' recall of their spraying activities in their various jobs may have been questionable. It can also be speculated that the 74% workers who reported having an alcohol problem (by reporting two or more positive responses on the CAGE questionnaire), may also have experienced problems with job history recall, since alcohol abuse is known to play a causal role in neurological symptoms (London et al, 2006), brain damage and memory loss (Anonymous, 2004).

The initial intent to use the DREAM method (van Wendel de Joode et al, 2004) to measure potential and actual pesticide exposure from the data on „frequency of exposure by days, weeks and months per job' was abandoned because of the limitations to the data obtained during the interviewing process. Hence, we resorted to the analysis of the cumulative and current exposure measurements for this study based on worker recall. An association between exposure to pesticides and the neuropsychiatric outcomes may have been identified if a better quality of data with less misclassification of exposure had been obtained. The cross-sectional design of the study also did not allow for any missing data to be revisited and re-collected.

In this study, bivariate analyses found the following associations between cumulative factors of exposure and adverse neuropsychiatric outcomes

Workers who reported cumulative years (> 11 years) of working in an agricultural sector were more likely to have decreased levels of aggression (Spearman r = -0.16), impulsivity (Spearman r = -0.15) and suicidal ideation (Spearman r = -0.13).

Farm workers who had cumulative years (≥ 13 years) of working as a tractor driver were more likely to have decreased levels of aggression (Spearman r = -0.20) and impulsivity (Spearman r = -0.20)

Farm workers who had cumulative years (≥ 13 years) of working as a head sprayer were more likely to have increased BSI Depression scores (Spearman r = 0.17, p = 0.05)

However, after controlling for all identified confounders (gender; age; farm type; CAGE[8] score; [9]PPE; [10]SES; psychiatric illness; past pesticide poisoning and cholinesterase levels), many of these associations fell away, e.g. depression and cumulative years working as a head sprayer were confounded by „age'. The only association that remained was the inverse association between cumulative years of working in agriculture and impulsivity in the crude (OR: 0.72) and multivariate (OR = 0.54) models of analysis, suggesting that the longer workers worked on a farm, the less impulsive they were likely to be. It can be speculated that there was a bias in the selection of participants for the study as workers who were impulsive may either have been dismissed from / or left their agricultural jobs prior to our cross-sectional survey, since workers who are impulsive may have a tendency to frequently change jobs or exhibit poor work performance.

After controlling for the relevant confounders in the multivariate model, an inverse association remained between cumulative years of working as a tractor

[8] CAGE: A screening test for alcohol use. A score ≥ 2 indicated that the participant was a possible problem drinker
[9] PPE: Amount of protective clothing received in current job. Range: 0 to 6 items.
[10] SES: Socio economic status represented by the amount of household items and having a bath / shower in the vicinity of the home. Range: 0 to 7 items

driver (> 13 years) and aggression in the crude (OR: 0.50) and adjusted (OR = 0.23) models of analysis, suggesting that farm workers who had ever worked as tractor driver, had diminished levels of aggression (score of ≤ 24.0 for the 12-item Aggression Questionnaire).

Workers with long-term exposure (cumulative years worked in agriculture and ever worked as a tractor driver) appeared to have lowered impulsivity (BIS-II score ≤ 55.0 and lowered aggression (AQ score ≤ 24.0), suggesting that these outcomes may pattern in similar directions in relation to exposure. Additionally, significant correlations were found between the neuropsychiatric instruments measuring impulsivity and aggression (Spearman r = 0.4; p < 0.01) (chapter 3, Table 3.5). The possible link between impulsivity and aggression is discussed by Houston and Stanford (2005) who found that impulsivity plays an important role in the expression of specific types of aggression, and a positive association was found between hostile aggression, anger, hostility and impulsiveness (Ramírez & Andreu, 2006). Hence it can be speculated that if farm workers were less impulsive the longer they worked in agriculture, then they were likely to be less aggressive the longer they worked in agriculture. Similarly, if tractor drivers were less aggressive the longer they worked on a farm then they were likely to be less impulsive the longer they worked on a farm. Moreover, the same selection effect would apply as aggressive workers would be more likely to suffer workplace dismissal whereas those who are less aggressive would be more likely to be retained.

In this study, recent exposure to pesticides was assessed by the tasks in which participants were currently involved at the time of the cross-sectional survey. It was found that since the participants in this study had both cumulative and recent occupational exposure to pesticides, the task specific exposure variables were significantly correlated, resulting in very similar findings in the different models of analyses where these variables were included.

For example, in this study the following task-specific inter-relationships were found: of the 227 „ever tractor drivers', 213 (94%) were „current tractor drivers' and 138 (61%) were „ever head sprayers'; of the 138 „ever head sprayers', 125 (91%) were „current sprayers' and 131 (95%) were „current tractor drivers'. In addition, those workers who were involved in any category of spraying (e.g.

hand spraying and backpack spraying) in their current jobs were regarded as the „high exposure' group. Moreover, highly significant correlations were found between the variables: „ever head sprayer' and „current sprayer' (Spearman r = 0.94); „ever tractor driver' and „current tractor driver' (Spearman r = 0.96); „ever tractor driver' and „ever head sprayer' (Spearman r = 0.73); „ever head sprayer' and „current tractor driver' (Spearman r = 0.71) and „ever tractor driver' and current head sprayer' (Spearman r = 0.69).

A concerning finding in this study was that 382 (80%) of the 480 workers who performed „high exposure' tasks, reported also working in the vineyards while the spraying of pesticides took place. This could have been due to the requirement for farm workers to perform multiple occupational tasks, which integrate „high' and „low' pesticide exposure (e.g. a spray operator may also do some vineyard maintenance work or harvesting) (Meijster et al n.d).

In the study, no positive association was found between the group executing „high exposure' tasks and any of the neuropsychiatric outcomes, but an inverse association was found between increased psychiatric disorders (high GHQ score) and the task of working in the vineyards during pesticide spraying (OR: 0.61; 95% CI: 0.38-0.98). It could be speculated that this finding could have been due to the protective effect of PPE in this group of workers considering that 63% of the workers who reported working in the vineyards during spraying of pesticides, were also part of the „high exposure' group who were provided with adequate PPE (85% of the „high exposure' group received ≥ 2 items of PPE), but since PPE was included in the multivariate model, this could not explain the finding. However, workers with a high GHQ score may have reported lower pesticide exposure because they could not recall being in the vineyards during spraying as clearly as workers who had a lower GHQ score (reverse causation).

A noteworthy finding is that, of the 480 (58.8%) workers who performed „high exposure' spraying activities, only 96 (2%) were females. The rest of the female workers in this study were therefore involved in non spraying activities.

As with the overall study finding of no association between any of the neuropsychiatric outcomes and cumulative years of occupational exposure, no positive association was found between recent pesticide exposure (measured by being a head sprayer or in the „high exposure' group in their current job, or / and being in the vineyards during spraying in their current job) and depression or any of the other neuropsychiatric outcomes in this study. The similarities in the findings for exposure effects for cumulative and recent exposure in this study, is supported by the findings of Kamel and Hoppin (2004), who found that most studies had participants who had sustained both chronic and acute exposures, but the exposure effects had not been disentangled because of the correlations between the two categories of exposure variables.

It can be further speculated that the lack of an association between cumulative and / or recent pesticide exposure and the neuropsychiatric outcomes could be due to pesticide spray operators and tractor drivers operating at a level of „best practice' and being more advantaged than the unexposed group because of having received training on pesticide handling (Holtman et al, unpublished), thereby highlighting their awareness around issues of safe handling of pesticides, necessity for wearing protective clothing and the maintenance of optimal health and safety practices in the workplace and at home. The health and safety training of farm workers was, however, not explored in this study.

A further explanation could be a different selection bias arising from the healthy worker effect, in that workers who were selected for more skilled tasks like spray operators, were probably workers who appeared to be responsible, had permanent status and were unlikely to demonstrate negative behaviour. Hence, workers who had a tendency to be impulsive, aggressive or demonstrated the symptoms of depression (like listlessness, malaise, fatigue, absenteeism) may have been excluded from more skilled jobs like pesticide handling and spraying. This means that not only were workers with neuropsychological illness selected out of the workforce, but workers were selected into high risk jobs because of a priori good health.

The role of personal protective clothing (PPE) and its supposedly protective effect in modifying exposure in pesticide applicators and handlers (Meijster et al n.d.; London et al 1998; van Wendel de Joode et al 2004; Coronado et al 2004; Dalvie et al, in press) should also be considered. The current study found that 76% of workers received 2 to 6 items of PPE (35% received 2 items) and 34%

received one or no items of PPE. In fact 78 workers (30 (16.8%) on wine grape farms; 48 (7.5%) on table grape farms) received no protective clothing at all. It was further found that of the „high exposure' group, 85% received two (2) or more items of PPE, while only 15% received one or no items of protective clothing, which confirms that workers who performed the pesticide spraying tasks were more likely to be provided with the appropriate PPE. The findings of the current study is similar to the findings of a cross-sectional study conducted by London et al (1998) on deciduous fruit farms in the Ceres / Koue Bokkeveld area of the Western Cape province, South Africa, which identified that 75% of pesticide applicators in the study population used some form of PPE and 22% used the maximum of five items recorded in that study.

However, despite the protective role that PPE might have played in this study, other unmeasured factors like the type of workers selected for more skilled tasks (responsible, stable, not impulsive, permanent workers), could have been more important as a confounder for occupational exposure and neuropsychiatric outcomes in this study.

The time contact with pesticide residues on vine branches and leaves, as a source of low level continuous exposure experienced by the 337 (41%) farm workers (30% males and 70% females) performing general vineyard maintenance tasks, as well as workers re-entering vineyards too soon after spraying, could also account for the increased neuropsychiatric levels amongst non-sprayers. These workers may have been exposed to unknown levels of pesticide residue on vines, as the protective measures of re-entry times into the vineyards (Krieger & Ross 1993) were not measured in this study. This suggestion finds agreement with Meijster et al's (n.d.) observational study conducted in the grape farming area of Worcester, South Africa, which concluded that because little was known about residue levels on vines after spraying, residue levels and re-entry times could be strong predictors of pesticide exposure, but required further investigation. Similarly, Simcox et al (1999), found that re-entry into sprayed orchards could be a cause of continued low levels of pesticide exposure for a substantial period after the actual application. Likewise, in a more recent study Dalvie et al (in press) suggested that increased post-spraying endosulfan levels amongst vineyard maintenance workers could be due to their direct contact with contaminated vines after spraying. This is an aspect of pesticide exposure that requires further investigation.

Furthermore, the vineyard maintenance workers in this study were provided with minimal or no PPE, which may have accentuated their exposure. The lack of PPE for farm maintenance workers was found in another South African study (Dalvie et al, in press) and has also been found to be common in the Yakima Valley of the United States of America (Coronado et al 2004).

An additional assessment of recent pesticide exposure was the measurement of erythrocyte acetyl-cholinesterase (RBC-AChE) levels on 95% (778) of the study participants. This was an opportunistic measurement of cholinesterase levels - for workers on wine grape farms it was close to a baseline measurement, and for table grape workers it was an in-season measurement. The results (mean 33.1 SD 6.0; median 32.6) showed that the level of RBC-AChE activity for most workers was within normal or acceptable levels of ≥ 31.4 U/g, confirming a lack of recent substantial exposure to organophosphates. These findings could be equated to those found in a survey of apple farm workers in the Western Cape, South Africa, where minimal change in serum and erythrocyte cholinesterase levels across the spraying season were found (Barnes, 1999).

Figure 5.1 Tractor driver wearing appropriate PPE while spraying a table grape vineyard

Figure 5.2 Examples of farm workers not wearing PPE appropriate for the task

Hand spraying shrub vines from the back of a tractor

Trimming (suiering) vineyards

5.3 Past Pesticide Poisoning – Outcome Results

In this study, a history of past pesticide poisoning was used as a potential covariate, and as a measurement of past pesticide exposure. It was found that 110 (13.5%) of participants had experienced one or more episodes of past pesticide, which is higher than a study conducted by London et al (1997) in the Western Cape province of South Africa where 8.9% respondents reported past pesticide poisoning in farming jobs, as well as other global studies. In a study of farmers in northeastern Colorado, Stallones and Beseler (2002) found that 9.2% of respondents reported a history of past pesticide poisoning. Similarly, 2 studies conducted on private pesticide applicators in Iowa and North Carolina found that 4% (Kamel et al, 2005) and 6.6% (Beseler et al, 2008) respondents reported past pesticide poisoning, as did 27 female spouses of the private pesticide applicators (Beseler et al, 2006).

In this study, of the 110 participants who reported past pesticide poisoning, 38 workers (8.2% wine grape and 26.4% table grape workers), of which 11 (29%) were females, had been admitted to a hospital for treatment of pesticide poisoning. Of the 37 (34%) female workers who had experienced past pesticide poisoning, 20 had been / currently still were involved in one of the categories of pesticide spraying (13 were current hand sprayers and 3 current back pack sprayers). The rest of the female workers (17) were general vineyard workers.

After controlling for relevant potential confounders, a positive association was found between a history of past pesticide poisoning and depression, as measured by the GHQ Depression subscale (OR: 1.62; 95% CI: 1.00 - 2.63) and with the GHQ total score (OR: 2.17; 95% CI: 1.26 - 3.72), but not for the other measures of depression, viz. the BDI and BSI Depression Symptom Dimension. Thus, moderate associations were found between a history of past pesticide poisoning and depression and psychiatric disorders in farm workers. These findings are consistent with several studies that have found an association between a history of past pesticide poisoning and depression (Stallone et al 2002; Beseler et al 2006; Beseler et al 2008). In fact Beseler et al's study findings (2006) were similar to the findings of this study, in that no association was found between depression and cumulative pesticide exposure, but a strong association was found between past pesticide poisoning and physician-diagnosed depression. These findings are also consistent with several studies that have reported chronic neurological sequelae following acute episodes of pesticide poisoning (Rosenstock et al 1991; Reidy et al 1992; Stallone & Beseler 2002

In this study, there may have been some misclassification of past poisoning. For example, the symptoms of pesticide poisoning were not explored and therefore workers who may have experienced undiagnosed pesticide poisoning may have been excluded from the study. Workers recall of an episode(s) of past pesticide poisoning may have been inhibited by the lack of severity of symptoms experienced by the worker or impaired memory as a sequel to unidentified pesticide poisoning Savage (1988). Hence, Kamel and Hoppin's (2004) argument that bias could be created by using self-diagnosed pesticide poisoning as a criteria for measuring exposure should be considered in future studies to avoid possible misclassification or exclusion of exposed workers. Moreover, farm workers are often ignorant of the link between their ill-health and occupational exposure (Gomes et al 1998) and may not be aware that they had experienced pesticide poisoning, as the symptoms of organophosphate poisoning (dizziness, headache, nausea, vomiting, diarrhoea) could be mistaken for the symptoms of other communicable diseases that commonly affect marginalized impoverished communities like farm workers (e.g. bilharzia and gastro-enteritis) (Bwititi 1987). On the other hand, farm workers may have reported past pesticide poisoning without having experienced this exposure, particularly since the symptoms of mild pesticide poisoning are similar to other conditions. It is therefore recommended that a prospective cohort study design and case definition matrix for acute pesticide poisoning (Thundiyil et al, 2008) be used with future studies to avoid this type of misclassification of pesticide poisoning.

5.4 Environmental Exposure – Outcome Relationships

In this study environmental exposure was measured by spray mist reaching the home and the smell of pesticides in the home on spraying days. Analyses found that 459 (56%) workers in the study population reported observing spray drift reaching their homes on spraying days, and 516 (63%) reported smelling pesticides in their homes on those days. Of the study population, 65% reported that they had lived next to vineyards during their years of living on a farm, and during their years of residence on farms 92% of pesticide spraying was performed by tractor drivers using a mist blower. Taking cognizance of all these exposure factors, it is apparent that more than half the study population had been exposed to, or was still subject to environmental routes of exposure to pesticides at the time of the study. These findings coincide with other studies. London (1994) noted that farm workers' homes are often within or adjacent to orchards, vineyards or fields. Dalvie et al (2004) reported that a third of the respondents in their survey lived within 10 metres of the nearest site of spraying and another report confirmed that „insecticides, fungicides, growth regulants and metabolic sprays are usually applied by mist blowers' (London and Myers 1995). Moreover, these factors were personally observed by the researcher during data collection and while conducting health and safety audits for WIETA[11] (2004 – 2007). Global literature discussing the role of pesticide drift in the aetiology of pesticide-related illnesses (Loewenherz et al, 1997; Lu et al, 2000; Colb 2004; Morrissey undated), also cite the close proximity of agricultural fields to farm workers houses and schools as a cause of pesticide-related illness from spray drift. In fact the literature has suggested that the closer a child lived to an orchard or vineyard, the greater the exposure to pesticides (Simcox et al, 1995; Loewenherz et al, 1997; Lu et al, 2000).

Additionally, pesticides volatilize and drift during the heat of the day and the oxon breakdown products (like chlorpyrifos oxon), which may have higher toxicity than the parent compound, result in continuing high exposures occurring during applications, as well as long after the applications had ended (Harnly et al, 2005). Of interest to this study is that Chlorpyrifos has been identified as the most commonly used OP insecticide in the wine and table grape sector of South Africa, and has been detected in the rural environmental water system in selected dams and rivers in the Hex River Valley (London et al, WRC Report No: 795/1/00), which supports the findings that participants may have experienced substantial environmental exposure in this study.

[11] Wine Industry Ethical Trade Association (WIETA) started conducting social audits on cellars and wine grape farms in 2004. In 2006, the organization included fruit farms and pack sheds in their audits.

In this study, after controlling for all potential covariates, multivariate analyses found that workers who reported smelling pesticides in their homes on spraying days were more depressed (OR: 1.66; 95% CI: 1.11 – 2.47) as measured by the GHQ Depression Subscale, and more aggressive (OR: 1.41; 95% CI: 1.00 – 2.00). Included in the group of workers smelling pesticides in their homes, were those workers with cumulative exposure to pesticides by ever having been a tractor driver (26.4%), and/or a head sprayer (14.0%), and workers regarded as being in the „high exposure' group (59.7%) in their current jobs, as they were involved in one or more spraying activity. Further multivariate analyses, controlling for all potential covariates and these categories of workers, found that this did not affect the positive associations between the variable „smelled pesticides in the home' and depression and aggression. Since suicidal behaviour may be characterised by aggressive outbursts and symptoms of depression or withdrawal (Shaffer 1974, cited by Garrison et al 1993), this study finding highlights the potential risk for farm workers exposed to pesticides through environmental routes of exposure, developing suicidal behaviour.

The discrepancy between the absence of occupational exposure-outcome relationships compared to the presence of environmental exposure-outcome relationships in this study is very interesting, particularly since occupational exposures are likely to be more intense, accurate and quantifiable. It should therefore be considered that farm workers who were depressed or had aggressive personalities may have over-reported the smell of pesticides in their homes on spraying days or over-reported their observation of spray drift reaching their homes, which could have given a spurious causal relationship where one did not exist.

Nonetheless, these study findings highlight the need for further research on the potential role that environmental exposure plays in the aetiology of overall pesticide-related conditions.

These study findings are also in agreement with the findings of a study conducted by Dalvie et al (in press), which suggested that increased post-spraying endosulfan levels amongst non-applicators (non sprayers) could probably be attributed to exposure to pesticide spray mist as the workers all worked in-field, and some walked through the vineyards during the spraying of pesticides. Other South African studies / reports have also suggested that spraydrift could be a potential measure of pesticide exposure (London & Myers 1995; London & Myers 1998; London & Rother 1998; Smetherham 2007; Meijster et al n.d.). In fact, London and Myers (1998) mentioned that routes of environmental exposure to pesticides, including spray drift, should be taken into account when conducting exposure-effect measurements. The fact that spray drift is a form of low level exposure to OP's and other pesticides cannot be ignored, particularly if workers had grown up on a farm and been exposed to spray drift since childhood (Loewenherz et al, 1997; Lu et al, 2000; Holtman et al, unpublished).

Figure 5.3 Farm workers' houses in close proximity to vineyards

5.5 Potential Covariates – Outcome Relationships

In the multivariate models, the factors that persisted after controlling for confounders were typically past pesticide poisoning; current / past psychiatric illness and low SES (represented by less than four household items including electricity and a bathroom or shower, ≤ 4 items) (past pesticide poisoning has been discussed in section 5.1).

5.5.1 Psychiatric Illness

Since one of the objectives of this study was to determine the current levels of depression and suicidality amongst participating farm workers, an assessment of their current and past mental health status was important. The variable current / past psychiatric illness included participants who had / currently were receiving treatment for depression or other psychiatric conditions (which in the Western Cape was also colloquially referred to as „nerves').

Of the 83 (10.2%) workers who reported treatment for a psychiatric illness, 52 (63%) were females and 87% (9 males; 63 females) reported current / past treatment for „nerves'. Only table grape workers (8 males; 14 females) reported current / past treatment for depression, and five workers (2 wine grape; 3 table grape) reported past / current treatment for a psychiatric condition. The analysis that follows is for the combined variable „psychiatric illness' (which encompasses depression, „nerves' and a psychiatric condition) (see chapter 3, section 3.7.1.4)

In this study, after adjusting for the appropriate potential covariates, it was found that workers who reported current / past psychiatric illness had a fourfold odds of an increased GHQ score (psychiatric morbidity) (OR 4.83) and had a threefold odds of an increased BSI GSI score (general distress) (OR 3.55). Moreover, the neuropsychiatric instruments used to measure depression in this study, found that workers who reported current / past psychiatric illness were more likely to be depressed (BDI, OR 6.02; GHQ Subscale Depression, OR 2.90; BSI Depression Symptom Dimension, OR 2.36).

There may have been some misclassification given variability in the participants understanding of the condition(s) referred to as „nerves', based on the manner in which they were introduced to the diagnosis by medical practitioners (Reynolds & Swartz 1993). But the consistency and strength of the associations in the expected directions with the key neuropsychiqtric outcome measures (depression, psychiatric disorders and general distress) suggests that any such misclassification was not substantial.

5.5.2 Socioeconomic status (SES)

Socio economic status as indexed by the possession of a refrigerator, television set, radio, telephone, and access to electricity and a bath and/or shower in the home, was assessed as a measure of poverty levels of participants. Farm workers on table grape farms owned / had access to more household items than their counterparts on wine grape farms (4 items versus 3 items). Workers who owned less than four items were regarded as having a low level of SES, representing more than half of wine grape farm workers (58.7%) in this SES category, compared to 31.3% of table grape workers who had a low level of SES ($p < 0.01$).

Overall findings reported by participants were that 96.5% had electricity, 74.1% had running water, 61.9% had a shower and 16.4% had a bath in their homes. 83% reported having flush toilets inside or outside their homes. However, twenty-nine participants (3.5%) reported having no toilets in the vicinity of their homes, and eight workers (four males and four females) had access to none of the items indexed for SES. A study conducted in the farming communities of the North-West province of South Africa using similar socioeconomic indicators (education, income, housing, sanitation and electricity), reported that „access to these facilities is often very poor and also varies between farms' (Kruger et al, 2006). A study conducted in Pittsburgh indexed SES by measures of family income and educational attainment (Matthews et al, 2000), while in Sri Lana socioeconomic deprivation was indexed as poor housing quality and low levels of education, but not unemployment (Manuel et al, 2008).

In this study, multivariate analyses found that after controlling for all potential covariates, all categories of workers who had a low SES reported significantly higher levels of depression (BSI Depression Symptom Dimension, OR 1.90); psychiatric disorders (GHQ, OR 1.62); general distress (BSI, OR 1.79); aggression (OR 1.45) and impulsivity (OR 1.48). Therefore workers with low SES were more likely to report higher levels of all the neuropsychiatric symptoms (except suicidal ideation), irrespective of their levels of pesticide exposure.

These study findings are supported by a study conducted by Matthews et al (2000) who found that a low SES was associated with aggression and impulsivity, which in turn was associated with reduced central serotonergic responsitivity. Global studies have found that.low serotonin levels, as well as aggression and impulsivity, are associated with depressive disorders (Patton et al, 1995; Davies, 1995; Felsten and Hill, 1999; Oquendo & Mann, 2000).

5.5.3 Age

The age range of workers in the survey was 17 to 79 years. A prevalence of 23% of the participants reported being in the age range of 8 -15 years when they started their first job, which reflects the historical practice of child labour on farms in South Africa (World Socialist Website (WSWS), 2003). Section 28 of the Constitution of South Africa (Act 108 of 1996, Chapter 2 „*Bill of Rights*') guarantees all children the right to freedom from harm, working in hazardous conditions and the right to protection, yet child labour on farms persists in selected parts of South Africa. Husy and Samson (2001) reported that in Kwazulu-Natal 16% of farms were reliant on child labour, and in certain districts in the Northern Province, Northern Free State and Gauteng nearly 20% of farms surveyed employed children on a regular basis. Similarly, News 24 (14 July 2004, 21:21) reported that farmers in North West Johannesburg were employing children as young as 8 years of age during the harvest season. In 2004, South Africa initiated a national plan on the elimination of child labour, the Child Labour Programme of Action (CPLA, lead by the Department of Labour and comprising a large group of local and provincial government stakeholders, including justice, policing, prosecution, social development and education departments (Anonymous, 2009).

In this study it was found that farm workers, who were older than 33 years of age, experienced higher levels of depression (BDI-IA OR: 2.41) and general physical, physiological and psychological distress (BSI GSI OR: 1.72), which is in agreement with research findings that the prevalence of depression increases with age (Winokaur 1979; Klerman 1980). Taking cognizance of the fact that 90% of all cases of suicide can be attributed to mental disorders particularly depression (WHO 2008), and in the last century, mortality from suicide has been higher in males (Ajdacic-Gross et al 2008), male farm workers in this study could be considered a suicidal risk as they become older. Support for this speculative association can be found in a record review of nine mortuaries in the Boland-Overberg region for the period January 1995 to December 1999, which found that males accounted for slightly over 75% of all unnatural deaths (Maruping et al n.d.).

5.5.4 Personal Protective Clothing (PPE)

In this study it was found that workers who received more items of PPE experienced lower levels of depression, general distress, impulsivity and suicidal ideation ($p < 0.01$). Additionally, male workers with more items of PPE were also more likely to experience less psychiatric disorders (GHQ; Spearman $r = -0.11$; $p < 0.01$) and aggression (Spearman $r = -0.11$; $p < 0.01$). These findings lead to the speculation that a lack of PPE may exacerbate higher levels of depression found in females as discussed in section 5.1, as overall female workers in this study received less items of PPE than males (two versus three items) or no items of PPE at all.

Generally, farm workers on table grape farms were provided with more items of PPE than those on wine grape farms (3 versus 2 items). However, it was only 2.3% workers (15 males; 4 females) on table grape farms who received all six items of PPE. Of these 19 workers, 17 (89.5%) were part of the „high exposure' group who performed more than one category of pesticide spraying and worked in the vineyard during pesticide spraying (multi-tasking of workers). A concerning finding was that 78 (9.5%; 48 table grape, 30 wine grape) workers received no PPE at all. The inadequate provision of PPE to farm workers in this study, particularly wine grape workers, indicates a lack of compliance with the

Occupational Health and Safety Act, No. 85 of 1993 (Section 17), regarding the duties of an employer to provide a healthy and safe working environment for all employees, on some of the farms.

A reason for table grape farm workers being provided with more PPE could be that at the time of the cross-sectional survey (2002), the members of the Hex Valley Producers' Association (table grape farmers) were already members of the global export market and preparing for accreditation with EurepGap, whose requirements are that farm workers be provided with the appropriate PPE and training on its use.

Multivariate analyses, controlling for all potential covariates and using more than eleven years worked in agriculture as a measure of cumulative exposure, found that workers who received one or no items of PPE were more likely to have higher levels of depression according to the BDI (OR: 1.84; 95% CI: 1.01-3.37). These findings reinforce the potentially protective role that PPE plays in minimising the effects of pesticide exposure (London et al 1998; Meijster et al n.d.; van Wendel de Joode et al 2004), emphasising the need for all farm workers to be supplied with PPE appropriate to the task being executed. In fact, Beseler et al (2008) found that after analysing the effects of different types of PPE worn by private pesticide applicators, merely wearing chemically resistant gloves was protective against being depressed. Furthermore, it can be postulated that workers with lower levels of depression may have an increased awareness of their exposure to pesticides, and therefore be more likely to request / wear / be issued with the required items of PPE, as well as practise safer handling of pesticides. Studies, however, have been carried out, which show that different types of PPE (e.g. gloves) have their shortcomings and should not be relied upon entirely to protect workers from exposure to pesticides (Methner & Fenske 1994; Gomes et al 1998). Therefore, sustainable coordinated methods like the Integrated Pest Management (IPM) program should rather be employed (Rother & London 1998; AVCASA et al 2003).

A more recent study conducted by Dalvie et al (in press) suggests that the low usage of relevant PPE could have played a role in the increased post-endosulfan levels found amongst vineyard maintenance workers. There are other studies that have supported the notion that although general vineyard workers are not pesticide applicators, they may be more vulnerable to pesticide exposure because they are provided with minimal or no protective clothing (Fenske 1997 and Gladen et al 1998 cited by Kamel and Hoppin 2004). This is therefore an area that requires more in depth investigation in future studies.

5.5.5 Alcohol Consumption

Since several studies have discussed the high rate of alcohol consumption amongst farm workers in the Western Cape (London et al, 1997; London et al, 1998; Barnes, 1999; Claassen, 1999; London, 2000; London et al, 2006; Matthews, 2004; Holtman et al, unpublished) and the neurotoxic effects of alcohol abuse is well-known (anxiety, anger, aggression, depression, memory loss), the level of alcohol use as a potential risk for depression was assessed. The assessment instrument was the CAGE Test, which diagnoses alcohol problems over a lifetime and asks questions about problems associated with alcohol use rather than the amount of alcohol consumed.

616 (62.8% males and 37.2% females) workers reported two or more positive responses, which classified them as having an alcohol problem. A score ≥ 2 was reported by 84.4% of wine grape workers and 73% of table grape workers. Of the 616 workers who reported a CAGE score ≥ 2, 319 (52%) workers reported a high level of aggression (score greater than 24). In the multivariate model, a modest but significant association was found between aggression and a high CAGE score (OR generally of the order of 1.2 to 1.3) irrespective of the cumulative exposure variable used in the multivariate logistic regression modelling.

The fact that in this study a high CAGE score was associated with aggression only, and not impulsivity (Chi-square, $p = 0.16$) and / or suicidal ideation (Chi-square, $p = 0.14$) is unexpected, particularly since the relationship between aggressive behaviour and high impulsivity has been commonly discussed in clinical and empirical literature (Houston & Stanford, 2004). Elevated impulsivity levels, heavy drinking and violence, which have been suggested as characteristics of the South African farm worker population (Baron & Byrne 1991; Andersson, 2003; Matthews, 2004), have also been cited as being responsible for raised aggression levels in problem drinkers (Heinz et al, 2001 & Higley, 2001, cited in Mattson, 2003).

However, when considering this association between alcohol abuse and aggression, cognisance should be given to the literature linking heavy / problem alcohol consumption with aggression (Fagan, 1990; Mattson, 2003) and the social and cultural environment of farm workers in South Africa where pervasive alcohol use, compounded by the legacy of the iniquitous „dop' system (London, 1999), has been part of their socialisation. This drinking culture, in which poverty and drinking to get intoxicated plays a key role, means that other factors might be at play in the relationship between alcohol, aggression and impulsivity, since the farm culture being very closed, is noted to be very different to other contexts.

In this study, the mean age at which participants started consuming alcohol was 19.5 years (SD 4.3), and 184 (51%) workers who reported a CAGE score of ≥ 2 were less than 19 years of age. In fact, three of the participants in this study reported being 7 years old when they started consuming alcohol, which coincides with Matthews study (2004) where some participants started drinking alcohol from the age of 6 years. The consequences of alcohol use at an early age is discussed by Jaffe et al and Moeller & Dougherty (cited in Mattson, 2003), who found that the aggressive personality was associated with an increased likelihood of early onset of alcoholism in men and the occurrence of increased aggression after consuming alcohol. Farm workers also learn aggressive behaviour (Baron & Byrne 1991), through the direct experience of interpersonal and workplace violence and abuse that some farm workers are sometimes subjected to (*South Africa's violent farms,* 2003; Andersson, 2003), or observation of the aggressive behaviour of others. Supporting the association between aggression and alcohol abuse is frustration, which for some time has been thought to be associated with aggression, particularly if the frustration is seen as arbitrary or unfair (Geen cited by Mattson, 2003) and that intoxication increases the effects of frustration on aggression (Ito et al, 1996, cited by Mattson, 2003). Considering the harsh and unfair working and living conditions of some farm workers (Kruger et al, 2006; Atkinson, 2007; South African Human Rights Commission, 2007), it can be speculated that a certain amount of frustration is experienced by these workers, which could account for the positive associations of aggression with alcohol abuse (OR of the order of 1.2 to 1.3) and aggression with a low SES (OR 1.45). Exploration of the frustration-aggression hypothesis in farm workers warrants further research.

5.6 Gendered Nature of Pesticide Exposure

This study showed that on grape farms in the Western Cape Province of South Africa there was a distinct difference between the type of farm work executed by male and female farm workers and therefore the extent of their exposure to pesticides. In this study, 35% of the study population was tractor drivers and head sprayers (predominantly male workers) and 65% were general farm / vineyard workers (predominantly female workers). Furthermore, this study showed that tractor drivers and spray operators (high exposure group of workers) received more items of PPE (85% of this group received ≥ 2 items of PPE) and therefore benefited from the supposedly protective effect of PPE in modifying pesticide exposure (Meijster et al, n.d.; London et al, 1998; van Wendel de Joode et al, 2004; Coronado et al, 2004; Dalvie et al, in press).

At the time of the study, the more skilled tasks of pesticide spraying and tractor driving were gender specific and carried out mainly by male workers, as confirmed by the finding that of the 331 female participants in the study, only 96 (29%) female workers were part of the „high exposure' group of workers, who were currently performing one or more pesticide spraying activity group (4 were tractor drivers, 27% performed spraying tasks using a hand gun apparatus and 8% were doing back pack spraying). The rest of the female workers (70%) in this study were therefore involved in non-spraying or general vineyard maintenance activities, and these workers were supplied with minimal or no PPE.

The female workers in this study constituted a large proportion of the group of non-sprayers who reported elevated neuropsychiatric symptoms, which supports the general study finding that female farm workers had higher levels of depression and suicidal ideation ($p < 0.01$) than their male counterparts.

Additionally, of the 83 (10.2%) workers who reported treatment for a psychiatric illness, 52 (63%) were females, indicating that female workers were at greater risk of developing mental health disorders.

It can therefore be concluded that at the time of the study, male farm workers on grape farms in the Western Cape Province of South Africa were more advantaged and protected than female farm workers.

5.7 Validity of measurements used in the study

The validity of the measurements used in the study is demonstrated by the following study findings, which coincide with the findings of other research studies:

- Female farm workers, for whom the mean age was 33 (SD 8.4) years, reported significantly higher levels of depression than male workers ($p < 0.01$). This finding is consistent with other studies which show that the lifetime prevalence of depression is usually twofold higher for women than for men with the peak prevalence for women occurring between 35 and 45 years of age (Winokur, 1979; Klerman, 1980; Grimsrud et al, 2009), and depression in women is common in developing countries (Mkize et al, 1998; Patel et al; 2001).

- The higher levels of suicidal ideation found amongst female farm workers is consistent with a South African study conducted by Joe et al (2008), which reported an increased risk for attempted suicide amongst Coloured females aged 18 – 34 years, and a Chinese study carried out by Zhang et al (2009) which reported higher levels of suicidal ideation amongst females in two rural areas in China. Additionally, globally it has been found that females tend to attempt suicide more often even though mortality from suicide is higher in males than females (Ajdacic-Gross et al 2008).

- The link between impulsivity and suicidal ideation is demonstrated in this study by the finding that female farm workers were significantly more impulsive than males ($p = 0.01$) in the „Nonplanning Impulsiveness' subfactor of the BIS-IA. This finding is supported by a study of rural Chinese women who reported contemplating the suicidal act for less than 2 hours before making the attempt (Gunnell & Eddlestone 2003; Bertolote et al 2006, Mudie, 2006) and a study conducted by Baca-Garcia et al (2005), which found that impulsive suicidal attempts were associated with low lethality and a lack of depression.

- The positive association between a history of past pesticide poisoning and depression and psychiatric morbidity found in this study is consistent with studies that have found an association between a history of past pesticide poisoning and depression (Stallone & Beseler, 2002; Beseler et al, 2006; Beseler et al, 2008) and those that have reported chronic neurological sequelae following acute episodes of pesticide poisoning (Savage et al, 1988; Rosenstock et al 1991; Reidy et al, 1992; Stallone & Beseler, 2002).

- The findings that 56% of workers in the study population observed spray drift reaching their homes on spraying days, 63% smelled pesticides in their homes on spraying days, and 65% of participants in this study reported living next to vineyards or orchards in their years of living on a farm, are similar to the findings of other agricultural studies conducted in South Africa (London, 1994; Dalvie et al,2004) and other countries (Simcox et al, 1995; Loewenherz et al, 1997; Lu et al, 2000). These studies emphasise the role that proximity of agricultural fields to farm workers houses and schools play in exposure to pesticides.

- The positive associations found between a low SES and depression, psychiatric disorders, general distress, aggression and impulsivity in this study are consistent with a study conducted by Matthews et al (2000) who found that a low SES was associated with aggression and impulsivity, and studies which have found that low serotonin levels, aggression and impulsivity are associated with depressive disorders (Patton et al 1995; Davies 1995; Felsten and Hill 1999; Oquendo & Mann 2000).

- The finding in this study that 616 (75.4%) participants reported an alcohol problem coincides with other South African studies that found a high rate of alcohol consumption amongst farm workers in the Western Cape province

(London et al, 1997; London et al, 1998; Barnes, 1999; London, 2000; London et al 2006; Matthews, 2004; Holtman et al, unpublished) and farming areas in other provinces in South Africa (Claassen, 1999).

- The significant association found between aggression and a high CAGE score, in the absence of an association with suicidal ideation, is supported by studies linking heavy / problem alcohol consumption with aggression (Fagan 1990; Mattson 2003) and a study conducted by Stanley et al (2000), who found that aggressive behaviour with no history of suicide attempts is related to altered serotonergic function.

These findings all suggest that the instruments used in this study were able to measure the outcomes or covariates intended since they produced associations with risk variables already established in the literature. Thus questions around the validity of the instruments are not likely to explain any failure to show exposure-outcome relationships in this study.

5.8 Limitations of the study

The 80% response rate in the random sample of table grape farms provided a reasonable generalisability for the table grape section of the study area. However, the convenience sample of 14% of wine grape farms may not have been truly representative of the wine grape section of the study area. The results for the wine grape sector of Worcester may therefore be biased because of the small number of participatory wine grape farms. It would be expected that in a low response rate, non-participating farms would be likely to be worse off than participants, which may explain a failure to demonstrate exposure-effect relationships for that stratum. However, the findings for the descriptive data in this study were quite similar to other studies (London et al 1997; Dalvie et al 1999; Patel et al 2001; Stallone & Beseler 2002; Coronado et al 2004; Beseler et al 2006; Grimsrud et al 2009), which lends credence to the notion that the study sample was typical of the area even though it was not entirely representative.

Being a cross-sectional study, information on risk factors (pesticide exposures) and disease (neuropsychiatric outcomes) was collected from the study population at a point in time. This study design lends itself to the „healthy worker effect', where the „exposed' workers selected for the study were healthier and protected because of being employed and, in this case, because of the skilled tasks they performed. On the other hand the „unexposed' workers selected, were possibly the problematic workers and those not employed in high risk / more skilled jobs. This type of bias may have led to an underestimation of the prevalence of neuropsychiatric outcomes for the „exposed' workers studied and may account, if not completely, then at least partly, for the contrary findings for the „unexposed' workers. Additionally, the timing of the survey (workers had just returned from their mid year holiday break and may have been feeling rested and relaxed) may have influenced workers' responses to the questionnaires resulting in an underestimation of workers actual neuropsychiatric status.

An important limitation of the study was the difficulties encountered with cumulative exposure characterisation. Observer error played an important role in the collection of data on frequency of pesticide application, particularly for days per week and weeks per month, as the quality of data obtained was questionable, despite this information being requested early in the interview. This resulted in an inability to calculate a JEM cumulative exposure metric, which may have improved the quality of the exposure characterisation (Miligi et al, 1993; London & Myers, 1998; Young et al, 2004). Additionally, information bias may have occurred as, despite interviewers being trained in the administration of the questionnaire, interviewer naivety regarding occupational exposure in agriculture (Stewart and Stewart 1994) may have resulted in interviewers under-estimating exposure by missing specific exposure tasks which were crucial to determining cumulative pesticide exposure.

Additionally, farm records on spraying schedules were also unavailable, even though it was requested as part of the data collection process. These would have provided vital information on the types of pesticides being sprayed as workers were often unable to remember the generic or trade names of pesticides and used the names understood by the farming community, which interviewers were not knowledgeable about. Hence, even though this data was collected, it was not analysed because of poor quality.

It can therefore be assumed that the resultant exposure findings in this study were not for organophosphates only, but for a mixture of pesticides, which introduces further misclassification (by type of pesticide) into the analysis and findings, a common problem in the literature (Kamel & Hoppin 2004) which could further account for a lack of exposure-effect relationships.

Besides the absence of useable information on pesticides workers were exposed to in this study, a further limitation was the lack of information regarding pesticide residue levels on vines after spraying and the extent of residue degradation, as the exposure questionnaire did not address the time periods for re-entry into the vineyards after spraying nor were any residue levels measured in this study. These factors may have assisted in pesticide exposure characterisation for general vineyard workers and provided an explanation for the counter-intuitive outcomes for this group of farm workers in that the putatively low-exposure group may have paradoxically had considerably higher exposure than estimated.

An additional factor which contributed to random error in the study was the difficulties encountered with regular checking of the quality of data being collected because of the number of interviewers employed daily (8 to 10 interviewers per day). Each interviewer conducted approximately four interviews per day each lasting 75 – 90 minutes and overall a range of 17 to 90 farm worker interviews were completed per interviewer over the study period. Limited time constraints for the completion of the data collection and the large study population necessitated the large group of interviewers.

The cross-sectional design of the study prevented the re-collection of data when errors were found. These types of errors may have been prevented by having interviewers who were more acquainted with the agricultural sector and the culture and language of farm workers and using a smaller group of interviewers. Despite piloting, these errors may have contributed to reduced precision and to misclassification of data.

The timing of the study allowed for mainly workers with permanent employment status to be included in the study population, thus excluding many seasonal workers who may have been involved in tasks with high pesticide exposure. The exclusion of these seasonal workers from the study may have affected the results for recent or past pesticide exposure as 69% of the seasonal workers included in the study were involved in one or more spraying activity. It is therefore recommended that future studies should endeavour to include all seasonal farm workers as well.

Lastly, there was one limitation about which little could be done – that is, for some exposures, gender could not be controlled for because so few women did those tasks.

All the abovementioned factors („healthy worker effect', timing of the study, nature of cumulative exposure metrics used, observer error, information bias, random error) highlight the possibility that some differential misclassification of exposure may have occurred in the study. Therefore the seemingly „high exposed' workers (spray operators and tractor drivers) were actually not „high exposed' and the seemingly „low exposed' workers (vineyard maintenance workers) actually had higher exposures, which was not measured in the study). The exposure misclassification resulted in a lack of association being identified between exposure to pesticides and the neuropsychiatric outcomes, which may not be entirely true for this study population.

It appears though that there was little bias evident for the confounders included in the study as the crude and adjusted estimates for these covariates were similar. Also, the measurements used to assess the levels of neuropsychiatric outcomes of farm workers in this study can be considered valid as they coincide with the findings of other research studies.

5.9 Summary

In investigating the neuropsychiatric effects of OP exposure in grape farming, the present study found no evidence for a positive association between cumulative and recent or current pesticide exposure and adverse neuropsychiatric effects on farm workers on wine and table grape farms. In fact the converse may be true for some of the neuropsychiatric outcomes, as cumulative exposure of more than eleven years of working in agriculture was associated with lower risk for impulsive behaviour (OR 0.54) and tractor drivers who had been working for longer than 13 years on a farm were less aggressive (OR 0.23). The latter findings suggest that skilled workers (tractor drivers and pesticide handlers) may have been selected into their jobs because they exhibited stable and trustworthy behaviour and therefore benefited from the accompanying relevant health and safety training. Additionally tractor drivers may have been partially protected from exposure by being provided with sufficient PPE and training on its use. Since farm workers are traditionally a close-knit community, the benefits of being a responsible worker may have had a positive influence on some of the general farm workers, resulting in a less impulsive workforce with > 11 years of working in agriculture, particularly if they were employed on a farm that rewarded good working practices.

A history of past pesticide poisoning amongst farm workers on grape farms was positively associated with an increase in psychiatric disorders as measured by the GHQ (OR 2.17) and increased depression as measured by the GHQ Depression Subscale (OR 1.62). This is a pattern consistent with the literature (Rosenstock et al 1991; Reidy et al 1992; Stallone et al 2002; Beseler et al 2006; Beseler et al 2008)

A notable finding in this study was the positive association found between reports of environmental (indirect) exposure by smelling pesticides in their homes on spraying days and depression as measured by the GHQ Depression Subscale (OR 1.66), and aggression (OR 1.41).This finding could suggest that in the agricultural grape sector, environmental exposure, rather than cumulative pesticide exposure, may be a more important cause of depression-related symptoms. Conversely, it cannot be ruled out that depressed and/or aggressive workers may have been more aware of the smell of pesticides in their homes. Hence, pesticide spray drift as a possible measure of low-level pesticide exposure, particularly for workers who had lived and worked on farms all their lives, should be considered. Because of their residency on farms, farm workers in this study may have been exposed to other forms of environmental exposure as well (drinking pesticide contaminated water, swimming in contaminated dams and rivers), which together with occupational exposure may have compounded their risks and could possibly account for the association with depression. This, however, is speculative, highlighting the need for further research in this area.

In the study, there appeared to be a protective association between the amount (number of items) of protective clothing (PPE) issued to workers and their levels of depression and suicidality. More pesticide spraying operators than non-spraying workers (50% versus 26%) were issued with 2 or more items of PPE. Female farm workers received significantly less PPE than males (2 versus 3 items), and more workers on table grape farms than wine grape farms (4:1) were issued with 2 or more items of PPE. The important role that PPE played in this study is highlighted by the multivariate model that found that workers who received one or no items of PPE had increased odds of being depressed (OR 1.90) according to the BDI. Moreover, in the study, the provision of PPE may have also been a reflection of the type of farm and the attitude towards the management of health and safety hazards on the farm, as well as compliance with the Occupational Health and Safety Act, No. 85 of 1993 (Section 17).

The construct validity of the 9 neuropsychiatric outcome instruments used in the study yielded anticipated associations with age, gender, current/past psychiatric illness, low socio economic status (SES), protective clothing (PPE) and alcohol consumption (CAGE score). Significant correlations of moderate strength (Spearman r's varied from 0.3 to 0.6) were found between all the neuropsychiatric outcome instruments (Tables 3.4 and 3.5), which affirmed the validity of the findings of the study. The GHQ (psychiatric morbidity) was most strongly correlated with the BDI (depression) (Spearman r's varied from 0.6 to 0.7), while general distress (BSI) was most strongly correlated with aggression, and suicide ideation was most strongly correlated with impulsivity and aggression (Spearman r = 0.4).

Additionally,.strong correlations were found between the cumulative and current exposure variables (Spearman r's varied from 0.7 to 0.9) (Table 3.3), which contributed to the similarities in the findings for these variables

Female workers on grape farms appeared to be more marginalized than their male counterparts. The gender issues that emerged from the study were: female workers were more likely to have higher levels of depression, suicidal ideation and nonplanning impulsiveness than males; females were mainly occupied with general maintenance vineyard work; males were employed in the more skilled work like pesticide handling and tractor driving; female workers received significantly less items of PPE than males (2 versus 3); more females than males reported being treated for a psychiatric illness (1.7:1), „nerves' (7:1) and hypertension (1.7:1). It was only with alcohol consumption that more males than females reported a higher CAGE score of 2 or more positive responses (1.7:1)

The high levels of alcohol abuse found amongst farm workers in the study are consistent with other studies conducted on farm workers in South Africa. The positive association between aggression and alcohol abuse was also as expected. However, the fact that there were no associations with alcohol abuse and any of the other neuropsychiatric constructs like impulsivity and suicidal ideation is unexpected and may be an indication of the need for further research into the culture of alcohol consumption on farms.

In the present study, the covariates low socio economic status (SES - indexed by having access to less than four household items) and treatment for a current or past psychiatric illness were significant predictors of all the neuropsychiatric outcomes except suicidal ideation, in the crude and adjusted models of analysis.

5.10 References

Ajdacic-Gross, V; Weiss, MG; Ring, M; Hepp, U; Bopp, M; Gutzwiller, F; Rössler, W 2008, „Methods of suicide: International suicide patterns derived from the WHO mortality database', *Bulletin of the World Health Organization,* vol. 86 no. 9, pp. 726 – 732.

Andersson, H 2003, *'Race tensions on South Africa's farms'*. Retrieved July 14, 2009, from http://news.bbc.co.uk

Anonymous 2009, *„Child Labour Programme of Action (South Africa)'*. Retrieved June 24, 2009 from http://www.child-labour.org.za/south-africa/national-plan-on-child-labour/plan-content/clpa-2/

Atkinson, D 2007, *'Going for broke. The fate of farm workers in arid South Africa'*, HSRC Press, Cape Town South Africa. www.hsrcpress.ac.za.

AVCASA, CropLife, ACDASA, SAAHA 2003, *'Guidelines for the Responsible Use of Crop Protection and Animal Health Products',* Lanzerac, Midrand, South Africa. www.avcasa.org

Baron, RA; Byrne, D 1991, *Social Psychology: Understanding Human Interaction,* 6th edn, Allyn and Bacon, USA.

Barnes, JM 1999, „Problems in monitoring overexposure among spray workers in fruit orchards chronically exposed to diluted organophosphate pesticides', *International Archives of Occupational and Environmental Health*, vol. 72 no. 3, M68 - M74. (Abstract)

Beseler, C; Stallones, L; Hoppin, JA; Alavanja, MCR; Blair, A; Keefe, T; Kamel, F 2006, „Depression and Pesticide Exposures in Female Spouses of Licensed Pesticide Applicators in the Agricultural Health Study Cohort', *JOEM,* vol.48 no.10, pp. 1005 - 1013.

Beseler, C; Stallones, L; Hoppin, JA; Alavanja, MCR; Blair, A; Keefe, T; Kamel, F 2008, „Depression and Pesticide Exposures among Private Pesticide Applicators Enrolled in the Agricultural Health Study', *Environmental Health Perspectives,* vol. 116 no.2, pp. 1713 - 1719.

Bwititi, T; Chikuni, O; Loewenson, R; Murambiwa, W; Nhachi, C; Nyazema, N 1987, „Health Hazards in Organophosphate Use among Farm Workers in the Large-scale Farming Sector', *Central African Journal of Medicine,* vol. 33 no. 5, pp. 120 – 126.

CERES Certification of Environmental Standards 2009, *EurepGap Certification.* Retrieved January 08, 2009, from http://www.ceres-cert.com/en_eurepgap_certification.html

Coronado, GD; Thompson, B; Strong, L; Griffith, WC; Islas, I 2004, „Agricultural Task and Exposure to Organophosphate Pesticides among Farmworkers', *Environmental Health Perspectives,* vol. 112 no. 2, pp. 142 - 147.

Dalvie, MA; White, N; Raine, R; Myers, JE; London, L; Thompson, M; Christiani, DC 1999, „Long term respiratory health effects of the herbicide, paraquat, among workers in the Western Cape', *Occup Environ Med*, vol. 56, pp. 391 - 396.

Dalvie, MA; Africa, A; Adams, A; Solomons, A; London, L; Brouwer, D; Kromhout, H in press, „Pesticide exposure and blood endosulfan levels after first season spray amongst workers in the Western Cape, South Africa', *Journal of Environmental Science and Health, Part B,* accepted for publication.

El Batawi, MA 2004, *Health of workers in agriculture,* World Health Organization Regional Publications, Eastern Mediterranean Series 25.

Environmental Justice Foundation (EJF) 2003, *What's Your Poison? Health Threats Posed by Pesticides in Developing Countries,* Environmental Justice Foundation, London, UK.

Fagan, J 1990, Intoxication and Aggression*, JSTOR: Crime and Justice*, vol. 13, pp. 241 - 320.

Farm Worker Pesticide Project 2006, *Children Breathing Dangerous Levels of Farm Pesticide, Chlorpyrifos (Lorsban): Government Inaction Drives Community to Conduct own Air Tests*, http://www.fwpp.org or http://www.panna.org

Felsten, G; Hill, V 1999, „Aggression Questionnaire hostility scale predicts anger in response to mistreatment', *Behaviour Research and Therapy,* vol. 37, pp. 87 - 97.

Garrison, CZ; McKeown, RE; Valois, RF; Vincent, ML 1993, „Aggression, Substance Use, and Suicidal Behaviors in High School Students, *American Journal of Public Health,* vol. 83 no. 2, pp. 179 - 184.

Gomes, J; Lloyd, O; Revitt, MD; Basha, M 1998, „Morbidity among farm workers in a desert country in relation to long-term exposure to pesticides', *Scand J Work Environ Health,* vol. 24 no. 3, pp. 213 - 219.

Grano, N; Keltikangas-Järvinen, L; Kouvonen, A; Virtanen, M; Elovainio, M; Vahtera, J; Kivimäki, M 2009, „Impulsivity as a predictor of newly diagnosed depression', *Scandinavian Journal of Psychology,* vol. 8 no.2, pp. 173 - 179. http://www.wileyinterscienceJournalsScandinavia

Grimsrud, A; Stein, DJ; Seedat, S; Williams, D; Myer, L 2009, „The Association between Hypertension and Depression and Anxiety Disorders: Results from a Nationally-Representative Sample of South African Adults', PLoS ONE 4 (5): e5552. doi:10.1371/journal.pone.0005552.

Harnly, M; McLaughlin, R; Bradman, A; Anderson, M; Gunier, R 2005, „Correlating Agricultural Use of Organophosphates with Outdoor Air Concentrations: A Particular Concern for Children', *Environmental Health Perspective,* vol. 113,pp. 1184-1189.

Holtman, Z; Shelmerdine, S; Flisher, AJ; London, L n.d., „Pesticides, Depression and Suicide: Perspectives of Five Suicide Survivors and their Families', unpublished

Houston, RJ; Stanford, MS 2005, „Electrophysiological substrates of impulsiveness: potential effects on aggressive behavior', *Progress in Neuro-Psychopharmacology,* vol. 29, pp. 305 - 313.

Husy, D; Samson, C 2001,'Promoting Development and Land Reform on South African farms', *Paper presented at the SARPN conference on Land Reform and Poverty Alleviation in Southern Africa,* Pretoria, South Africa.

Kamel, F ; Hoppin, JA 2004, „Association of Pesticide Exposure with Neurologic Dysfunction and Disease', *Environmental Health Perspectives,* vol. 112 no. 9, pp. 950 - 958.

Klerman, GL 1980, „Overview of affective disorders', in Kaplan HI et al (eds), *Comprehensive Textbook of Psychiatry,* Williams & Wilkins , 3rd ed. Vol. 2, pp. 1305 - 1319.

Krieger, RI; Ross, JH 1993, „Risk Assessments in the Pesticide Regulatory Process', *Annals Occupational Hygiene,* vol.37, pp. 565 - 578.

Kromhout, H & Vermeulen, R n.d. „Application of Job-Exposure Matrices in studies of the general population. Some clues to their performance', submitted to *European Respiratory Review.*

Kruger, A; Lemke, S; Phometsi, M; van't Riet, H; Pienaar, AE; Kotze, G 2006, „Poverty and household food security of black South African farm workers: the legacy of social inequalities', *Public Health Nutrition,* vol. 9 no. 7, pp. 830 - 836.

Loewenherz, C; Fenske, RA; Simcox, NJ; Bellamy, G; Kalman, D 1997, „Biological Monitoring of Organophosphorus Pesticide Exposure among Children of Agricultural Workers in Central Washington State', *Environmental Health Perspectives, vol. 105, no. 12*. http://ehpnet1.niehs.nih.gov/members/1997/105-12/loewenherz-full.html

London, L 1994, „Agrichemical safety practices on farms in the Western Cape', *SAMJ,* vol. 84, pp. 273 - 278.

London, L & Myers, JE 1995, „Critical Issues for Agrichemical Safety in South Africa', *American Journal of Industrial Medicine,* vol. 27, pp. 1 - 14.

London, L & Myers, J 1995, „Agrichemical usage patterns and workplace exposure in the major farming sectors in the southern region of South Africa', *South African Journal of Science,* vol.91, pp. 515 - 522.

London, L; Myers, JE; Nell, V; Taylor, T; Thompson, M-L 1997, „An Investigation into Neurologic and Neurobehavioral Effects of Long-Term Agrichemical Use among Deciduous Fruit Farm Workers in the Western Cape, South Africa', *Environmental Research,* vol. 73, pp. 132 - 145.

London, L & Myers, JE 1998, „Use of a crop and job specific exposure matrix for retrospective assessment of long term exposure in studies of chronic neurotoxic effects of agrichemicals', *Occup Environ Med,* vol. 55, pp. 1 - 8.

London, L; Nell, V; Thompson, M-L; Myers, JE 1998, „Health status among farm workers in the Western Cape – collateral evidence from a study of occupational hazards', *SAMJ,* vol. 88 no. 9, pp. 1096 - 1101.

London, L & Rother, A 1998, „Pesticides - time to take action', *SA Labour Bulletin,* vol. 22 no.5, pp.73 - 79.

London, L 1999, „The „dop' system, alcohol abuse and social control amongst farm workers in South Africa: A public health challenge, *Social Science and Medicine,* vol. 48, pp. 1407 - 1414.

London, L; Flisher, AJ; Wesseling, C; Mergler, D; Kromhout, H 2005, „Suicide and Exposure to Organophosphate Insecticides: Cause or Effect?', *American Journal of Industrial Medicine,* vol. 47, pp. 308 - 321.

London, L; Thompson, M-L; Myers, J 2006, „Measurement of alcohol consumption amongst South African farm workers', *Public Health and Human Rights APHA 134th Annual Meeting and Exposition,* Boston, MA.

Lu, C; Fenske, RA; Simcox, NJ; Kalman, D 2000, „Pesticide Exposure of Children in an Agricultural Community: Evidence of Household Proximity to Farmland and Take Home Exposure Pathways', *Environmental Research Section A,* vol. 84, pp. 290 -302.

Matthews, KA; Flory, JD; Muldoon, MF; Manuck, SB 2000, „Does Socioeconomic Status Relate to Central Serotonergic Responsivity in Healthy Adults?', *Psychosomatic Medicine,* vol. 62, pp. 231 – 237.

Matthews, BMF 2004, „An Exploratory Study of Aspects on Environmental Conditions Associated with Alcohol and Drug Abuse and Criminal Behaviour', M.A. (Child and Family Studies) Mini-thesis, University of Western Cape.

Mattson, MP 2003, *Neurobiology of Aggression,* http://books.google.co.za

Meijster, T; Wendel de Joode, B; Major, V; Maruping, M; London, L; Kromhout, H n.d., „Dermal exposure assessment for an epidemiological study among wine – and table grape farm workers', unpublished.

Methner, MM & Fenske, RA 1994, „Pesticide Exposure During Greenhouse Applications, Part II. Chemical Permeation Through Protective Clothing in Contact with Treated Foliage', *Appl. Occup. Environ. Hygiene,* vol. 9 no. 8, pp. 567 - 574.

Miligi, L; Settimi, L; Masala, G; Maltoni, SA; Constantini, AS; Vineis, P; and the working group on pesticide exposure assessment 1993, „Pesticide Exposure Assessment: A Crop Exposure Matrix', *International Journal of Epidemiology*, vol. 22 no.6, pp. S42 - S45.

Patton, JH; Stanford, MS; Barratt, ES 1995, „Factor structure of the Barratt Impulsiveness Scale', *Journal of Clinical Psychology,* vol. 51, pp. 768 – 774.

Patel, V; Abas, M; Broadhead, J; Todd, C; Reeler, A 2001, „Depression in developing countries: lessons from Zimbabwe', *BMJ,* vol. 322, pp.482 - 484.

Ramírez, JM; Andreu, JM 2006, „Aggression, and some related psychological constructs (anger, hostility, and impulsivity). Some comments from a research project', *Neuroscience and Behavioral Reviews,* vol. 30, pp. 276 - 291.

Rother, H-A & London L 1998, „Pesticide Health and Safety Policy Mechanisms in South Africa: The State of the Debate, Working Paper No.1', *Occupational &*

Environmental Health Research Unit, Department of Community Health, University of Cape Town.

Simcox, NJ; Fenske, RA; Wolz, SA; Lee, I-C; Kalman, DA 1995, „Pesticides in Household Dust and Soil: Exposure Pathways for Children of Agricultural Families', *Environmental Health Perspectives,* vol. 103, no. 12, pp. 1126 - 1134.

Simcox, NJ; Camp, J; Kalman, D; Stebbis, A; Bellamy, G; Lee, I; Fenske, R 1999, „Farmworkers Exposure to Organophosphate Pesticide Residues during Apple Thinning in Central Washington State', *American Industrial Hygiene Association Journal,* vol. 60, pp. 752 - 761.

Smetherham, J-A 2007, 'Deadly haze drifts in from the vineyards', *Cape Times,* 13 November, pp. 4 - 5.

Smetherham, J-A 2007, 'Farmers' arsenal of toxins claims a human toll', *Cape Times,* 13 November, p. 5.

South African Human Rights Commission 2007, *„South African farming communities still battle with human rights violations despite various government policies to bring about change',* Report issued by the Information and Communication Programme.

„South Africa's violent farms', *BBC News,* 03 September 2003. Retrieved 14 July 2009 from http://news.bbc.co.uk/2/hi/africa/320287.stm

Stallones, L & Beseler, C 2002, „Pesticide Poisoning and Depressive Symptoms among Farm Residents', *Ann Epidemiol,* vol. 12 no. 6, pp. 389 - 394.

Stanley, B; Molcho, A; Stanley, M; Winchel, R; Gameroff, MJ; Parsons, B; Mann, JJ 2000, „Association of Aggressive Behaviour with Altered Serotonergic

Function in Patients who are not Suicidal', *Am J Psychiatry,* vol. 157 no. 4, pp. 609 - 614.

Stewart, WF and Stewart, PA 1994, „Occupational Case-Control Studies: I. Collecting information on Work Histories and Work-Related Exposures', *American Journal of Industrial Medicine,* vol. 26, pp. 297 - 312.

Thundiyil, JG; Stober, J; Besbelli, N; Pronczuk, J 2008, „ Acute pesticide poisoning: a proposed classification tool**',** *Bulletin World Health Organisation,* vol. 86, no.3, pp. 205 - 209.

van Wendel de Joode B, 2004. „An Occupational DREAM: Development, evaluation and application of a DeRmal Exposure Assessment Method'. Chapter 3*,* PhD Thesis, Utrecht University. PrintPartners Ipskamp B.V.

Van Wijngaarden, E 2003, „An Exploratory Investigation of Suicide and Occupational Exposure', *JOEM,* vol. 45 no.1, pp. 96 - 101.

Van Wijngaarden, E 2003, „Mortality of Mental Disorders in Relation to Potential Pesticide Exposure', *JOEM,* vol. 45 no.5, pp. 564 - 568.

Winokur, G 1979, „Unipolar depression: Is it divisible into autonomous types?' *Arch Gen Psychiatry,* vol. 36, pp. 47 - 52.

World Socialist Web Site (WSWS) 2003, *South Africa: report reveals dire conditions facing farm workers.* Retrieved September 21, 2008 from www.wsws.org

Young, HA; Mills, PK; Riordan, D; Cress, R 2004, „Use of a crop and job specific exposure matrix for estimating cumulative exposure to triazine herbicides among females in a case-control study in the Central Valley of California', *Occupational Environmental Medicine*, vol. 61, no.11, pp. 945-951.

Zhang, J; Stewart, R; Phillips, M; Shi, Q; Prince, M 2009, „Pesticide exposure and suicidal ideation in rural communities in Zheijiang province, China', *WHO and Chinese Ministry of Health: Mental Health Project,* published online 28 July 2009.

CHAPTER 6

The most important asset in any industry / organization / institution is its workers or person power. As with all other industries, this philosophy is applicable to the agricultural industry as well. The farming workforce is a major component of the agricultural industry and the person(s) owning or managing the farms have a duty to provide a healthy and safe working and living environment for its workers (Occupational Health and Safety Act No.85 of 1993, Section 8(1)), since most farm workers reside on their place of employment.

6.1 Recommendations

The findings of this study suggest that environmental and safety issues (environmental exposure to pesticides, a lack of / or minimal protective clothing and past pesticide poisoning) and health and psychosocial issues (a past or current psychiatric illness, alcohol abuse and low socio economic status) were risk factors for depression and suicidality amongst grape farm workers in the Breede Valley. These findings should be extremely significant for the Breede Valley Municipality as 40% of their economic activity is concentrated in agriculture (Schroeder, 2002) and therefore their involvement in the recommended solutions for the adversities highlighted in this study is essential.

6.1.1 Environmental and Safety Issues

Spray drift reaching farm workers homes and the smell of pesticides in the home highlight the proximity of farm workers' residences to the vineyards and the lack / or inadequacy of pesticide regulatory practice to identify and monitor these hazards (Harrison, 2008).

Residing within the National Departments of Agriculture (DOA), Labour (DOL, Health (DOH) and Environmental Affairs and Tourism (DEAT) is the legal frameworks required to manage the health and safety of the occupational and residential environment of farm workers in South Africa. However, the enforcement of the existing legislation remains a prevailing challenge and requires an integrated, non-fragmented approach involving all these departments at national, provincial and local level. Some of the legislation that protects the agricultural environment and the health and safety of farm workers in the workplace are:

- Environmental rights under section 24 of the Constitution of South Africa (Act 108 of 1996, Chapter 2 „*Bill of Rights*'), 'everyone has the right to an environment that is not harmful to their health or well-being'.
- Section 8(1) of the Occupational Health and Safety Act (Act No. 85 of 1993) (OHSA), „every employer shall provide and maintain a working environment that is safe and without risk to the health of its employees'.
- Section 9 of the Occupational Health and Safety Act (Act No. 85 of 1993) (OHSA), „every employer shall conduct his undertaking in such a manner as to ensure that persons other than those in his employment who may be affected by his activities are not exposed to hazards to their health or safety'.
- The Environmental Conservation Act (Act No. 73 of 1989) makes provision for the protection of the natural environment.
- Fertiliser, Farm Feeds and Agricultural Remedies Act (Act No. 36 of 1947) regulates the registration process of pesticides, which is the responsibility of the National DOA. In terms of the registration process, labels are meant to indicate how pesticides can be applied safely without human exposure or environmental contamination. Once registered, applying a pesticide in violation of the label conditions becomes a criminal offence. Hence, this is an important, though under-enforced mechanism for occupational and environmental safety.
- The National Water Act (NWA) (Act No. 36 of 1998) facilitates the use of water resources in a sustainable manner, by the prevention and control of both point and non-point sources of water pollution
- Section 20 of the Health Act (Act No. 63 of 1977) states that every local authority has a responsibility to do everything lawful, necessary and reasonably practical to safeguard the health of any person within its jurisdiction by preventing the occurrence of any nuisance, water pollution or any other condition which could be harmful or dangerous to the health of these persons. Therefore, the management of environmental hazards like pesticide spray drift could be included in the realm of their functions.

Since agriculture is one of the primary pillars of the Western Cape Province's economy and the Western Cape produces between 55% and 60% of South Africa's agricultural exports, of which deciduous fruits and viticulture or two of the main contributors, the implementation of this national legislation which includes the regulation of pesticide use should be a priority for the relevant national and provincial departments. The current system is uncoordinated and chaotic because even though legislative mandates are given to the aforementioned and other relevant government departments, no one actually monitors the entire situation and therefore nothing is properly implemented (Rother & London, 1998; Rother et al, 2008). It may thus be beneficial to all stakeholders and role players in agriculture, to have the aforementioned departments adopt an integrated approach and appoint one specific inter-departmental government body to oversee and regulate the amendment, enforcement and monitoring of the relevant agricultural, pesticide and environmental legislation (terms and references for this government body will have to be developed by the constituent departments). The non-statutory committee, the Inter-Departmental Advisory Committee for the Protection of Man against Poisons (INDAC), which functions in an advisory capacity to the registrar of pesticides (DOA) could be transformed into this proposed inter-departmental government body.

The focus of this inter-departmental government body should be on human and environmental safety (Rother and London, 1998), including mandatory medical surveillance and biological monitoring of all farm workers (not only pesticide handlers) and agricultural labour practices. Farm owners and managers compliance with relevant occupational and labour legislation and practice should be monitored regularly and legal action instituted where there is failure to comply with legislation. Additionally, it should be mandated that the health department, as well as all other government departments, including the Compensation Commissioner for Occupational Injuries and Diseases (COID), report all cases of pesticide poisoning cases to the proposed inter-departmental body so that a database of these incidents can be maintained and incidents of poisoning investigated by the relevant authorities and followed up accordingly.

This inter-departmental government regulatory body should have the authority to develop and initiate pesticide policies that would be mandatory for farm owners and managers and thereby solutions to issues like environmental pesticide exposure could be addressed and monitored. Some of the ways in which the existing legislation could be used to minimize environmental exposure would be to

- Mandate farmers to inform farm workers and residents of the days that pesticide spraying will take place so that the necessary precautions can be taken to ensure the safety and protection of children, animals and the farm workers' homes
- Mandate the establishment of buffer zones between vineyards where pesticides are sprayed and workers' homes. Ongoing research into ways of reducing pesticide spray drift and its effects in the Netherlands, have found that „increasing unsprayed buffer zones around crops is critical to the success of any new strategy to prevent the harmful impact of pesticides' (European Commission, Environment DG, 2008). Another study conducted in the Netherlands (de Snoo & de Witt, 1998) found that a 6-metre buffer zone posed no risk to aquatic organisms despite a maximum wind speed of 4.5 metres/second.
- Enforce the removal of grapevines close to workers' homes, or the relocation of farm workers' houses to areas completely removed from the vineyards.
- Ensure that dams used as sources of drinking water are not positioned in or downwind from vineyards. Where this does occur, these dams should be firmly covered with suitable material and appropriately labeled
- Ensure that farm workers doing vineyard maintenance work are completely removed from the block being sprayed when spraying of pesticides takes place, and post spraying re-entry times into vineyards rigorously adhered to (this would involve developing regulations for re-entry)
- Ensure that all farm workers (irrespective of their gender) are provided with appropriate protective clothing and equipment (PPE) pertinent to the type of tasks they perform. This should apply to workers engaged in maintenance vineyard tasks, women and seasonal workers, as well.

The empowerment of farm owners, managers, all categories of farm workers and farm residents with knowledge of the signs and symptoms of pesticide poisoning and the need to seek immediate medical assistance should over-exposure occur is vital, to prevent cases of pesticide poisoning being ignored or minimized. Farmers should be encouraged to provide all workers with continuous training and education on all aspects of pesticide management and exposure; sources of environmental exposure; wearing of appropriate PPE; need for adherence to post-spraying re-entry times into vineyards and the dangers of using empty pesticide containers.

Academic and health institutions in agriculturally intensive areas should be encouraged to assist farmers with the training of their workers. It could form part of learners experiential / service learning or community outreach projects.

6.1.2 Health and Psychosocial Issues

The World Health Organization's (WHO) definition of health (1948) as „a state of complete physical, mental and social well-being, not only the absence of disease or infirmity' and the fact that „everyone has the right to an environment that is not harmful to their health or well-being' (South African Constitution, Act 108 of 1996, Chapter 2 „Bill of Rights'), should underpin the interventions to address health, safety and social issues affecting farm workers.

The findings of this study should be presented to The Department of Rural Development and Land Reform (former Department of Land Affairs) who is responsible for the national Comprehensive Rural Development Programme (CRDP). The CRDP is a national, collective strategy in the joint fight against poverty, hunger, unemployment and lack of development in rural areas. The CRDP's social and economic interventions in the rural areas will be based on the individual community's Integrated Development Plan (IDP), which is the platform for integrated and efficient implementation of the national plan at local level. Therefore the effectiveness of interventions already put in place by the Breede Valley Municipality's IDP (2002 – 2007) and Municipal Systems Act (Act 32 of 2000), which addresses issues of poverty reduction, management of alcohol abuse and improvement of mental health services for the rural and farming community should be assessed for further intervention by the CRDP.

One of the requirements of the proposed government regulatory body (suggested in section 6.1.1) should be to mandate local authorities in conjunction with the local Department of Labour, to conduct social audits to assess the current working and residential situation on farms and to determine whether conditions relevant to labour and health and safety legislation, are being met on all farms in South Africa, irrespective of international accreditation.

Sustainable core partnerships should be formed between government and municipal Departments of Health and Social Services, civil society, farmers' associations and the South African Agricultural Union to address possible solutions to the general and socio economic issues experienced by farm workers.

The DOH should work towards community psychiatric and social health services becoming more easily accessible and available to farm workers and other rural residents so that psychiatric and social conditions can be followed up at community health level. The DOH and farmer and farm worker associations should develop a closer working relationship regarding solutions to providing optimal health for farm workers. Additionally, farmers should be encouraged to implement Occupational Health Services into the grape farming industry as this could play an important role in improving health and social conditions for farm workers. This would also be in line with the South African government's ratification of the C155 Occupational Health and Safety Convention, 1981 (supplemented by P155 Protocol of 2002) of the International Labour Organisation (ILO) in June 2004. Moreover, all farms should be encouraged to have a minimum of one trained farm health worker to be the liaison person between farm workers and the health services. This farm health worker should be encouraged to liaise with community and non-governmental organizations, who can assist with life skills and other training programs for workers. In this way, organizations like Alcoholics Anonymous (AA) can be invited to present talks and programs to workers with problems of alcohol abuse.

The Comprehensive Agriculture Support Programme (CASP) that resides in the DOA and focuses on on-and-off farm infrastructure and capacity building training courses can be approached by farmers and other relevant role players and stakeholders to present life-skills and empowerment training programs to all levels of farm workers. The monitoring of the inclusion of women and general farm workers in this training should be one of the functions of the proposed inter-departmental government body.

6.2. Areas for further research

Given the limitations of this cross-sectional survey conducted in 2002, it is recommended that

- future studies in the grape farming sector be designed as cohort studies to determine the directionality of any association of pesticide exposure with any of the neuropsychiatric outcomes related to depression and suicidality and to partly reduce the consequences of the healthy worker effect.
- further exploratory or descriptive studies be conducted on the wine grape farming sector to establish the true nature / magnitude of pesticide exposure in this area of farming
- exposures may have changed temporally; therefore, data should be collected over time on table and wine grape farms to track any trends for future studies.
- methods of exposure assessment that have better reliability and validity be developed to maximize the quality of data collected as sole reliance on job history recall and measurement of frequency and intensity of pesticide spraying as a measure of cumulative exposure, may not be suitable for this group of workers
- more attention be given to the characterization of pesticide exposure in general farm workers with particular reference to pesticide residues on vines and post-spraying re-entry time into vineyards

It is suggested that any future research should pay attention to the following areas in greater depth

- To be more precise when including a history of past pesticide poisoning as a measure of exposure in future research, as the symptoms of pesticide poisoning could mimic the symptoms of other communicable diseases that commonly affect marginalized impoverished communities like farm workers (Bwititi et al, 1987; Gomes et al, 1998).
- To develop more precise measurements of psychiatric illness than „nerves’
- Environmental exposure and biomarkers for exposure should factored into existing or revised Job Exposure Matrices to provide better estimates of exposure
- The extent of alcohol abuse in the grape farming sector and the reasons for their alcohol abuse

The following future studies are suggested:

(a) Cohort and qualitative studies on the same study population to assess the impact of regulatory organizations like EurepGap, Nature’s Choice, and the IDP processes on the working and living conditions and mental health status of farm workers

(b) Studies exploring: (1) discrimination against women in agricultural work and gender differences in the distribution of farm work, particularly the more skilled farming tasks; (2) whether child labour is still being practiced in the farming industry; (3) farm workers knowledge, attitude and practice regarding their labour rights

It is proposed that every municipality attached to an agricultural sector attempt to maintain an updated database of farm worker population statistics (at least permanent and constant seasonal farm workers), which is readily accessible and available for planning community and health interventions, and research purposes.

6.3 References

Bwititi, T; Chikuni, O; Loewenson, R; Murambiwa, W; Nhachi, C; Nyazema, N 1987, „Health Hazards in Organophosphate Use among Farm Workers in the Large-scale Farming Sector', *Central African Journal of Medicine,* vol. 33 no. 5, pp. 120 – 126

De Snoo, GR; de Witt, PJ 1998, „Buffer Zones for Reducing Pesticide Drift to Ditches and Risks to Aquatic Organisms', *Ecotoxicology and Environmental Safety*, vol. 41, no.1, pp. 112 - 118.

European Commission, Environment DG 2008, „Reducing the negative impacts of pesticides', *CBI Polymers DeconGel.* Retrieved February 04, 2010 from http://www.bufferzone.info/Reducing the negative impacts of pesticides on Environmental Expert.html

Harrison J 2008, „Lessons learned from pesticide drift: a call to bring production agriculture, farm labour, and social justice back into agrifood research and activism', *Agric Hum Values,* vol. 25, pp. 163 - 167.

Gomes, J; Lloyd, O; Revitt, MD; Basha, M 1998, „Morbidity among farm workers in a desert country in relation to long-term exposure to pesticides', *Scand J Work Environ Health,* vol. 24 no. 3, pp. 213 - 219.

Rother H-A, London L 1998, „Pesticide Health and Safety Policy Mechanisms in South Africa: The State of the Debate', *Occupational & Environmental Health Research Unit Working Paper No.1,* Department of Community Health, University of Cape Town.

Rother, H-A; Hall, R; London, L 2008, „Pesticide use among farmers in South Africa: contributing factors and stakeholder perceptions', *Development Southern Africa,* vol. 25, no. 4, pp. 399 - 424.

Schroeder CV, 2002, *Breede Valley Municipality Final IDP Document 2002 – 2007*.

World Health Organization 1948, *Preamble to the Constitution of the World Health Organization,* Official Records of the World Health Organization, no. 2, p. 100.

APPENDIX A

CONSENT FORMS

(English and Afrikaans translations)

CONSENT TO PARTICIPATE IN A STUDY ON THE EFFECTS OF ORGANOPHOSPHATE PESTICIDES ON FARM WORKERS

1. Title of Research Project

The role of organophosphate pesticides in the causation of depression amongst farm workers

2. Purpose of the Research Project

The University of Cape Town, in partnership with Peninsula Technikon and Utrecht University, Holland, is conducting this study to determine whether there is any relationship between long term exposure to organophosphate pesticides and depression and suicide amongst farm workers.

3. Description of the Research Project

Once we have obtained your written consent to participate in the study, the following will happen:
A research assistant, using a structured questionnaire, will interview you. The interview will last approximately one-and-a-half hours.
On completing the questionnaire, a nurse will do a finger prick test to obtain a blood sample to measure the effect/level of organophosphate pesticides in your blood. This finger prick test will be repeated in October/November 2002.

4. Expected benefits to you and others

The study will give an indication of your current mental health status. Should it be found that you are depressed, the study will indicate the cause of the depression. You will then be referred to the appropriate health facility in your area for follow-up management. Treatment of the depression will help you to live a more active and happy life, and may improve your relationships with your family and friends.
The finger prick blood test will indicate whether you have been exposed to increased levels of organophosphate pesticides or not.

5. Costs to you resulting from participation in the study

The study is offered at no cost to you.

6. Confidentiality of information collected

You will not be personally identified in any reports on this study.

7. Documentation of the consent

One copy of this document will be kept together with our research records on this study. A second copy will be given to you to keep.

8. Contact person

You may contact the following person for answers to further questions about the research, your rights, or any injury you may feel is related to the study:

NAME OF PERSON: Ms Vicky Major
TELEPHONE: 021 – 959 6352/6274
CELLPHONE: 082 2020646
FAX: 021 – 959 6015

9. Consent of the Participant

I have read the information given above. I understand the meaning of this information.

I hereby consent to participate in the study.

-- -------------------------------------
Printed Name of Participant Signature

-- -------------------------------------
Printed Name of Interviewer Signature

Date: ……………………………………..

TOESTEMMING OM TE DEEL AAN 'N STUDIE OP DIE UITWERKING VAN ORGANOFOSFAAT GIFSTOWWE OP PLAASWERKERS

Hierdie studie ondersoek die verwantskap tussen organofosfaat gifstowwe en depressie by plaaswerkers. Die title van die projek is die rol van organofosfaat gifstowwe as 'n oorsaak van depressie by plaaswerkers.

Die studie word gelei deur navorsingpersone van die Universiteit van Kaapstad, die Skiereiland Technikon en Utrecht Universiteit, Holland. As gevolg van die studie, hoop ons te verstaan of daar enige verwantskap bestaan tussen langtermyn blootstelling aan organofosfaat gifstowwe, depressie en selfmoord by plaaswerkers, en die verbetering van gesondheid en veilighed te aanbeveel.

Wat sal gebeur in hierdie studie, is dat daardie werkers wie instem om aan die studie deel te neem, sal:

- Deur „n navorsingsassistent ondervra word Die onderhoud sal ongeveer een en „n half uur duur, en sal vrae omtrent u agtergrond, u gesondheid, u werksgeskiedenis en hoe u voel, insluit.
- Nadat die vraelys voltooi is, sal „n verpleegster „n vingerprik doen om „n bloedmonster te verkry om die effek/vlak van organofosfaat in u bloed te bepaal.
- Hierdie vingerprik toets sal herhaal word in Oktober/November 2002.
- Al die inligting wat ons kollekteer sal vertroulik gehou word. Hierdie inligting sal aan niemand gegee word sonder u toestemming nie. U sal nie persoonlik geïdentifiseer word in enige verslae van die studie nie.
- Indien ons gedurende die studie, 'n rede vind om u na 'n gesondheidsfasiliteit te verwys, sal ons aan u verduidelik wat fout is en u toestemming kry om inligting omtrent u gesondheid aan die dokter of verpleegster te verskaf.
- Indien daar gedurende die studie, bewys word dat u aan gifstowwe blootgestel word, sal ons die bevindings aan u verduidelik en u toestemming kry om 'n aanbeveling te maak aan u werkgewer om u van die blootstelling te verwyder.

Werkers moet vrywillig instem om in die studie deel te neem. Niemand kan u dwing om 'n deelnemer te wees, as u nie wil nie. Nietemin, as u gewillig is om deel te neem, sal u gevra word om te teken (as u nie kan skryf nie, moet u 'n merk maak in die teenwoordigheid van nog 'n persoon/getuie) aan die einde van hierdie vorm, om te bewys dat u toestem om 'n deelnemer te wees.
Onthou, as u nie wil deelneem nie, sal nie gemaak te laat boet nie. As u op enige tydstip voel dat u uit die studie wil onttrek, is u vry om dit te doen.

Verwagte voordele vir u en ander

- Die studie sal „n indikasie gee van u huidige stand van geestesgesondheid
- Indien daar gevind word dat u aan enige mediese probleme ly, sal u verwys word na die toepaslike gesondheidsfasiliteit in u area, vir opvolg bestuur /behandeling.
- Behandeling van die depressie sal daartoe bydra dat u „n meer aktiewe en gelukkige lewe lei wat u verhoudings met u familie en vriende behoort te verbeter.
- Die vingerprik bloedtoets sal aandui of u aan verhoogde vlakke van organofosfaat gifstowwe blootgestel was, al dan nie. Ons sal aanbevele maak om te help met die monitor van werkers, om toekomstige blootstelling te verhoed.

Hierdie studie word teen geen koste aan u aangebied

Een kopie van hierdie dokument sal saam met ons navorsingsrekords bewaar word.
„n Tweede kopie sal aan u gegee word om te hou. Aan die einde van die studie, sal 'n rekord van u mediese bevindings en 'n verduideling daarvan, aan u verskaf word.

U mag die volgende persoon kontak vir antwoorde op verder vrae in verband met die navorsing, u regte of enige besering wat u voel hou verband met die studie.

NAAM VAN PERSOON:	Me Vicky Major
TELEFOON:	(021) 959 6352/6274
FAKS:	(021) 959 6093/6015
SELFOON:	082 2020646

Toestemming van deelnemer:

Ek het die inligting gelees soos hierbo uiteengesit. Ek verstaan wat bedoel word met die informasie.

Hiermee verleen ek my toestemming om aan die studie deel te neem.

__________________________ ________________

Gedrukte naam van deelnemer **Handtekening**

__________________________ ________________

Gedrukte naam van ondervraer **Handtekening**

Datum: __________________________

__________________________ ______________________

Gedrukte naam van Getuie **Handtekening**
(indien deelnemer nie sy naam
kan skryf nie)

APPENDIX B

EXPOSURE & OUTCOME QUESTIONNAIRES

(English and Afrikaans)

General health questionnaire

1. In the past two months, have you been feeling perfectly well and in good health?

Better than usual ❸
Same as usual ❸
Worse than usual ❸
Much worse than usual ❸

2. In the past two months, have you been feeling in need of a good tonic?

Not at all ❸
No more than usual ❸
Rather more than usual ❸
Much more than usual ❸

3. In the past two months, have you been feeling run down and out of sorts?

Not at all ❸
No more than usual ❸
Rather more than usual ❸
Much more than usual ❸

4. In the past two months, have you felt that you are ill?

Not at all ❸
No more than usual ❸
Rather more than usual ❸
Much more than usual ❸

5. In the past two months, have you been getting any pains in your head?

Not at all ❸
No more than usual ❸
Rather more than usual ❸
Much more than usual ❸

6. In the past two months, have you been getting a feeling of tightness or pressure in your head?

Not at all ❸
No more than usual ❸
Rather more than usual ❸
Much more than usual ❸

7. In the past two months, have you been having hot or cold spells?

Not at all
No more than usual
Rather more than usual
Much more than usual

8. In the past two months, have you lost much sleep over worry?

Not at all
No more than usual
Rather more than usual
Much more than usual

9. In the past two months, have you had difficulty in staying asleep once you are off?

Not at all
No more than usual
Rather more than usual
Much more than usual

10. In the past two months, have you felt constantly under strain?

Not at all
No more than usual
Rather more than usual
Much more than usual

11. In the past two months, have you been getting edgy and bad-tempered?

Not at all
No more than usual
Rather more than usual
Much more than usual

12. In the past two months, have you been getting scared or panicky for no good reason?

Not at all
No more than usual
Rather more than usual
Much more than usual

13. In the past two months, have you found everything getting on top of you?

Not at all ❸
No more than usual ❸
Rather more than usual ❸
Much more than usual ❸

14. In the past two months, have you been feeling nervous and strung-up all the time?

Not at all ❸
No more than usual ❸
Rather more than usual ❸
Much more than usual ❸

15. In the past two months, have you been managing to keep yourself busy and occupied?

More so than usual ❸
Same as usual ❸
Rather less than usual ❸
Much less than usual ❸

16. In the past two months, have you been taking longer over the things that you do?

Quicker than usual ❸
Same as usual ❸
Longer than usual ❸
Much longer than usual ❸

17. In the past two months, have you felt on the whole that you were doing things well?

Better than usual ❸
About the same ❸
Less than usual ❸
Much less well ❸

18. In the past two months, have you been satisfied with the way you've carried out your tasks?

More so than usual ❸
Same as usual ❸
Less so than usual ❸

Much less than usual ❸ ❸

19. In the past two months, have you felt that you are playing a useful part in things?

More so than usual ❸ ❸
Same as usual ❸ ❸
Rather less than usual ❸ ❸
Much less than usual ❸ ❸

20. In the past two months, have you felt capable of making decisions about things?

More so than usual ❸ ❸
Same as usual ❸ ❸
Rather less than usual ❸ ❸
Much less than usual ❸ ❸

21. In the past two months, have you been able to enjoy your normal day-to-day activities?

More so than usual ❸ ❸
Same as usual ❸ ❸
Rather less than usual ❸ ❸
Much less than usual ❸ ❸

22. In the past two months, have you been thinking of yourself as a worthless person?

Not at all ❸ ❸
No more than usual ❸ ❸
Rather more than usual ❸ ❸
Much more than usual ❸ ❸

23. In the past two months, have you felt that life is entirely hopeless?

Not at all ❸ ❸
No more than usual ❸ ❸
Rather more than usual ❸ ❸
Much more than usual ❸ ❸

24. In the past two months, have you felt that life isn't worth living?

Not at all ❸ ❸
No more than usual ❸ ❸
Rather more than usual ❸ ❸
Much more than usual ❸ ❸

25. In the past two months, have you thought of the possibility that you might make away with yourself?

Definitely not ❸
I don't think so ❸
Has crossed my mind ❸
Definitely have ❸

26. In the past two months, have you found at times you couldn't do anything because your nerves were too bad?

Not at all ❸
No more than usual ❸
Rather more than usual ❸
Much more than usual ❸

27. In the past two months, have you found yourself wishing you were dead and away from it all?

Not at all ❸
No more than usual ❸
Rather more than usual ❸
Much more than usual ❸

28. In the past two months, have you found that the idea of taking your own life kept coming into your own mind?

Definitely not ❸
I don't think so ❸
Has crossed my mind ❸
Definitely have ❸

BECK DEPRESSION INVENTORY

This part of the questionnaire looks at feelings of sadness and other difficulties which many people experience at some point in their lives.

This questionnaire is arranged in groups of statements. Please read each group carefully.

Then pick out ONLY ONE statement in each group which best describes the way you have been feeling OVER THE PAST FOUR WEEKS including today. Tick the box beside the statement you picked. Be sure to read all the statements in each group before making your choice.

1. a. I do not feel sad. ☐
   b. I feel sad. ☐
   c. I am sad all the time but I can't snap out of it. ☐
   d. I am so sad or unhappy that I can't snap out of it. ☐ ☐

2

2. a. I am not particularly discouraged about the future. ☐
   b. I feel discouraged about the future. ☐
   c. I feel I have nothing to look forward to. ☐
   d. I feel that the future is hopeless and that things can't improve. ☐ ☐ **3**

3. a. I do not feel like a failure. ☐
   b. I feel I have failed more than the average person. ☐
   c. As I look back on my life all I can see is a lot of failures. ☐
   d. I feel I am a complete failure as a person. ☐ ☐ **4**

4. a. I get as much satisfaction out of things as I used to. ☐
   b. I don't enjoy things the way I used to. ☐
   c. I don't get real satisfaction out of anything anymore. ☐
   d. I am dissatisfied or bored with everything. ☐ ☐

5. a. I don't feel particularly guilty. ☐
   b. I feel guilty a good part of the time. ☐
   c. I feel quite guilty most of the time. ☐
   d. I feel guilty all of the time. ☐ ☐

6. a. I don't feel I am being punished. ☐
   b. I feel I may be punished. ☐
   c. I expect to be punished. ☐
   d. I feel I am being punished. ☐ ☐

7

7. a. I don't feel disappointed in my self. ☐
   b. I am disappointed in myself. ☐
   c. I am disgusted in myself. ☐
   d. I hate myself. ☐ ☐

8

8. a. I don't feel I am any worse than anybody else. ☐
b. I am critical of myself for my weaknesses or my mistakes. ☐
c. I blame myself all the time for my faults. ☐
d. I blame myself for everything bad that happens. ☐ ☐

9. a. I don't have any thought of killing myself. ☐
b. I have thoughts of killing myself but I would not carry them out. ☐
c. I would like to kill myself. ☐
d. I would kill myself if I had the chance. ☐ ☐

10

10. a. I don't cry any more than usual. ☐
b. I cry more than I used to. ☐
c. I cry all the time now. ☐
d. I used to be able to cry, but now I can't cry even when I want to ☐ ☐

11

11. a. I am no more irritated now than I ever am. ☐
b. I get annoyed or irritated more easily than I used to. ☐
c. I feel irritated all the time now. ☐
d. I don't get irritated at all by the things that used to irritate me. ☐ ☐

12

12. a. I have not lost interest in other people. ☐
b. I am less interested in other people than I used to be. ☐
c. I have lost most of my interest in other people. ☐
d. I have lost all my interest in other people. ☐ ☐

13

13. a. I make decisions about as well as I ever could. ☐
b. I put off making decisions more than I used to. ☐
c. I have greater difficulty in making decisions than before. ☐
d. I can't make decisions at all any more. ☐ ☐

14. a. I don't feel I look any worse than I used to. ☐
b. I am worried that I am looking old and unattractive. ☐
c. I feel that there are permanent changes in my appearance and they make me look unattractive. ☐
d. I feel I am ugly or repulsive looking. ☐ ☐

15

15.	a.	I can work about as well as before.	☐
	b.	It takes extra effort to get started at doing something.	☐
	c.	I have to push myself very hard to do anything.	☐
	d.	I can't do any work at all.	☐ ☐
			16
16.	a.	I can sleep as well as usual.	☐
	b.	I don't sleep as well as I used to.	☐
	c.	I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.	☐
	d.	I wake up several hours earlier than I used to and cannot get back to sleep.	☐ ☐
17.	a.	I don't get more tired than usual.	☐
	b.	I get tired more easily than I used to.	☐
	c.	I get tired from doing almost anything.	☐
	d.	I am too tired to do anything.	☐ ☐
18.	a.	My appetite is no worse than normal.	☐
	b.	My appetite is not as good as it used to be.	☐
	c.	My appetite is much worse now.	☐
	d.	I have no appetite at all anymore.	☐ ☐
			19
19.	a.	I have not lost much weight, if any, lately.	☐
	b.	I have lost more than 2 kilograms (5 pounds).	☐
	c.	I have lost more than 4 kilograms (10 pounds).	☐
	d.	I have lost more than 6 kilograms (15 pounds).	☐ ☐
			20
20.	a.	I am no more worried about my health than usual.	☐
	b.	I am worried about my physical problems such as aches and pains, or upset stomach, or constipation.	☐
	c.	I am very worried about my physical problems and it's hard to think of much else.	☐
	d.	I am so worried about my physical problems that I cannot think about anything else.	☐ ☐
21.	a.	I have not noticed any recent change in my interest in sex.	☐
	b.	I am less interested in sex than I used to be.	☐
	c.	I am much less interested in sex now.	☐
	d.	I have lost interest in sex completely.	☐ ☐
			22

Additional Suicidal Ideation Questions

22. During the past 12 months have you ever seriously thought about injuring yourself in a manner that may cause your death?

Yes ☐ No ☐

If yes, when last did it happen:..

23. During the past 12 months did you ever tell someone that you were planning to end you life?

Yes ☐ No ☐

If yes, when last did it happen:……………………………………………………

24. During the past 12 months have you ever really tried to end your life?

Yes ☐ No ☐

If yes, when last did it happen:……………………………………………………

25. Have any of your attempts at self-injury, poisoning or overdose, result in you having to be treated by a doctor or nurse?

Yes ☐ No ☐

Part 3 – Brief Symptom Inventory (BSI)
(Interviewer write the answer of the worker, according to the given ratings, in the appropriate block)

NOT AT ALL	***0***
A LITTLE BIT	***1***
MODERATELY	***2***
QUITE A BIT	***3***
EXTREMELY	***4***

This is a list of problems that people sometimes experience. Please. listen to each one carefully and choose the one which best describes THE EXTENT TO WHICH THIS PROBLEM HAS UPSET/DISTURBED YOU DURING THE PAST 7 DAYS, INCLUDING TODAY

1. .Nervousness or shakiness inside.	☐
2. Faintness or dizziness	☐
3. The idea that someone else can control your thoughts.	☐
4. Feeling others are to blame for most of your troubles	☐
5. Trouble remembering things	☐
6. Feeling easily annoyed or irritated	☐
7. Pains in heart or chest	☐
8. Feeling afraid in open spaces or on street	☐
9. Thoughts of ending your life	☐
10. Feeling that most people cannot be trusted	☐
11. Poor appetite	☐
12. Suddenly scared for no reason	☐
13. Temper outbursts that you could not control	☐
14. Feeling lonely even when you are with people	☐
15. Feeling blocked in getting things done	☐
16. Feeling lonely	☐
17. Feeling blue	☐
18. Feeling no interest in anything	☐
19. Feeling fearful	☐
20. Your feelings being easily hurt	☐

21. Feeling that people are unfriendly or dislike you	☐
22. Feeling inferior to others	☐
23. Nausea or upset stomach	☐
24. Feeling that you are watched or talked about by others	☐
25. Trouble falling asleep	☐
26. Having to check and double-check what you do	☐
27. Difficulty making decisions	☐
28. Feeling afraid to travel on buses, subways or trains	☐
29. Trouble getting your breath	☐
30. Hot or cold spells	☐
31. Having to avoid certain things, places, or activities because they frighten you	☐
32. Your mind going blank	☐
33. Numbness or tingling in parts of your body	☐
34. The idea that you should be punished for your sins	☐
35. Feeling hopeless about the future	☐
36. Trouble concentrating	☐
37. Feeling weak in parts of your body	☐
38. Feeling tense or keyed up	☐
39. Thoughts of death or dying	☐
40. Having urges to beat, injure, or harm someone	☐
41. Having urges to break or smash things	☐
42. Feeling very self-conscious with others.	☐
43. Feeling uneasy in crowds, such as shopping or at a movie	☐
44. Never feeling close to another person	☐
45. Spells of terror or panic	☐
46. Getting into frequent arguments	☐
47. Feeling nervous when you are left alone	☐
48. Others not giving you proper credit for your achievements	☐
49. Feeling so restless you couldn't sit still	☐
50. Feelings of worthlessness.	☐

51. Feeling that people will take advantage of you if you let them.	☐
52. Feelings of guilt.	☐
53. The idea that something is wrong with your mind	☐

Part 4 – REFINED FOUR-FACTOR MEASUREMENT MODEL OF THE AGGRESSION QUESTIONNAIRE

(Interviewer to use a number line ranging from 1 – 6)

The following questions deal with the way you sometimes feel and act:

Please, answer the questions using a scale of 1 – 6, ranging from:

(1) extremely uncharacteristic of me, TO
(6) extremely characteristic of me

1. Given enough provocation, I may hit another person.
2. There are people who pushed me so far that we came to blows.
3. There are times when I have threatened people I know
4. I often find myself disagreeing with people
5. I can't help getting into arguments when people disagree with me
6. My friends say that I am somewhat argumentative
7. I flare up quickly but get over it quickly
8. Sometimes I fly off the handle for no good reason
9. I have trouble controlling my temper
10. At times I feel I have gotten a raw deal out of life
11. I feel that other people always seem to get the breaks
12 I wonder why sometimes I feel so bitter about things

Part 5 – BARRAT IMPULSIVENESS SCALE (BIS – II)

The following questions look at the way you act/react in situations on a daily basis.

Please, answer the questions using the options indicated.

1. You "squirm" at plays/lectures(training sessions or talks)

Rarely/Never❸ ❸
Occasionally❸ ❸
Often❸ ❸
Almost Always/Always❸ ❸

2. You are restless at the theatre/lectures (during training sessions /talks)

Rarely/Never❸ ❸
Occasionally❸ ❸
Often❸ ❸
Almost Always/Always❸ ❸

3. You don't "pay attention" (when someone talks to you/during a training session)

Rarely/Never❸ ❸
Occasionally❸ ❸
Often❸ ❸
Almost Always/Always❸ ❸

4. You concentrate easily (when you have to learn to do something)

Almost Always/Always❸ ❸
Often❸ ❸
Occasionally❸ ❸
Rarely/Never❸ ❸

5 You are a steady thinker

Almost Always/Always❸ ❸
Often❸ ❸
Occasionally❸ ❸
Rarely/Never❸ ❸

6. You act "on impulse"

Rarely/Never❸ ❸
Occasionally❸ ❸
Often❸ ❸
Almost Always/Always❸ ❸

7. You act on the spur of the moment

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

8. You buy things on impulse

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

9. You make up your mind quickly (when you have to decide on something)

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

10 You do things without thinking (of the consequences)

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

11. You spend or charge ("buy on tick") more than you earn

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

12. You are happy-go-lucky

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

13. You are a careful thinker

Almost Always/Always ❸
Often ❸
Occasionally ❸
Rarely/Never ❸

14 You plan tasks carefully

Almost Always/Always ❸
Often ❸
Occasionally ❸
Rarely/Never ❸

15. You are self-controlled

Almost Always/Always ❸
Often ❸
Occasionally ❸
Rarely/Never ❸

16. You plan trips (tasks) well ahead of time

Almost Always/Always ❸
Often ❸
Occasionally ❸
Rarely/Never ❸

17. You plan for job security (how you will not be replaced in your job/position)

Almost Always/Always ❸
Often ❸
Occasionally ❸
Rarely/Never ❸

18. You say things without thinking

Rarely/Never ❸
Occasionally ❸
Often ❸
Almost Always/Always ❸

19. You like to think about complex problems

Almost Always/Always ❸

Often❸
Occasionally❸
Rarely/Never❸

20. You like puzzles

Almost Always/Always❸
Often❸
Occasionally❸
Rarely/Never❸

21. You save regularly

Almost Always/Always❸
Often❸
Occasionally❸
Rarely/Never❸

22. You are more interested in the present than the future

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

23. You get easily bored when solving thought problems
(You lose interest quickly when solving problems you have to think about)

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

24. You change residences quite frequently

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

25. You change jobs quite frequently

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

26. You are future oriented (plan for the future)

Almost Always/Always❸
Often❸
Occasionally❸
Rarely/Never❸

27. You can only think about one problem at a time

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

28. You often have extraneous thoughts when thinking (When thinking/concentrating on a specific thing, you often have other irrelevant thoughts)

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

29. You have "racing" thoughts

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

30. You change hobbies

Rarely/Never❸
Occasionally❸
Often❸
Almost Always/Always❸

Part 6 – SCALE FOR SUICIDE IDEATION

(NB – *Interviewers, please note the responses to the following questions. If the rating is 30 and above, it indicates that the farm worker is extremely suicidal. This person must be referred to me immediately for further assessment, and possible referral to the relevant health authority)*

You are required to answer the following questions according to the three (3) options indicated:

1. (How strong is your) wish to live

Moderate to Strong❸
Weak❸
None❸

2. (How strong is your) wish to die

None❸
Weak❸
Moderate to Strong❸

3. (Which is stronger – your) reasons for living/dying

For living outweigh for dying❸
About equal❸
For dying outweigh for living❸

4. (How strong is your) desire to make (an) active suicide attempt

None❸
Weak❸
Moderate to Strong❸

5. (How would you describe your) passive suicidal desire

Would take precautions to save life❸
Would leave life/death to chance❸
Would avoid steps necessary to save or maintain life❸

6. Time dimension: Duration of suicide ideation/wish
(When you think about committing suicide, for how long do these thoughts last)

Brief, fleeting periods❸
Longer periods❸
Continuous (chronic) or almost continuous❸

7. Time dimension: Frequency of suicide
(How often do you think about committing suicide)

Rare, occasional❸
Intermittent❸
Persistent or continuous❸

8. Attitude towards ideation/wish

(How do you feel about suicidal ideation/wish)

Rejecting❸
Ambivalent; indifferent❸
Accepting❸

9. (Do you have any) control over suicidal action/acting - out wish

Has sense of control❸
Unsure of control❸
Has no sense of control❸

10. Deterrents to active attempt [e.g., family, religion, irreversibility]
(What role would deterrents play in you actively committing/attempting to commit suicide)

Would not attempt because of a deterrent❸
Some concern about deterrents❸
Minimal or no concern about deterrents❸

11. (What is your) reason for contemplating an attempt

To manipulate the environment; get attention/revenge❸
Combination of 0 & 2❸
Escape, surcease, solve problems❸

12. Method: Specificity/planning of contemplated event
(What method will you use to commit suicide)

Not considered❸
Considered, but details not worked out❸
Details worked out/well formulated❸

13. Method: Availability/opportunity for contemplated attempt
(What is the availability of the method being contemplated)

Method not available; no opportunity❸
Method would take time/effort opportunity not readily available❸
(a)Method & opportunity available❸
(b)Future opportunity/availability of method anticipated❸

14. Sense of "capability" to carry out attempt
(How capable are you of carrying out a suicidal attempt)

No courage; too weak; afraid;incompetent ❸
Unsure of courage/competence❸
Sure of competence/courage❸

15. Expectancy/anticipation of actual attempt
(When will actual attempt occur)

No
Uncertain; not sure
Yes

16. (What) actual preparation (have you made)for the contemplated attempt

None
Partial (e.g., staring to collect pills)
Complete(e.g., have pills, etc.)

17. (Have you written a) suicide note

None
Started, but not completed; only thought about it
Completed

18. (Have you completed any) final acts in anticipation of death(e.g. insurance, will, burial policy)

None
Thought about or made some arrangements
Made definite plans or completed arrangements

19. Deception/Concealment of contemplated suicide (Have you mentioned your thoughts/plans about the contemplated suicide to anyone)

Revealed ideas openly
Held back on revealing
Attempted to deceive, conceal, lie

GENERAL HEALTH QUESTIONNAIRE (AFRIKAANS)

(Onderhoudvoerder merk met (X) in die toepaslike blok)

Nou 'n paar vrae oor jou algemene gesondheid.

1. Het jy oor die **afgelope** twee maande heeltemal goed en gesond gevoel?

Beter as gewoonlik

Dieselfde as gewoonlik

Slegter as gewoonlik

Baie slegter as gewoonlik

2. Het jy oor die afgelope twee maande gevoel dat jy „n tonikum

nodig het?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

3 Het jy oor die afgelope twee maande afgemat, en olik gevoel?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

4. Het jy in die afgelope twee maande gevoel dat jy siek is?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

5. Het jy in die afgelope twee maande pyne in jou kop gekry?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

6. Het jy in die afgelope twee maande „n drukking of spanning in jou kop gevoel?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

7. Het jy in die afgelope twee maande soms koud en dan weer warm gekry?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

8. Het jy in die afgelope twee maande baie slaap verloor as gevolg van bekommernis?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

9. Het jy in die afgelope twee maande gesukkel om aan die slaap te bly nadat jy aan die slaap geraak het?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

10. Het jy in die afgelope twee maande gevoel dat jy gedurig in spanning of onder druk verkeer?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

11. Het jy in die afgelope twee maande gevoel dat jy prikkelbaar/gespanne en humeurig is?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

12. Het jy in die afgelope twee maande vir geen rede bang of paniekerig begin gevoel?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

13 Het jy in die afgelope twee maande gevoel dat alles net te veel vir jou geword het?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

14. Het jy in die afgelope twee maande die hele tyd senuweeagtig en gespanne gevoel?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

15. Het jy in die afgelope twee maande daarin geslaag om jouself besig te hou?

Meer as gewoonlik

Dieselfde as gewoonlik

Nogal minder as gewoonlik

Baie minder as gewoonlik

16. Het jy in die afgelope twee maande langer geneem met dit wat jy moet doen?

Vinniger as gewoonlik

Dieselfde as gewoonlik

Langer as gewoonlik

Baie langer as gewoonlik

17. Het jy in die afgelope twee maande gevoel dat jy dit wat jy moet doen oor die algemeen goed gedoen het?

Beter as gewoonlik

Omtrent dieselfde

Minder as gewoonlik

Baie minder as gewoonlik

18. Het jy in die afgelope twee maande tevrede gevoel met die manier waarop jy jou werk gedoen het?

Meer as gewoonlik

Dieselfde as gewoonlik

Minder as gewoonlik

Baie minder as gewoonlik

19. Het jy in die afgelope twee maande gevoel dat jy „n nuttige rol speel in die lewe?

Meer as gewoonlik

Dieselfde as gewoonlik

Nogal minder as gewoonlik

Baie minder as gewoonlik

20. Het jy in die afgelpoe twee maande gevoel dat jy besluite oor sake kan neem?

Meer as gewoonlik

Dieselfde as gewoonlik

Nogal minder as gewoonlik

Baie minder as gewoonlik

21. Het jy in die afgelope twee maande daarin geslaag om jou normale alledaagse bedrywighede te geniet?

Meer as gewoonlik

Dieselfde as gewoonlik

Nogal minder as gewoonlik

Baie minder as gewoonlik

22. Het jy in die afgelope twee maande aan jouself as „n nuttelose persoon gedink?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik.

23. Het jy in die afgelope twee maande gevoel dat jou lewe heeltemal hopeloos is?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

24. Het jy in die afgelope twee maande gevoel dat die lewe nie die moeite werd is nie?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

25. Het jy in die afgelope twee maande aan die moontlikheid gedink om „n einde aan jou lewe te maak?

Definitief nie

Ek dink nie so nie

Dit het deur my gedagte gegaan

Dit het definitief.

26. Het jy in die afgelope twee maande gevind dat jy by tye niks kon doen nie omdat jou senuwees te sleg was?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

27. Het jy in die afgelope twee maande gewens dat jy dood was en weg van alles was?

Glad nie

Nie meer as gewoonlik nie

Nogal meer as gewoonlik

Baie meer as gewoonlik

28. Het jy in die afgelope twee maande gevind dat die idee om jou eie lewe te neem aanmekaar deur jou gedagte geflits het?

Definitief nie

Ek dink nie so nie

Dit het deur my gedagte gegaan

Definitief

Part 2 – BECK DEPRESSION INVENTORY (BDI-10) (AFRIKAANS)

(*Onderhoudvoerder merk met (X) in die toepaslike blok*

Hierdie afdeling van die vraelys gaan oor gevoelens van treurigheid en ander moeilikhede wat baie mense ervaar tydens sekere tye in hul lewens

Hierdie afdeling van die vraelys is in groepe van stellings gerangskik. Ek sal die stellings lees waarna u goed moet luister. Kies EEN stelling uit elke groep wat die beste beskryf hoe u gedurende die AFGELOPE VIER WEKE, insluitende vandag, voel.

1. a. U voel nie treurig nie ☐

b. U voel treurig ☐

c. U voel heeltyd treurig, maar u kan uself regruk ☐

d. U is so treurig of hartseer dat u nie uself kan regruk nie □ □

2. a. U is nie besonder ontmoedig oor die toekoms nie □

b. U voel ontmoedig oor die toekoms □

c. U voel dat u niks het om na uit te sien nie □

d. U voel dat die toekoms hopeloos is en dat dinge nie kan verbeter nie □ □

3. a. U voel nie soos „n "druipeling" nie □

b. U voel dat u meer as die gewone persoon gedruip het □

c. As u terugkyk na u lewe, al wat u sien is baie tekortkomings □

d. U voel dat u „n totale "druipeling" as „n persoon is. □ □

4. a. U kry net soveel bevrediging uit dinge as wat u voorheen gekry het □

b. U geniet nie meer dinge soos u dit voorheen geniet het nie. □

c. U kry nie meer volle bevrediging uit enigiets nie. □

d. U is ontevrede of verveeld met alles □ □

5. a. U voel nie besonder skuldig nie. □

b. U voel heel dikwels skuldig □

c. U voel die meeste van die tyd taamlik skuldig □

d. U voel die heeltyd skuldig □ □

6. a. U voel nie asof u gestraf word ☐
b. U voel dat u gestraf mag word ☐
c. U verwag om gestraf te word ☐
d. U voel dat u gestraf word ☐ ☐

7. a. U voel nie teleurgesteld met uself nie ☐
b. U is teleurgesteld met uself ☐
c. U voel verwalging vir uself ☐
d. U haat uself ☐ ☐

8. a. U voel nie dat u slegter is as enigiemand anders nie ☐
b. U is krities teenoor uself oor u swakhede of u foute ☐
c. U blameer uself die heeltyd vir u foute ☐
d. U blameer uself vir alles wat sleg is, wat gebeur ☐ ☐

9. a. U het geen gedagtes on uself dood te maak nie ☐
b. U het gedagtes om uself dood te maak, maar u sal dit nie uitvoer nie ☐
c. U sou uself doodmaak as u die kans gehad het ☐
d. U sou uself doodmaak ☐ ☐

10. a. U huil nie meer as gewoonlik nie ☐
b. U huil meer as wat u in die verlede gehuil het ☐
c. U huil nou heeltyd. ☐

d. U kon in die verlede huil, maar nou kan u nie huil nie, selfs wanneer u wil
.

11. a. U is nou nie meer vererg as gewoonlik nie

b. U raak makliker vererg of prikkelbaar as voorheen

c. U voel nou heeltyd vererg.

d. U raak glad nie vererg oor die dinge wat u in die verlede geirriteer het

12. a. U het nie belangstelling in ander mense verloor nie

b. U is minder geïnteresseerd in ander mense as voorheen

c. U het die meeste van u belangstelling in ander mense verloor

d. U het al u belangstelling in ander mense verloor

13. a. U maak besluite net so goed soos voorheen

b. U stel die neem van besluite meer uit as wat u van tevore gedoen het

c. U vind dit moeiliker as voorheen om besluite te nee

d. U kan deesdae glad nie besluite neem nie

14. a. U voel nie dat u slegter lyk as voorheen nie

b. U is bekommerd dat u oud en onaantreklik lyk

c. U voel dat daar permanente veranderinge in u voorkoms is en dat dit u onaantreklik maak

d. U voel dat u lelik of afstootlik lyk

15. a. U kan omtrent so goed werk as voorheen □
b. U vind dit moeiliker om met iets te begin □
c. U moet uself baie hard dryf om enigiets te doen □
d. U kan hoegenaamd geen werk doen nie □ □

16. a. U slaap so goed soos gewoonlik □
b. U slaap nie so goed soos u voorheen geeslaap het nie
c. U word 1-2 ure vroeër as gewoonlik wakker en vind dit moeilik om weer aan die slaap te raak □
d. U word „n hele paar ure vroeër as gewoonlik wakker en vind dit ontmoontlik om weer aan die slaap te raak □ □

17. a. U word nie moeër as gewoonlik nie □
b. U raak meer makliker moeg as voorheen. □
c. U raak moeg as u amper enigiets doen □
d. U is te moeg om enigiets te doen □ □

18. a. U eetlus is nie slegter as gewoonlik nie □
b. U eetlus is nie so goed soos voorheen nie □
c. U eetlus is nou baie slegter. □
d. U het deesdae geen eetlus nie □ □

19. a. U het onlangs min, indien enige, gewig verloor □
b. U het meer as 2 kilogram (5 pond) verloor. □
c. U het meer as 4 kilogram (10 pond) verloor. □
d. U het meer as 6 kilogram (15 pond) verloor □ □

20. a. U is nie meer as gewoonlik bekommerd oor u gesondheid nie. ☐

b. U is bekommerd oor u fisiese probleme soos pyne, omgekrapte maag of hardlywigheid. ☐

c. U is baie bekommerd oor u fisiese probleme en dis moeilik om oor enigiets anders te dink. ☐

d. U is so bekommerd oor u fisiese probleme dat u nie oor enigiets anders kan dink nie. ☐ ☐

21. a U het nie onlangs enige verandering in seks opgelet nie ☐

b. U stel minder belang in seks as voorheen ☐

c. U stel nou baie minder belang in seks. ☐

d. U het alle belangstelling in seks verloor ☐ ☐

Additional Suicidal Ideation Questions (AFRIKAANS)

22. Gedurende die *afgelope 12 maande*, het u ooit ernstig daaroor gedink om uself te beseer op „n manier wat u dood mag veroorsaak?

Ja ☐ *Nee* ☐

INDIEN JA:

Wanneer laas het dit gebeur?

23. Het u ooit gedurende die afgelope *12 maande* iemand vertel dat u van plan is om „n einde te maak aan u lewe?

Ja ☐ *Nee* ☐

INDIEN JA:

Wanneer laas het dit gebeur?

24. Het u gedurende die *afgelope 12 maande* ooit werklik probeer om „n einde aan u lewe te maak?

Ja ☐ *Nee* ☐

INDIEN JA:
Wanneer laas het dit gebeur?

....

25. Het enige van u pogings van selfbesering, vergifting of oordosis, veroorsaak dat u deur 'n dokter/verpleegster behandel moes word?

Ja ☐ *Nee* ☐

Part 3 – BRIEF SYMPTOM INVENTORY (BSI) (AFRIKAANS)
(Onderhoudvoerder skryf die punte van die werker se gegewe antwoorde in die toepaslike blok)

Glad nie	***0***
'n Klein bietjie	***1***
Taamlik	***2***
Nogal	***3***
Uiters	***4***

Hierdie is 'n lys probleme wat mense soms ondervind. Luister asseblief na elkeen noukeurig, en kies die een wat die beste beskrywing gee van HOEVEEL DAARDIE PROBLEEM U OM KRAP OF ONTSTEL HET GEDURENDE DIE AFGELOPE 7 DAE, INSLUITENDE VANDAG.

1. Senuweeagtigheid of bewerigheid van binne.	☐
2. Flouheid of duiseligheid.	☐

3. Die idee dat iemand anders u gedagtes kan beheer.	☐
4. Die gevoel dat andere te blameer is vir die meeste van u probleme	☐
5. Sukkel om dinge te onthou	☐
6. U voel u word maklik vererg of geïrriteerd	☐
7. Pyne in die hart of bors	☐
8. 'n Bang gevoel wanneer u in oop areas of op straat is	☐
9. Gedagtes om u lewe te beëindig	☐
10. „n Gevoel dat die meeste mense nie vertrou kan word nie	☐
11. „n swak eetlus	☐
12. 'n Skielike bang gevoel sonder rede	☐
13. Woedeuitbarstings wat u nie kan beheer nie	☐
14. „n Gevoel van alleenheid selfs wanneer u by ander mense is.	☐
15. „n Gevoel van blokkering om dinge gedoen te kry.	☐
16. „n Gevoel van eensaamheid	☐
17. „n Gevoel van neerslagtigheid	☐
18. Geen belangstelling in dinge te hê nie	☐
19. „n Gevoel van vrees	☐

20. Dat u gevoelens maklik seergemaak word.	☐
21. „n Gevoel dat mense onvriendelik is en nie van u hou nie	☐
22. „n Gevoel van minderwaardigheid teenoor andere	☐
23. Naarheid of „n omgekrapte maag	☐
24. „n Gevoel dat andere u dophou of oor u praat	☐
25. Sukkel om aan die slaap te raak	☐
26. „n Behoefte om dinge oor en oor na te gaan	☐
27. Sukkel om besluite te neem	☐
28. Bang om per bus of trein te reis	☐
29. Om te sukkel om asem te haal	☐
30. Warm of koue gloede te kry	☐
31. Die vermy van sekere dinge en plekke, of die vermy om dinge te doen omdat dit u bang maak.	☐
32. Die gevoel dat u gedagtes stilstaan en nie wil werk nie - "going blank"	☐
33. „n Dooie gevoel of tinteling in dele van u liggaam	☐
34. Die idee dat u gestraf moet word vir u sondes.	☐
35. „n Gevoel van moedeloosheid oor die toekoms.	☐

36. Om te sukkel om te konsentreer	☐
37. „n Gevoel van swakheid in dele van u liggaam	☐
38. „n Gevoel van spanning of opgewerktheid	☐
39. Om te dink aan die dood of doodgaan.	☐
40. Drange om iemand te slaan, te beseer of skade aan te doen	☐
41. Drange om dinge te breek of stukkend te slaan	☐
42. Baie selfbewus tussen ander mense te voel.	☐
43. „n Gevoel van ongemak tussen baie mense (soos in „n winkel of by 'n fliek)	☐
44. Nooit geheg aan iemand anders te voel nie	☐
45. Tye van angs of paniek.	☐
46. Gedurig in argumente betrokke te raak.	☐
47. Senuweeagtigheid wanneer u alleen gelaat word.	☐
48. Andere gee u nie die nodige erkenning vir u prestasies nie.	☐
49. U is so rusteloos dat u nie kan stilsit nie.	☐
50. „n Gevoel van waardeloosheid.	☐
51. „n Gevoel dat mense u sal misbruik as u dit toelaat.	☐
52. Skuldgevoelens.	☐

53. Die idee dat daar iets verkeerd is met u brein	☐

Part 4 – REFINED FOUR-FACTOR MEASUREMENT MODEL OF THE AGGRESSION QUESTIONNAIRE (AFRIKAANS)

(Onderhoudvoerder moet 'n getallelyn tussen 1-6 gebruik. Skryf die gegewe getal in die toepaslike blok)

Die volgende vrae het te doen met hoe u somtyds voel en optree:

Beantwoord, asseblief, die volgende vrae. Gebruik 'n skaal wat wissel van 1 –6, waar
(1) = uiters onkarakteristiek van my , TOT
(6) = uiters karakteristiek van my

1. Indien u genoeg uitgetart word, sal u „n ander persoon slaan. ☐
2. Sekere mense het u al sover gekry dat julle vuisgeslaan het ☐
3. By tye het u al van u kenisse gedreig ☐
4. U verskil gereeld van mense ☐

5. As mense met u verskil, kan u nie help om in argumente betrokke te raak nie ☐

6. U vriende sê u is ietwat stryerig ☐

7. U is opvlieënd maar kom gou daaroor ☐

8. Partykeer ontplof u sonder „n goeie rede ☐

9. Dit is moeilik om u woedebui te beheer ☐

10. Partykeer voel u die lewe behandel u nie goed nie. ☐

11. U voel ander mense kry altyd die kanse ☐

12. U wonder hoekom u partykeer so bitter voel oor dinge ☐

Part 5 – BARRAT IMPULSIVENESS SCALE (BIS – II) (AFRIKAANS)

(Onderhoudvoerder merk met (X) in die toepaslike blok

Die volgende vrae kyk na die manier hoe u in verskillende daaglikse situasies reageer.

1. U voel baie ongemaklik gedurende opleiding sessies/praatjies

Amper nooit/nooit	
Soms	
Gereeld	
Amper altyd/altyd	

2. U is rusteloos gedurende opleiding sessies/praatjies

Amper nooit/nooit	
Soms	

Gereeld
Amper altyd/altyd

3. U is nie aandagtig gedurende opleiding sessies/praatjies nie

Amper nooit/nooit
Soms
Gereeld
Amper altyd/altyd

4. Dit is vir u maklik om te konsentreer indien u moet leer om iets te doen

Amper altyd/altyd
Soms
Gereeld
Amper nooit/nooit nie

5. U is „n standvastige/gelykmatige denker

Amper altyd/altyd
Soms
Gereeld
Amper nooit/nooit nie

6. U tree impulsief op

Amper nooit/nooit
Soms
Gereeld
Amper altyd/altyd

7. U koop goed impulsief

Amper nooit/nooit
Soms
Gereeld
Amper altyd/altyd

8. U besluit vinnig oor iets

Amper nooit/nooit

Soms

Gereeld

Amper altyd/altyd

9. U doen dinge sonder om aan die gevolge te dink

Amper nooit/nooit

Soms

Gereeld

Amper altyd/altyd

10. U spandeer meer / of koop op rekening vir meer, as wat u verdien

Amper nooit/nooit

Soms

Gereeld

Amper altyd/altyd

11. U is traak-my-nieagtig

Amper nooit/nooit

Soms

Gereeld

Amper altyd/altyd

12. U is „n versigtige dinker

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

13. U beplan take noukeurig/sorgvuldig

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

14. U het selfbeheersing

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

15. U beplan reise / take vroegtydig

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

16. U beplan vir werksekerheid (hoe u nie vervang sal word in u pos/werksposisie nie)

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

17. U sê dinge sonder om te dink

Amper nooit/nooit

Soms

Gereeld

Amper altyd/altyd

18. U hou daarvan om oor ingewikkelde probleme te dink/uit te werk

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

19. U hou daarvan om spele te speel wat bekwaamheid benodig, bv. Kaartspele soos klawerjas en dominospel

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

20. U betaal u assuransie/begrafnis polis/spaar geld /sit geld in „stokvel' gereeld

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

21. U is meer geïnterresseerd in die huidige as die toekoms

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

22. U verloor vinnig belangstelling terwyl u probleme moet oplos waar u hoef te dink

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

23. U verhuis gereeld

Amper altyd/altyd

Gereeld

Soms

Amper nooit/nooit

24. U verander gereeld van werk

Amper nooit/nooit

Soms
Gereeld
Amper altyd/altyd

25. U is gerig op die toekoms/ beplan vir die toekoms

Amper altyd/altyd
Gereeld
Soms
Amper nooit/nooit

26. U kan slegs aan een probleem op „n slag dink

Amper altyd/altyd
Gereeld
Soms
Amper nooit/nooit

27. U het gereeld gedagtes van buite terwyl u dink / terwyl u aan „n spesifieke ding dink/konsentreer, dwaal u gedagtes na iets wat nie relevant is nie

Amper altyd/altyd
Gereeld
Soms
Amper nooit/nooit

28. U het gedagtes wat jaag/ het gedagtes wat vinnig kom en gaan/kan nie een gedagtegang vir lank behou nie

Amper altyd/altyd
Gereeld
Soms
Amper nooit/nooit

29. U verander van stokperdjies

Amper nooit/nooit	
Soms	
Gereeld	
Amper altyd/altyd	

Part 6 – SCALE FOR SUICIDE IDEATION (AFRIKAANS)

(NB – Interviewers, please note the responses to the following questions. If the rating is 20 and above, it indicates that the farm worker is extremely suicidal. This person must be referred to me immediately for further assessment, and possible referral to the relevant health authority)

Score all answers from top to bottm using the prescribed ratings

0
1
2

Beantwoord, asseblief, die volgende vrae. Gebruik die drie opsies aangedui.

1. Hoe sterk is u wil om te lewe

Gemiddeld tot sterk	
Swak	
Geen	

2. Hoe sterk is u wil om te sterf

Geen	
Swak	
Gemiddeld tot sterk	

3. Watter een is van meer belang – u redes vir lewe / dood

Om te sterf weeg swaarder as om te leef	
Omtrent dieselfde vir albei	
Om te leef weeg swaarder as om te sterf	

4. Hoe sterk verlang u om „n selfmoord poging aan te wend

Geen	
Swak	
Gemiddeld tot Swak	

5. As u tussen lewe en dood moet kies, hoe sou u kies

Sou u voorsorg tref om te lewe	
Sou u lewe/dood tot kans los	
Sou u die nodige stappe vermy wat 'n lewe bewaar of spaar	

6. Hoe lank bly die gedagtes by u, indien u aan selfmoord pleeg dink

Kort, vlugtige tye	
Langer tye	
Aanhoudend/amper aanhoudend	

7. Hoe gereeld dink u aan selfmoord

Weinig, toevallig	
Periodik, af en toe	
Aanhoudend	

8. Hoe voel u oor die gedagte / wens vir selfmoord

Verwerp/weier	
Dubbelsinnig, onpartydig	

Aanvaarbaar ☐

9. Het u enige beheer oor selfmoord aksie / uitvoering wense?

Daar is 'n gevoel van beheer ☐
Onseker van beheer ☐
Daar is geen gevoel van beheer nie ☐

10. Indien u daaraan dink om selfmoord to pleeg, is daar enigiets wat u sal weerhou van die daad (bv. familie, geloof, ensovoort)

Sou nie probeer nie omdat daar iets is wat vir u sal terughou ☐
Bekommerdheid oor die dinge wat u terughou ☐
Geen bekommernis oor enigiets wat u kan terughou ☐

11. Om watter rede sal u aan „n selfmoordpoging dink?

Om die omgewing to manipuleer; aandag te trek/wraak te neem ☐
Kombinasie van die die ander twee ☐
Om te ontsnap van probleme/probleme op te los ☐

12. Watter mode sou u gebruik om selfmoord te pleeg?

Nie in ag geneem nie ☐
In ag geneem, maar besonderhede nie uitgewerk nie ☐
Besonderhede uitgewerk, plan goed vasgestel ☐

13. Hoe beskikbaar is die mode waaraan u dink?

Metode nie beskikibaar nie; geen geleentheid nie ☐
Metode & geleentheid beskikbaar ☐
(a)Metode & geleentheid beskikbaar ☐
(b)Toekomstige geleentheid/beskikbaarheid van metode voorsien ☐

14. Hoe bevoeg is u om „n selfmoordpoging uit te voer?

Geen moed nie; te swak; bang; onbekwaam ☐
Onseker van moed/bekwaamheid ☐
Seker van bekwaamheid/moed ☐

15. Verwag u dat „n werklike selfmoordpoging sal gebeur?

Geen	
Onseker	
Ja	

16. Watter werklike voorbereiding is alreeds gemaak vir die voorgenome poging?

Geen	
Gedeeltelik (bv. pille word versamel)	
Voltooi (bv. pille is alreeds versamel)	

17. Het u alreeds „n selfmoordnota / brief geskryf?

Geen	
Begin, maar nog nie voltooi nie; net daaraan gedink	
Voltooi	

18. Het u al enige finale voorbereidings getref in afwagting van die dood (bv. versekering / assuransie, testament, begrafnispolis)

Geen	
Daaraan gedink/sommige reëlings gemaak	
Presiese planne gemaak/reëlings is voltooi	

19. Is enige iemand al vertel van u gedagtes / planne vir die voorgenome selfmoord?

Gedagtes is openbaar gemaak	
Gedagtes is teruggehou	
Poging gemaak om weg te steek, te mislei, te lieg	

APPENDIX C

ADDITIONAL ADJUSTED MULTIVARIATE RESULTS

(Tables C2 to C9)

Table C1 Spearman Rank Correlation of Age and Occupational Tasks depicting Cumulative Years of Exposure

		Age **(N = 808)**	**Years worked as a Head Sprayer** **(N = 138)**	**Years worked as a Tractor Driver** **(N = 227)**	**Years worked in Agriculture** **(N = 796)**
Age	Correlation Coefficient	**1.000**			
Years worked as a head sprayer	Correlation Coefficient	.562**	**1.000**		
Years worked as a tractor driver	Correlation Coefficient	.726**	.853**	**1.000**	
Years worked in agriculture	Correlation Coefficient	.790**	.719**	.885**	**1.000**

** Correlation is significant at the 0.01 level (2-tailed).

Table C2 Adjusted Multivariate Results (Sequential Models)

Table C2.1 Psychiatric Disorders (GHQ total score cut-off 23/24) associated with Cumulative years of Occupational Exposure, adjusted for all Potential Covariates

(N = 174)	Prevalence Odds Ratio	Confidence Interval	p – value
Years worked as tractor driver [> 13 = 1 (n = 91), ≤ 13 = 0 (n = 83)]	0.71	0.27 – 1.89	0.488
<u>Potential Covariates</u>			
Farm type [Table grapes = 1 (n = 138), Wine grapes = 0 (n = 36)]	1.02	0.29 – 3.52	0.979
C.A.G.E. Score	1.13	0.73 – 1.74	0.588
Psychiatric Ilness [Yes =1 (n = 10, No =0 (n = 164)]	2.84	0.59 – 13.65	0.192
PPE [≤ 1 = 1 (n = 23) , ≥ 2 = 0 (n = 151)]	0.70	0.14 – 3.56	0.669
SES [< 4 = 1 (n = 50), ≥ 4 = 0 (n = 124)]	1.60	0.61 – 4.23	0.344
Previous pesticide poisoning [Yes = 1 (n = 35), No = 0 (139)]	1.66	0.59 – 4.66	0.338
Cholinesterase quartiles:			
○ > 36.3 U/g (n = 49)	1.00		
○ ≤ 28.9 U/g (n = 36)	**0.11**	**0.01 – 0.92**	**0.042**
○ > 28.9 U/g and ≤ 32.6 U/g (n = 40)	0.74	0.23 – 2.31	0.598
○ > 32.6 U/g and ≤ 36.3 U/g (n = 49)	0.43	0.13 – 1.42	0.164

	Prevalence Odds Ratio	Confidence Interval	p – value
(N = 110)			
Years worked as a head sprayer [> 13 = 1 (n = 57), ≤ 13 = 0 (n = 53)]	0.48	0.15 – 1.49	0.202
<u>Potential Covariates</u>			
Farm type [Table grapes = 1 (n = 94), Wine grapes = 0 (n = 16)]	0.65	0.15 – 2.81	0.560
C.A.G.E. Score	1.07	0.62 – 1.86	0.802
Psychiatric Ilness [Yes = 1 (n = 4), No = 0 (n = 106)]	4.34	0.46 – 40.96	0.200
PPE [≤ 1 = 1 (n = 9), ≥ 2 = 0 (n = 101)]	0.93	0.10 – 9.07	0.949
SES [< 4 = 1 (n = 33, ≥ 4 = 0 (n = 77)]	0.85	0.26 – 2.77	0.784
Previous pesticide poisoning [Yes = 1 (n = 26), No = 0 (n = 84)]	1.49	0.44 – 5.05	0.520
Cholinesterase quartiles			
○ > 36.3 U/g (n = 33)	1.00		
○ ≤ 28.9 U/g (n = 21)	0.14	0.02 – 1.31	0.085
○ > 28.9 U/g and ≤ 32.6 U/g (n = 23)	0.60	0.14 – 2.54	0.483
○ > 32.6 U/g and ≤ 36.3 U/g (n = 33)	0.47	0.12 – 1.80	0.268

(N = 619)			
A spray person at some time during their working life [Yes = 1 (n = 109); No = 0 (n = 510)]	1.15	0.63 – 2.09	0.657
<u>Potential Covariates</u>			
Age [> 33 = 1 (n = 324), ≤ 33 = 0 (n = 295)]	1.57	0.98 – 2.51	0.061
Farm type [Table grapes = 1 (n = 481), Wine grapes = 0 (n = 138)]	0.66	0.39 – 1.12	0.122
C.A.G.E. Score	1.01	0.82 – 1.24	0.965
Psychiatric Ilness [Yes =1 (n = 54); No =0 (n = 565)]	**5.51**	**2.94 – 10.34**	**0.000**
PPE [≤ 1 = 1 (n = 142); ≥ 2 = 0 (n = 477)]	1.09	0.65 – 1.83	0.759
SES [< 4 = 1 (n = 243); ≥ 4 = 0 (n = 376)]	**1.60**	**1.01 – 2.55**	**0.046**
Previous pesticide poisoning [Yes = 1 (n = 95); No = 0 (n = 524)]	**2.06**	**1.21 – 3.54**	**0.008**
Cholinesterase quartiles:			
○ > 36.3 U/g (n = 161)	1.00		
○ ≤ 28.9 U/g (n = 142)	1.09	0.57 – 2.08	0.788
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.50	0.80 – 2.81	0.205
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	0.99	0.53 – 1.88	0.984

Table C2.2 Psychiatric Disorders (GHQ) associated with Current Occupational Exposure, adjusted for all Potential Covariates

(N = 619)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Current spray person [Yes = 1 (n = 98); No =0 (n = 521)]	0.93	0.49 – 1.76	0.814
<u>Potential Covariates</u>			
Age (> 33 = 1; ≤ 33 = 0)	**1.61**	**1.01 – 2.58**	**0.046**
Farm type (Table grapes = 1; Wine grapes = 0)	0.67	0.40 – 1.13	0.134
C.A.G.E. Score	1.01	0.82 – 1.24	0.949
Psychiatric Ilness (Yes = 1; No = 0)	**5.38**	**2.87 – 10.07**	**0.000**
PPE (≤ 1 = 1; ≥ 2 = 0)	1.05	0.63 – 1.77	0.844
SES (< 4 = 1; ≥ 4 = 0)	**1.59**	**1.00 – 2.52**	**0.051**
Previous pesticide poisoning (Yes = 1; No = 0)	**2.11**	**1.23 – 3.60**	**0.007**
Cholinesterase quartiles			
o > 36.3 U/g	1.00		
o ≤ 28.9 U/g	1.08	0.57 – 2.06	0.812
o > 28.9 U/g and ≤ 32.6 U/g	1.48	0.79 – 2.77	0.218
o > 32.6 U/g and ≤ 36.3 U/g	0.99	0.53 – 1.88	0.981

(N = 619)	Prevalence Odds Ratio	Confidence Interval	p – value
Currently involved in one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 235)]	**0.61**	**0.38 – 0.98**	**0.040**
Potential Covariates			
Gender [Male =1 (n = 393); Female =0 (n = 226)]	0.95	0.57 - 1.58	0.833
Age (> 33 = 1, ≤ 33 = 0)	**1.61**	**1.01 – 2.56**	**0.046**
Farm type (Table grapes = 1, Wine grapes = 0)	0.62	0.36 – 1.05	0.074
C.A.G.E. Score	1.01	0.82 – 1.25	0.920
Psychiatric Ilness (Yes =1, No =0)	**5.24**	**2.79 – 9.83**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	0.91	0.53 – 1.56	0.733
SES (< 4 = 1, ≥ 4 = 0)	**1.63**	**1.02 – 2.59**	**0.041**
Previous pesticide poisoning (Yes = 1, No = 0)	**2.17**	**1.26 – 3.72**	**0.005**
Cholinesterase quartiles			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	1.06	0.55 – 2.02	0.868
○ > 28.9 U/g and ≤ 32.6 U/g	1.44	0.77 – 2.69	0.259
○ > 32.6 U/g and ≤ 36.3 U/g	0.99	0.52 – 1.87	0.974

Currently worked in vineyard during spraying [Yes = 1 (n = 457); No = 0 (n = 162)]	0.81	0.49 – 1.35	0.417
Potential Covariates			
Gender (Male =1, Female =0)	0.79	0.49 – 1.27	0.329
Age (> 33 = 1, ≤ 33 = 0)	**1.59**	**1.00 – 2.53**	**0.050**
Farm type (Table grapes = 1, Wine grapes = 0)	0.66	0.39 – 1.11	0.116
C.A.G.E. Score	1.02	0.82 – 1.25	0.890
Psychiatric Ilness (Yes =1, No =0)	**5.41**	**2.90 – 10.11**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	1.06	0.63 – 1.77	0.837
SES (< 4 = 1, ≥ 4 = 0)	**1.60**	**1.00 – 2.53**	**0.048**
Previous pesticide poisoning (Yes = 1, No = 0)	**2.15**	**1.25 – 3.68**	**0.006**
Cholinesterase quartiles			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	1.07	0.56 – 2.03	0.842
○ > 28.9 U/g and ≤ 32.6 U/g	1.47	0.78 – 2.75	0.231
○ > 32.6 U/g and ≤ 36.3 U/g	0.96	0.51 – 1.83	0.904

Table C2.3 Psychiatric Disorders (GHQ) associated with Environmental Exposure, adjusted for all Potential Covariates

(N = 599)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Observed pesticide spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)	1.21	0.75 – 1.95	0.438
<u>Potential Covariates</u>			
Gender [Male = 1 (n = 379); Female = 0 (n = 220)]	0.83	0.50 – 1.36	0.452
Age [> 33 = 1 (n = 313); ≤ 33 = 0 (n = 286)]	**1.64**	**1.02 – 2.65**	**0.042**
Farm type [Table grapes = 1 (n = 465); Wine grapes = 0 (n = 134)]	0.69	0.40 – 1.19	0.179
C.A.G.E. Score	1.00	0.80 – 1.24	0.970
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 546)]	**5.27**	**2.78 – 9.97**	**0.000**
PPE [≤ 1 = 1 (n = 134); ≥ 2 = 0 (n = 465)]	1.06	0.61 – 1.82	0.844
SES [< 4 = 1 (n = 234); ≥ 4 = 0 (n = 365)]	1.54	0.96 – 2.46	0.074
Previous pesticide poisoning [Yes = 1 (n = 89); No = 0 (n = 510)]	**2.00**	**1.14 – 3.49**	**0.015**
Cholinesterase quartiles			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 138)	1.09	0.57 – 2.10	0.800
○ > 28.9 U/g and ≤ 32.6 U/g (n = 154)	1.45	0.77 – 2.76	0.254
○ > 32.6 U/g and ≤ 36.3 U/g (n = 150)	1.02	0.53 – 1.95	0.959

(N = 612)	Prevalence Odds Ratio	Confidence Interval	p – value
Observed the smell of pesticides in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	1.06	0.65 – 1.73	0.815
<u>Potential Covariates</u>			
Gender [Male = 1 (n = 386); Female = 0 (n = 226)]	0.83	0.51 – 1.36	0.465
Age [> 33 = 1 (n = 321); ≤ 33 = 0 (n = 291)]	**1.68**	**1.05 – 2.68**	**0.032**
Farm type [Table grapes = 1 (n = 475); Wine grapes = 0 (n = 137)]	0.65	0.38 – 1.10	0.110
C.A.G.E. Score	0.98	0.80 – 1.21	0.859
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 559)]	**5.36**	**2.83 – 10.15**	**0.000**
PPE [≤ 1 = 1 (n = 141); ≥ 2 = 0 (n = 471)]	1.01	0.59 – 1.72	0.967
SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 375)]	**1.59**	**1.00 – 2.54**	**0.050**
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 519)]	**2.00**	**1.16 – 3.46**	**0.013**
Cholinesterase quartiles			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 139)	1.14	0.60 – 2.18	0.696
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.48	0.78 – 2.80	0.226
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	1.01	0.53 – 1.92	0.978

Table C3 Adjusted Multivariate Results (Sequential Models)

Table C3.1 Depression (GHQ Subscale D) associated with Cumulative years of Occupational Exposure, adjusted for all Potential Covariates

(N = 174)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Years worked as tractor driver [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	1.16	0.53 – 2.54	0.717
<u>Potential Covariates</u>			
Farm type [Table grapes = 1 (n = 138); Wine grapes = 0 (n = 36)]	**0.40**	**0.17 – 0.96**	**0.041**
C.A.G.E. Score	0.76	0.54 – 1.06	0.103
Psychiatric Ilness [Yes =1 (n = 10); No =0 (n = 164)]	0.73	0.14 – 3.91	0.709
PPE [≤ 1 = 1 (n = 23); ≥ 2 = 0 (n = 151)]	1.82	0.64 – 5.16	0.264
SES [< 4 = 1 (n = 50); ≥ 4 = 0 (n = 124)]	1.16	0.52 – 2.58	0.715
Previous pesticide poisoning [Yes = 1 (n = 35); No = 0 (n = 139)]	2.10	0.90 – 4.90	0.087
Cholinesterase quartiles:			
o > 36.3 U/g (n = 49)	1.00		
o ≤ 28.9 U/g (n = 36)	**0.29**	**0.10 – 0.83**	**0.022**
o > 28.9 U/g and ≤ 32.6 U/g (n = 40)	**0.28**	**0.09 – 0.82**	**0.020**
o > 32.6 U/g and ≤ 36.3 U/g (n = 49)	**0.30**	**0.11 – 0.81**	**0.017**

	Prevalence Odds Ratio	Confidence Interval	p – value
Years worked as a head sprayer (N = 110) [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	1.00	0.35 – 2.87	0.995
<u>Potential Covariates</u>			
Farm type [Table grapes = 1 (n = 94); Wine grapes = 0 (n = 16)]	0.33	0.09 – 1.25	0.104
C.A.G.E. Score	0.77	0.48 – 1.26	0.304
Psychiatric Ilness [Yes =1 (n = 4); No =0 (n = 106)]	0.00	0.00	1.00
PPE [≤ 1 = 1 (n = 9); ≥ 2 = 0 (n = 101)]	1.66	0.30 – 9.31	0.564
SES [< 4 = 1 (n = 33); ≥ 4 = 0 (n = 77)]	0.84	0.28 – 2.54	0.761
Previous pesticide poisoning [Yes = 1 (n = 26); No = 0 (n = 84)	**3.02**	**1.02 – 8.95**	**0.046**
Cholinesterase quartiles			
○ > 36.3 U/g (n = 33)	1.00		
○ ≤ 28.9 U/g (n = 21)	0.28	0.07 – 1.17	0.080
○ > 28.9 U/g and ≤ 32.6 U/g (n = 23)	**0.18**	**0.04 – 0.83**	**0.027**
○ > 32.6 U/g and ≤ 36.3 U/g (n = 33)	**0.24**	**0.06 – 0.93**	**0.038**

(N = 619) **A spray person at some time during their working life** [Yes = 1 (n = 109); No = 0 (n = 510)]	0.74	0.44 – 1.24	0.248
<u>Potential Covariates</u>			
Age [> 33 = 1 (n = 324); ≤ 33 = 0 (n = 295)]	1.05	0.72 – 1.52	0.818
Farm type [Table grapes = 1 (n = 481); Wine grapes = 0 (n = 138)]	**0.43**	**0.29 – 0.66**	**0.000**
C.A.G.E. Score	0.91	0.77 – 1.06	0.231
Psychiatric Ilness [Yes =1 (n = 54); No =0 (n = 565)]	**3.19**	**1.76 – 5.81**	**0.000**
PPE [≤ 1 = 1 (n = 142); ≥ 2 = 0 (n = 477)]	1.21	0.80 – 1.84	0.374
SES [< 4 = 1 (n = 243); ≥ 4 = 0 (n = 376)]	**1.50**	**1.03 – 2.16**	**0.033**
Previous pesticide poisoning [Yes = 1 (n = 95); No = 0 (n = 524)]	1.55	0.96 – 2.51	0.072
Cholinesterase quartiles:			
○ > 36.3 U/g (n = 161)	1.00		
○ ≤ 28.9 U/g (n = 142)	1.06	0.63 – 1.79	0.819
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.46	0.88 – 2.41	0.141
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	0.88	0.52 – 1.46	0.613

Table C3.2 Depression (GHQ Subscale D) associated with Current Occupational Exposure, adjusted for all Potential Covariates

(N = 619)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Current spray person [Yes =1 (n = 98); No =0 (n = 521)]	0.67	0.39 – 1.16	0.152
<u>**Potential Covariates**</u>			
Age (> 33 = 1, ≤ 33 = 0)	1.05	0.72 – 1.53	0.793
Farm type (Table grapes = 1, Wine grapes = 0)	**0.44**	**0.29 – 0.66**	**0.000**
C.A.G.E. Score	0.91	0.77 – 1.06	0.231
Psychiatric Ilness (Yes =1, No =0)	**3.19**	**1.75 – 5.80**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	1.20	0.79 – 1.82	0.397
SES (< 4 = 1, ≥ 4 = 0)	**1.49**	**1.03 – 2.16**	**0.035**
Previous pesticide poisoning (Yes = 1, No = 0)	1.56	0.96 – 2.51	0.071
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	1.07	0.64 – 2.80	0.805
○ > 28.9 U/g and ≤ 32.6 U/g	1.46	0.88 – 2.41	0.143
○ > 32.6 U/g and ≤ 36.3 U/g	0.88	0.52 – 1.47	0.616

(N = 619)	Prevalence Odds Ratio	Confidence Interval	p – value
Currently involved in one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 235)]	1.16	0.76 – 1.78	0.491
Potential Covariates			
Gender [Male =1 (n = 393); Female =0 (n = 226)]	**0.59**	**0.38 – 0.90**	**0.015**
Age (> 33 = 1, ≤ 33 = 0)	1.06	0.73 – 1.54	0.756
Farm type (Table grapes = 1, Wine grapes = 0)	**0.39**	**0.26 – 0.60**	**0.000**
C.A.G.E. Score	0.90	0.77 – 1.06	0.192
Psychiatric Ilness (Yes =1, No =0)	**3.06**	**1.68 – 5.58**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	1.15	0.75 – 1.78	0.526
SES (< 4 = 1, ≥ 4 = 0)	**1.51**	**1.04 – 2.19**	**0.030**
Previous pesticide poisoning (Yes = 1, No = 0)	1.55	0.96 – 2.50	0.074
Cholinesterase quartiles			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	1.04	0.62 – 1.75	0.883
○ > 28.9 U/g and ≤ 32.6 U/g	1.38	0.83 – 2.29	0.212
○ > 32.6 U/g and ≤ 36.3 U/g	0.87	0.52 – 1.45	0.582

Currently worked in vineyard during spraying [Yes = 1 (n = 457); No = 0 (n = 162)]	1.01	0.67 – 1.54	0.947
Potential Covariates			
Gender (Male =1, Female =0)	**0.62**	**0.42 – 0.92**	**0.018**
Age (> 33 = 1, ≤ 33 = 0)	1.05	0.73 – 1.53	0.782
Farm type (Table grapes = 1, Wine grapes = 0)	**0.39**	**0.25 – 0.60**	**0.000**
C.A.G.E. Score	0.90	0.77 – 1.06	0.199
Psychiatric Ilness (Yes =1, No =0)	**3.05**	**1.67 – 5.56**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	1.12	0.73 – 1.71	0.613
SES (< 4 = 1, ≥ 4 = 0)	**1.52**	**1.05 – 2.20**	**0.027**
Previous pesticide poisoning (Yes = 1, No = 0)	1.55	0.96 – 2.51	0.072
Cholinesterase quartiles			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	1.04	0.62 – 1.75	0.879
○ > 28.9 U/g and ≤ 32.6 U/g	1.38	0.83 – 2.29	0.213
○ > 32.6 U/g and ≤ 36.3 U/g	0.87	0.52 – 1.46	0.596

Table C3.3 Depression (GHQ Subscale D) associated with Environmental Exposure, adjusted for all Potential Covariates

(N = 599)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Observed pesticide spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	1.31	0.89 – 1.91	0.170
<u>Potential Covariates</u>			
Gender [Male =1 (n = 379); Female =0 (n = 220)]	**0.61**	**0.41 – 0.91**	**0.015**
Age [> 33 = 1 (n = 313); ≤ 33 = 0 (n = 286)]	1.02	0.70 – 1.50	0.901
Farm type [Table grapes = 1 (n = 465); Wine grapes = 0 (n = 134)]	**0.39**	**0.25 – 0.60**	**0.000**
C.A.G.E. Score	0.89	0.75 – 1.05	0.160
Psychiatric Ilness [Yes =1 (n = 53; No =0 (n = 546)]	**3.11**	**1.69 – 5.74**	**0.000**
PPE [≤ 1 = 1 (n = 134); ≥ 2 = 0 (n = 465)]	1.20	0.78 – 1.86	0.408
SES [< 4 = 1 (n = 234); ≥ 4 = 0 (n = 365)]	**1.54**	**1.06 – 2.25**	**0.024**
Previous pesticide poisoning [Yes = 1 (n = 89); No = 0 (n = 510)]	1.34	0.81 – 2.21	0.254
Cholinesterase quartiles			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 138)	1.01	0.60 – 1.71	0.974
○ > 28.9 U/g and ≤ 32.6 U/g (n = 154)	1.39	0.83 – 2.32	0.212
○ > 32.6 U/g and ≤ 36.3 U/g (n = 150)	0.86	0.51 – 1.46	0.576

(N = 612)	Prevalence Odds Ratio	Confidence Interval	p – value
Observed the smell of pesticides in the home [Yes = 1 (n = 396); No = 0 (n = 216)	**1.66**	**1.11 – 2.47**	**0.013**
<u>Potential Covariates</u>			
Gender [Male =1 (n = 386); Female =0 (n = 226)]	**0.63**	**0.42 – 0.93**	**0.020**
Age [> 33 = 1 (n = 321); ≤ 33 = 0 (n = 291)]	1.01	0.69 – 1.47	0.967
Farm type [Table grapes = 1 (n = 475); Wine grapes = 0 (n = 137)]	**0.38**	**0.25 – 0.58**	**0.000**
C.A.G.E. Score	0.89	0.75 – 1.05	0.158
Psychiatric Ilness [Yes =1 (n = 53); No =0 (559)]	**3.08**	**1.67 – 5.70**	**0.000**
PPE [≤ 1 = 1 (n = 141); ≥ 2 = 0 (n = 471)]	1.15	0.75 – 1.77	0.533
SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 375)]	**1.51**	**1.04 – 2.21**	**0.031**
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 519)]	1.35	0.83 – 2.21	0.233
Cholinesterase quartiles			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 139)	1.10	0.65 – 1.87	0.731
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.40	0.84 – 2.35	0.199
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	0.94	0.55 – 1.58	0.801

Table C4 **Adjusted Multivariate Results (Sequential Models)**

Table C4.1 Depression (BDI) associated with Cumulative years of Occupational Exposure, adjusted for all Potential Covariates

(N = 174)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Years worked as tractor driver [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	0.92	0.26 – 3.29	0.898
<u>Potential Covariates</u>			
Farm type [Table grapes = 1 (n = 138); Wine grapes =0 (n = 36)]	0.64	0.15 – 2.69	0.543
C.A.G.E. Score	0.88	0.50 – 1.57	0.670
Psychiatric Sickness [Yes =1 (n = 10); No = 0 (n = 164)]	**7.83**	**1.47 – 41.63**	**0.016**
PPE [≤ 1 = 1 (n = 23); ≥ 2 = 0 (n = 151)]	3.07	0.72 – 13.16	0.131
SES [< 4 = 1 (n = 50); ≥4 = 0 (n = 124)]	1.79	0.53 – 6.07	0.350
Previous pesticide poisoning [Yes = 1 (n = 35); No = 0 (n = 139)]	0.68	0.13 – 3.43	0.637
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 49)	1.00		
○ ≤ 28.9 U/g (n = 36)	0.26	0.04 – 1.57	0.140
○ > 28.9 U/g and ≤ 32.6 U/g (n = 40)	0.35	0.06 – 2.13	0.255
○ > 32.6 U/g and ≤ 36.3 U/g (n = 49)	0.46	0.10 – 2.08	0.310

	Prevalence Odds Ratio	Confidence Interval	p – value
(N = 110)			
Years worked as a head sprayer			
[> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	0.41	0.06 – 2.68	0.351
<u>Potential Covariates</u>			
Farm type [Table grapes =1 (n = 94); Wine grapes = 0 (n = 16)]	0.21	0.03 – 1.73	0.148
C.A.G.E. Score	0.50	0.22 – 1.15	0.101
Psychiatric Ilness [Yes = 1 (n = 4); No = 0 (n = 106)]	6.42	0.35 – 116.91	0.209
PPE [≤ 1 = 1 (n = 9); ≥ 2 = 0 (n = 101)]	2.70	0.18 – 41.81	0.477
SES [< 4 = 1 (n = 33); ≥ 4 = 0 (n = 77)]	0.57	0.07 – 4.58	0.599
Previous pesticide poisoning [Yes = 1 (n = 26); No = 0 (n = 84)]	1.48	0.22 – 9.90	0.685
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 33)	1.00		
○ ≤ 28.9 U/g (n = 21)	0.39	0.03 – 4.80	0.462
○ > 28.9 U/g and ≤ 32.6 U/g (n = 23)	0.19	0.01 – 2.82	0.224
○ > 32.6 U/g and ≤ 36.3 U/g (n = 33)	0.21	0.02 – 2.30	0.200

(N = 619)			
A spray person at some time during their working life [Yes = 1 (n = 109); No = 0 (n = 510)]	0.64	0.27 – 1.55	0.323
<u>Potential Covariates</u>			
Age [> 33 = 1 (n = 324); ≤ 33 = 0 (n = 295)]	**2.28**	**1.27 – 4.11**	**0.006**
Farm type [Table grapes = 1 (n = 481); Wine grapes = 0 (n = 138)]	**0.24**	**0.13 – 0.43**	**0.000**
C.A.G.E. Score	1.03	0.79 – 1.34	0.806
Psychiatric Ilness [Yes =1 (n = 54); No =0 (n = 565)]	**6.62**	**3.20 – 13.67**	**0.000**
PPE [≤ 1 = 1 (n = 142); ≥ 2 = 0 (n = 477)]	**1.87**	**1.05 – 3.33**	**0.035**
SES [< 4 = 1 (n = 243); ≥ 4 = 0 (n = 376)]	1.67	0.94 – 2.94	0.079
Previous pesticide poisoning [Yes = 1 (n = 95); No = 0 (n = 524)]	1.61	0.82 – 3.17	0.171
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 161)	1.00		
○ ≤ 28.9 U/g (n = 142)	1.32	0.63 – 2.75	0.467
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.28	0.59 – 2.80	0.532
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	0.67	0.29 – 1.53	0.341

Table C4.2 Depression (BDI) associated with Current Occupational Exposure, adjusted for all Potential Covariates

(N = 619)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Current spray person [Yes =1 (n = 98); No =0 (n = 521)]	0.77	0.32 – 1.88	0.571
<u>Potential Covariates</u>			
Age (> 33 = 1, ≤ 33 = 0)	**2.22**	**1.23 – 4.00**	**0.008**
Farm type (Table grapes = 1, Wine grapes = 0)	**0.24**	**0.13 – 0.43**	**0.000**
C.A.G.E. Score	1.03	0.80 – 1.35	0.803
Psychiatric Ilness (Yes =1, No =0)	**6.75**	**3.27 – 13.94**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	**1.91**	**1.07 – 3.41**	**0.028**
SES (< 4 = 1, ≥ 4 = 0)	1.68	0.95 – 2.97	0.074
Previous pesticide poisoning (Yes = 1, No = 0)	1.58	0.80 – 3.11	0.185
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	1.34	0.64 – 2.80	0.434
○ > 28.9 U/g and ≤ 32.6 U/g	1.30	0.60 – 2.83	0.512
○ > 32.6 U/g and ≤ 36.3 U/g	0.67	0.30 – 1.53	0.345

(N = 619)	Prevalence Odds Ratio	Confidence Interval	p – value
Currently involved in one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 235)]	0.63	0.33 – 1.19	0.153
<u>Potential Covariates</u>			
Gender [Male =1 (n = 393); Female =0 (n = 226)]	0.94	0.48 – 1.83	0.854
Age (> 33 = 1, ≤ 33 = 0)	**2.20**	**1.23 – 3.96**	**0.008**
Farm type (Table grapes = 1, Wine grapes = 0)	**0.21**	**0.11 – 0.39**	**0.000**
C.A.G.E. Score	1.04	0.79 – 1.35	0.795
Psychiatric Ilness (Yes =1, No =0)	**6.53**	**3.13 – 13.63**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	1.71	0.94 – 3.12	0.082
SES (< 4 = 1, ≥ 4 = 0)	1.74	0.98 – 3.06	0.058
Previous pesticide poisoning (Yes = 1, No = 0)	1.62	0.82 – 3.20	0.164
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	1.30	0.62 – 2.72	0.488
○ > 28.9 U/g and ≤ 32.6 U/g	1.23	0.56 – 2.69	0.609
○ > 32.6 U/g and ≤ 36.3 U/g	0.64	0.28 – 1.48	0.299

Currently worked in vineyard during spraying [Yes = 1 (n = 457); No = 0 (n = 162)]	0.73	0.39 – 1.36	0.325
<u>Potential Covariates</u>			
Gender (Male =1, Female =0)	0.80	0.44 – 1.47	0.475
Age (> 33 = 1, ≤ 33 = 0)	**2.19**	**1.22 – 3.94**	**0.009**
Farm type (Table grapes = 1, Wine grapes = 0)	**0.22**	**0.12 – 0.40**	**0.000**
C.A.G.E. Score	1.04	0.80 – 1.36	0.771
Psychiatric Ilness (Yes =1, No =0)	**6.66**	**3.21 – 13.80**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	**1.82**	**1.01 – 3.30**	**0.048**
SES (< 4 = 1, ≥ 4 = 0)	1.69	0.96 – 2.98	0.070
Previous pesticide poisoning (Yes = 1, No = 0)	1.64	0.83 – 3.23	0.156
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	1.30	0.62 – 2.71	0.489
○ > 28.9 U/g and ≤ 32.6 U/g	1.23	0.56 – 2.71	0.600
○ > 32.6 U/g and ≤ 36.3 U/g	0.62	0.27 – 1.42	0.257

Table C4.3 Depression (BDI) associated with Environmental Exposure, adjusted for all Potential Covariates

(N = 599)	Prevalence Odds Ratio	Confidence Interval	p – value
Observed pesticide spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	0.90	0.51 – 1.61	0.733
Potential Covariates			
Gender [Male =1 (n = 379); Female =0 (n = 220)]	0.74	0.40 – 1.36	0.332
Age [> 33 = 1 (n = 313); ≤ 33 = 0 (n = 286)]	**2.18**	**1.20 – 3.96**	**0.011**
Farm type [Table grapes =1 (n = 465); Wine grapes =0 (n = 134)]	**0.25**	**0.13 – 0.47**	**0.000**
C.A.G.E. Score	1.05	0.79 – 1.40	0.723
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 546)]	**6.60**	**3.16 – 13.81**	**0.000**
PPE [≤ 1 = 1 (n = 134); ≥ 2 = 0 (n = 465)]	**1.90**	**1.04 – 3.48**	**0.037**
SES [< 4 = 1 (n = 234); ≥ 4 = 0 (n = 365)]	1.74	0.98 – 3.10	0.061
Previous pesticide poisoning [Yes = 1 (n = 89); No = 0 (n = 510)]	1.74	0.88 – 3.46	0.112
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 138)	1.36	0.64 – 2.88	0.429
○ > 28.9 U/g and ≤ 32.6 U/g (n = 154)	1.28	0.57 – 2.84	0.552
○ > 32.6 U/g and ≤ 36.3 U/g (n = 150)	0.75	0.32 – 1.72	0.491

(N = 612)	Prevalence Odds Ratio	Confidence Interval	p – value
Observed the smell of pesticides in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	1.06	0.58 – 1.93	0.861
<u>Potential Covariates</u>			
Gender [Male =1 (n = 386); Female =0 (n = 226)]	0.80	0.44 – 1.47	0.472
Age [> 33 = 1 (n = 321); ≤ 33 = 0 (n = 291)]	**2.17**	**1.21 – 3.89**	**0.010**
Farm type [Table grapes =1 (n = 475); Wine grapes =0 (n = 137)]	**0.23**	**0.12 – 0.42**	**0.000**
C.A.G.E. Score	1.01	0.78 – 1.32	0.927
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 559)]	**6.60**	**3.15 – 13.82**	**0.000**
PPE [≤ 1 = 1 (n = 141); ≥ 2 = 0 (n = 471)]	**1.83**	**1.01 – 3.32**	**0.046**
SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 375)]	1.75	0.99 – 3.08	0.055
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 519)]	1.57	0.79 – 3.10	0.196
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 139)	1.35	0.64 – 2.82	0.429
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.24	0.57 – 2.72	0.588
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	0.65	0.28 – 1.48	0.302

Table C5 Adjusted Multivariate Results (Sequential Models)

Table C5.1 General Distress Levels (BSI GSI) associated with Cumulative years of Occupational Exposure, adjusted for all Potential Covariates

(N = 174)		**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Years worked as tractor driver [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]		1.09	0.50 – 2.34	0.833
<u>Potential Covariates</u>				
Farm type [Table grapes = 1 (n = 138); Wine grapes =0 (n = 36)]		0.77	0.31 – 1.94	0.583
C.A.G.E. Score		0.96	0.68 – 1.35	0.807
Psychiatric Sickness [Yes =1 (n = 10); No = 0 (n = 164)]		2.23	0.55 – 9.05	0.261
PPE [≤ 1 = 1 (n = 23); ≥ 2 = 0 (n = 151)]		0.94	0.31 – 2.92	0.920
SES [< 4 = 1 (n = 50); ≥4 = 0 (n = 124)]		0.92	0.41 – 2.07	0.842
Previous pesticide poisoning [Yes = 1 (n = 35); No = 0 (n = 139)]		1.67	0.71 – 3.89	0.239
Cholinesterase Levels (quartiles):				
○ > 36.3 U/g	(n = 49)	1.00		
○ ≤ 28.9 U/g	(n = 36)	0.34	0.11 – 1.07	0.064
○ > 28.9 U/g and ≤ 32.6 U/g	(n = 40)	0.53	0.19 – 1.50	0.230
○ > 32.6 U/g and ≤ 36.3 U/g	(n = 49)	0.85	0.34 – 2.11	0.723

	Prevalence Odds Ratio	Confidence Interval	p – value
(N = 110)			
Years worked as a head sprayer			
[> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	1.18	0.45 – 3.08	0.738
Potential Covariates			
Farm type			
[Table grapes =1 (n = 94); Wine grapes = 0 (n = 16)]	0.71	0.20 – 2.52	0.598
C.A.G.E. Score	0.79	0.50 – 1.24	0.294
Psychiatric Ilness [Yes = 1 (n = 4); No = 0 (n = 106)]	2.39	0.28 – 20.15	0.424
PPE [≤ 1 = 1 (n = 9); ≥ 2 = 0 (n = 101)]	2.45	0.54 – 11.04	0.243
SES [< 4 = 1 (n = 33); ≥ 4 = 0 (n = 77)]	0.78	0.28 – 2.23	0.647
Previous pesticide poisoning			
[Yes = 1 (n = 26); No = 0 (n = 84)]	1.59	0.56 – 4.52	0.388
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 33)	1.00		
○ ≤ 28.9 U/g (n = 21)	0.44	0.11 – 1.82	0.257
○ > 28.9 U/g and ≤ 32.6 U/g (n = 23)	0.45	0.11 – 1.81	0.262
○ > 32.6 U/g and ≤ 36.3 U/g (n = 33)	0.83	0.26 – 2.64	0.751

(N = 619)			
A spray person at some time during their working life [Yes = 1 (n = 109); No = 0 (n = 510)]	0.96	0.57 – 1.60	0.866
Potential Covariates			
Age [> 33 = 1 (n = 324); ≤ 33 = 0 (n = 295)]	**1.55**	**1.04 – 2.30**	**0.031**
Farm type			
[Table grapes = 1 (n = 481); Wine grapes = 0 (n = 138)]	0.68	0.44 – 1.07	0.092
C.A.G.E. Score	1.11	0.93 – 1.32	0.256
Psychiatric Ilness [Yes =1 (n = 54); No =0 (n = 565)]	**3.58**	**1.96 – 6.52**	**0.000**
PPE [≤ 1 = 1 (n = 142); ≥ 2 = 0 (n = 477)]	1.02	0.65 – 1.59	0.941
SES [< 4 = 1 (n = 243); ≥ 4 = 0 (n = 376)]	**1.82**	**1.24 – 2.69**	**0.002**
Previous pesticide poisoning			
[Yes = 1 (n = 95); No = 0 (n = 524)]	1.41	0.86 – 2.32	0.171
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 161)	1.00		
○ ≤ 28.9 U/g (n = 142)	0.82	0.46 – 1.45	0.489
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.54	0.90 – 2.62	0.115
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	1.66	0.99 – 2.77	0.054

Table C5.2 General Distress Levels (BSI GSI) associated with Current Occupational Exposure, adjusted for all Potential Covariates

(N = 619)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Current spray person [Yes =1 (n = 98); No =0 (n = 521)]	0.97	0.57 – 1.65	0.899
<u>**Potential Covariates**</u>			
Age (> 33 = 1, ≤ 33 = 0)	**1.54**	**1.04 – 2.29**	**0.031**
Farm type (Table grapes = 1, Wine grapes = 0)	0.68	0.44 – 1.06	0.091
C.A.G.E. Score	1.11	0.93 – 1.32	0.257
Psychiatric Ilness (Yes =1, No =0)	**3.58**	**1.97 – 6.53**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	1.02	0.65 – 1.59	0.936
SES (< 4 = 1, ≥ 4 = 0)	**1.83**	**1.24 – 2.69**	**0.002**
Previous pesticide poisoning (Yes = 1, No = 0)	1.41	0.86 – 2.31	0.172
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	0.82	0.46 – 1.45	0.492
○ > 28.9 U/g and ≤ 32.6 U/g	1.54	0.90 – 2.62	0.115
○ > 32.6 U/g and ≤ 36.3 U/g	1.66	0.99 – 2.77	0.054

(N = 619)	Prevalence Odds Ratio	Confidence Interval	p – value
Currently involved in one or more spraying activity			
[Yes = 1 (n = 384); No = 0 (n = 235)]	0.79	0.51 – 1.23	0.296
Potential Covariates			
Gender [Male =1 (n = 393); Female =0 (n = 226)]	1.24	0.79 – 1.95	0.357
Age (> 33 = 1, ≤ 33 = 0)	**1.51**	**1.02 – 2.23**	**0.039**
Farm type (Table grapes = 1, Wine grapes = 0)	0.68	0.43 – 1.07	0.097
C.A.G.E. Score	1.11	0.93 – 1.33	0.246
Psychiatric Ilness (Yes =1, No =0)	**3.68**	**2.01 – 6.74**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	1.01	0.63 – 1.60	0.976
SES (< 4 = 1, ≥ 4 = 0)	**1.85**	**1.25 – 2.74**	**0.002**
Previous pesticide poisoning (Yes = 1, No = 0)	1.41	0.86 – 2.30	0.174
Cholinesterase Levels (quartiles):			
○ 36.3 U/g	1.00		
○ ≤ 28.9 U/g	0.83	0.47 – 1.47	0.516
○ > 28.9 U/g and ≤ 32.6 U/g	1.57	0.92 – 2.68	0.102
○ > 32.6 U/g and ≤ 36.3 U/g	**1.67**	**1.00 – 2.80**	**0.051**

Currently worked in vineyard during spraying			
[Yes = 1 (n = 457); No = 0 (n = 162)]	0.85	0.55 – 1.30	0.454
Potential Covariates			
Gender (Male =1, Female =0)	1.14	0.75 – 1.74	0.532
Age (> 33 = 1, ≤ 33 = 0)	**1.52**	**1.03 – 2.24**	**0.037**
Farm type (Table grapes = 1, Wine grapes = 0)	0.69	0.44 – 1.08	0.106
C.A.G.E. Score	1.12	0.93 – 1.33	0.228
Psychiatric Ilness (Yes =1, No =0)	**3.69**	**2.01 – 6.76**	**0.000**
PPE (≤ 1 = 1, ≥ 2 = 0)	1.06	0.67 – 1.67	0.809
SES (< 4 = 1, ≥ 4 = 0)	**1.84**	**1.25 – 2.71**	**0.002**
Previous pesticide poisoning (Yes = 1, No = 0)	1.43	0.87 – 2.34	0.161
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	0.82	0.46 – 1.45	0.493
○ > 28.9 U/g and ≤ 32.6 U/g	1.56	0.91 – 2.67	0.106
○ > 32.6 U/g and ≤ 36.3 U/g	1.63	0.97 – 2.73	0.066

Table C5.3 General Distress Levels (BSI GSI) associated with Environmental Exposure, adjusted for all Potential Covariates

(N = 599)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Observed pesticide spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	1.10	0.73 – 1.63	0.656
Potential Covariates			
Gender [Male =1 (n = 379); Female =0 (n = 220)]	1.08	0.70 – 1.65	0.736
Age [> 33 = 1 (n = 313); ≤ 33 = 0 (n = 286)]	**1.53**	**1.03 – 2.29**	**0.036**
Farm type [Table grapes =1 (n = 465); Wine grapes =0 (n = 134)]	0.74	0.47 – 1.18	0.207
C.A.G.E. Score	1.10	0.91 – 1.32	0.343
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 546)]	**3.76**	**2.03 – 6.95**	**0.000**
PPE [≤ 1 = 1 (n = 134); ≥ 2 = 0 (n = 465)]	1.04	0.65 – 1.67	0.857
SES [< 4 = 1 (n = 234); ≥ 4 = 0 (n = 365)]	**1.85**	**1.24 – 2.75**	**0.002**
Previous pesticide poisoning [Yes = 1 (n = 89); No = 0 (n = 510)]	1.58	0.95 – 2.61	0.076
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 138)	0.85	0.48 – 1.54	0.599
○ > 28.9 U/g and ≤ 32.6 U/g (n = 154)	1.58	0.91 – 2.74	0.104
○ > 32.6 U/g and ≤ 36.3 U/g (n = 150)	**1.76**	**1.04 – 2.99**	**0.036**

(N = 612)	Prevalence Odds Ratio	Confidence Interval	p – value
Observed the smell of pesticides in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	1.08	0.72 – 1.62	0.711
<u>Potential Covariates</u>			
Gender [Male =1 (n = 386); Female =0 (n = 226)]	1.14	0.75 – 1.74	0.548
Age [> 33 = 1 (n = 321); ≤ 33 = 0 (n = 291)]	**1.51**	**1.02 – 2.24**	**0.039**
Farm type [Table grapes =1 (n = 475); Wine grapes =0 (n = 137)]	0.69	0.44 – 1.09	0.108
C.A.G.E. Score	1.11	0.93 – 1.33	0.266
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 559)]	**3.78**	**2.05 – 6.97**	**0.000**
PPE [≤ 1 = 1 (n = 141); ≥ 2 = 0 (n = 471)]	1.08	0.68 – 1.70	0.751
SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 375)]	**1.81**	**1.22 – 2.68**	**0.003**
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 519)]	1.43	0.87 – 2.35	0.163
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 139)	0.89	0.50 – 1.59	0.692
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.63	0.94 – 2.80	0.081
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	**1.74**	**1.03 – 2.93**	**0.038**

Table C6 Adjusted Multivariate Results (Sequential Models)

Table C6.1 Depression (BSI Symptom Dimension) associated with Cumulative Years of Occupational Exposure, adjusted for all Potential Covariates

(N = 174)	Prevalence Odds Ratio	Confidence Interval	p – value
Years worked as a tractor driver [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	1.34	0.62 – 2.87	0.457
<u>Potential Covariates</u>			
Farm type [Table grapes = 1 (n = 138); Wine grapes =0 (n = 36)]	**0.38**	**0.16 – 0.87**	**0.022**
C.A.G.E. Score	0.95	0.68 – 1.33	0.750
Psychiatric Sickness [Yes =1 (n = 10); No = 0 (n = 164)]	**3.93**	**1.02 – 15.18**	**0.047**
PPE [≤ 1 = 1 (n = 23); ≥ 2 = 0 (n = 151)]	1.25	0.45 – 3.47	0.674
SES [< 4 = 1 (n = 50); ≥4 = 0 (n = 124)]	1.61	0.75 – 3.46	0.224
Previous pesticide poisoning [Yes = 1 (n = 35); No = 0 (n = 139)]	1.68	0.72 – 3.90	0.229
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 49)	1.00		
○ ≤ 28.9 U/g (n = 36)	0.75	0.27 – 2.13	0.594
○ > 28.9 U/g and ≤ 32.6 U/g (n = 40)	1.04	0.38 – 2.87	0.939
○ > 32.6 U/g and ≤ 36.3 U/g (n = 49)	0.81	0.31 – 2.14	0.675

	Prevalence Odds Ratio	Confidence Interval	p – value
Years worked as a head sprayer (N = 110) [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	1.12	0.40 – 3.13	0.823
<u>Potential Covariates</u> Farm type [Table grapes =1 (n = 94); Wine grapes = 0 (n = 16)]	**0.21**	**0.06 – 0.69**	**0.011**
C.A.G.E. Score	0.83	0.51 – 1.34	0.442
Psychiatric Ilness [Yes = 1 (n = 4); No = 0 (n = 106)]	0.00	0.00	0.999
PPE [≤ 1 = 1 (n = 9); ≥ 2 = 0 (n = 101)]	1.49	0.27 – 8.22	0.645
SES [< 4 = 1 (n = 33); ≥ 4 = 0 (n = 77)]	0.74	0.24 – 2.24	0.589
Previous pesticide poisoning [Yes = 1 (n = 26); No = 0 (n = 84)]	2.95	0.98 – 8.88	0.055
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 33)	1.00		
○ ≤ 28.9 U/g (n = 21)	0.62	0.14 – 2.71	0.523
○ > 28.9 U/g and ≤ 32.6 U/g (n = 23)	0.78	0.19 – 3.18	0.728
○ > 32.6 U/g and ≤ 36.3 U/g (n = 33)	0.98	0.27 – 3.57	0.978

(N = 619) **A spray person at some time during their working life** [Yes = 1 (n = 109); No = 0 (n = 510)]	0.74	0.44 – 1.25	0.260
<u>Potential Covariates</u> Age [> 33 = 1 (n = 324); ≤ 33 = 0 (n = 295)]	1.23	0.84 – 1.80	0.295
Farm type [Table grapes = 1 (n = 481); Wine grapes = 0 (n = 138)]	**0.45**	**0.30 – 0.69**	**0.000**
C.A.G.E. Score	1.09	0.92 – 1.29	0.330
Psychiatric Ilness [Yes =1 (n = 54); No =0 (n = 565)]	**2.01**	**1.09 – 3.70**	**0.025**
PPE [≤ 1 = 1 (n = 142); ≥ 2 = 0 (n = 477)]	0.84	0.54 – 1.30	0.425
SES [< 4 = 1 (n = 243); ≥ 4 = 0 (n = 376)]	**1.88**	**1.29 – 2.73**	**0.001**
Previous pesticide poisoning [Yes = 1 (n = 95); No = 0 (n = 524)]	1.34	0.82 – 2.18	0.242
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 161)	1.00		
○ ≤ 28.9 U/g (n = 142)	1.01	0.59 – 1.72	0.972
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.30	0.77 – 2.18	0.327
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	1.12	0.67 – 1.87	0.669

Table C6.2 Depression (BSI Symptom Dimension) associated with Current Occupational Exposure, adjusted for all Potential Covariates

(N = 619)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Current spray person [Yes =1 (n = 98); No =0 (n = 521)]	0.73	0.42 – 1.26	0.262
<u>Potential Covariates</u>			
Age (> 33 = 1, ≤ 33 = 0)	1.22	0.83 – 1.79	0.303
Farm type (Table grapes = 1, Wine grapes = 0)	**0.45**	**0.30 – 0.69**	**0.000**
C.A.G.E. Score	1.09	0.92 – 1.29	0.334
Psychiatric Ilness (Yes =1, No =0)	**2.02**	**1.10 – 3.71**	**0.024**
PPE (≤ 1 = 1, ≥ 2 = 0)	0.84	0.54 – 1.30	0.425
SES (< 4 = 1, ≥ 4 = 0)	**1.88**	**1.29 – 2.73**	**0.001**
Previous pesticide poisoning (Yes = 1, No = 0)	1.33	0.82 – 2.17	0.248
Cholinesterase Levels (quartiles):			
o > 36.3 U/g	1.00		
o ≤ 28.9 U/g	1.02	0.60 – 1.73	0.954
o > 28.9 U/g and ≤ 32.6 U/g	1.30	0.77 – 2.18	0.327
o > 32.6 U/g and ≤ 36.3 U/g	1.12	0.67 – 1.87	0.667

(N = 619)	Prevalence Odds Ratio	Confidence Interval	p – value
Currently involved in one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 235)]	0.86	0.56 – 1.32	0.481
Potential Covariates			
Gender [Male =1 (n = 393); Female =0 (n = 226)]	**1.93**	**1.22 – 3.04**	**0.005**
Age (> 33 = 1, ≤ 33 = 0)	1.11	0.76 – 1.63	0.585
Farm type (Table grapes = 1, Wine grapes = 0)	**0.48**	**0.31 – 0.74**	**0.001**
C.A.G.E. Score	1.09	0.92 – 1.29	0.325
Psychiatric Ilness (Yes =1, No =0)	**2.35**	**1.26 – 4.38**	**0.007**
PPE (≤ 1 = 1, ≥ 2 = 0)	0.98	0.62 – 1.55	0.933
SES (< 4 = 1, ≥ 4 = 0)	**1.94**	**1.33 – 2.83**	**0.001**
Previous pesticide poisoning (Yes = 1, No = 0)	1.26	0.78 – 2.05	0.350
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	1.07	0.62 – 1.83	0.810
○ > 28.9 U/g and ≤ 32.6 U/g	1.43	0.85 – 2.43	0.180
○ > 32.6 U/g and ≤ 36.3 U/g	1.13	0.67 – 1.89	0.653

Currently worked in vineyard during spraying [Yes = 1 (n = 457); No = 0 (n = 162)]	0.68	0.45 – 1.03	0.070
Potential Covariates			
Gender (Male =1, Female =0)	**1.88**	**1.23 – 2.87**	**0.004**
Age (> 33 = 1, ≤ 33 = 0)	1.11	0.76 – 1.62	0.597
Farm type (Table grapes = 1, Wine grapes = 0)	**0.47**	**0.31 – 0.73**	**0.001**
C.A.G.E. Score	1.11	0.93 – 1.31	0.254
Psychiatric Ilness (Yes =1, No =0)	**2.36**	**1.27 – 4.41**	**0.007**
PPE (≤ 1 = 1, ≥ 2 = 0)	1.01	0.64 – 1.59	0.968
SES (< 4 = 1, ≥ 4 = 0)	**1.94**	**1.33 – 2.84**	**0.001**
Previous pesticide poisoning (Yes = 1, No = 0)	1.31	0.80 – 2.15	0.276
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	1.05	0.61 – 1.80	0.869
○ > 28.9 U/g and ≤ 32.6 U/g	1.42	0.84 – 2.41	0.196
○ > 32.6 U/g and ≤ 36.3 U/g	1.07	0.64 – 1.80	0.802

Table C6.3 Depression (BSI Symptom Dimension) associated with Environmental Exposure, adjusted for all Potential Covariates

(N = 599)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Observed pesticide spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	1.10	0.74 – 1.62	0.647
<u>Potential Covariates</u>			
Gender [Male =1 (n = 379); Female =0 (n = 220)]	**1.82**	**1.18 – 2.80**	**0.007**
Age [> 33 = 1 (n = 313); ≤ 33 = 0 (n = 286)]	1.07	0.73 – 1.58	0.735
Farm type [Table grapes =1 (n = 465); Wine grapes =0 (n = 134)]	**0.50**	**0.33 – 0.78**	**0.002**
C.A.G.E. Score	1.12	0.94 – 1.35	0.214
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 546)]	**2.30**	**1.22 – 4.34**	**0.010**
PPE [≤ 1 = 1 (n = 134); ≥ 2 = 0 (n = 465)]	0.93	0.58 – 1.49	0.760
SES [< 4 = 1 (n = 234); ≥ 4 = 0 (n = 365)]	**1.83**	**1.24 – 2.69**	**0.002**
Previous pesticide poisoning [Yes = 1 (n = 89); No = 0 (n = 510)]	1.34	0.81 – 2.20	0.256
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 138)	1.06	0.61 – 1.84	0.830
○ > 28.9 U/g and ≤ 32.6 U/g (n = 154)	1.42	0.83 – 2.43	0.199
○ > 32.6 U/g and ≤ 36.3 U/g (n = 150)	1.06	0.62 – 1.80	0.830

(N = 612)	Prevalence Odds Ratio	Confidence Interval	p – value
Observed smell of pesticides in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	1.18	0.79 – 1.76	0.422
<u>Potential Covariates</u>			
Gender [Male =1 (n = 386); Female =0 (n = 226)]	**1.74**	**1.14 – 2.66**	**0.011**
Age [> 33 = 1 (n = 321); ≤ 33 = 0 (n = 291)]	1.13	0.77 – 1.65	0.546
Farm type [Table grapes =1 (n = 475); Wine grapes =0 (n = 137)]	**0.48**	**0.31 – 0.74**	**0.001**
C.A.G.E. Score	1.09	0.91 – 1.29	0.347
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 559)]	**2.22**	**1.18 – 4.18**	**0.014**
PPE [≤ 1 = 1 (n = 141); ≥ 2 = 0 (n = 471)]	1.01	0.64 – 1.59	0.978
SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 375)]	**1.81**	**1.23 – 2.65**	**0.002**
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 519)]	1.32	0.81 – 2.16	0.270
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 139)	1.10	0.64 – 1.91	0.729
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.50	0.88 – 2.56	0.136
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	1.21	0.72 – 2.05	0.470

Table C7 Adjusted Multivariate Results (Sequential Models)

Table C7.1 Aggression associated with Cumulative Years of Occupational Exposure, adjusted for all Potential Covariates

(N = 174)	Prevalence Odds Ratio	Confidence Interval	p – value
Years worked as tractor driver [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	**0.23**	**0.15 – 0.60**	**0.001**
<u>Potential Covariates</u>			
Farm type [Table grapes =1(n =138); Wine grapes =0(n =36)]	1.01	0.45 – 2.29	0.977
C.A.G.E. Score	1.32	0.98 – 1.78	0.068
Psychiatric Sickness[Yes =1(n =10); No =0(n =164)]	0.56	0.14 – 2.29	0.416
PPE [≤ 1 = 1 (n = 23); ≥ 2 = 0 (n = 151)]	0.67	0.25 – 1.77	0.415
SES [< 4 = 1 (n = 50); ≥4 = 0 (n = 124)]	0.69	0.34 – 1.43	0.323
Previous pesticide poisoning [Yes = 1 (n = 35); No = 0 (n = 139)]	1.67	0.74 – 3.70	0.219
Cholinesterase Levels (quartiles):			
o > 36.3 U/g (n = 49)	1.00		
o ≤ 28.9 U/g (n = 36)	**0.37**	**0.14 – 0.97**	**0.044**
o > 28.9 U/g and ≤ 32.6 U/g (n = 40)	0.46	0.18 – 1.18	0.105
o > 32.6 U/g and ≤ 36.3 U/g (n = 49)	0.48	0.20 – 1.15	0.101

	Prevalence Odds Ratio	Confidence Interval	p – value
(N = 110)			
Years worked as a head sprayer			
[> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	0.71	0.31 – 1.66	0.430
Potential Covariates			
Farm type			
[Table grapes =1(n =94);Wine grapes =0 (n =16)]	0.96	0.31 – 3.02	0.941
C.A.G.E. Score	1.01	0.67 – 1.51	0.975
Psychiatric Ilness [Yes =1 (n =4); No =0 (n =106)]	1.85	0.17 – 20.56	0.616
PPE [≤ 1 = 1 (n = 9); ≥ 2 = 0 (n = 101)]	0.27	0.05 – 1.47	0.131
SES [< 4 = 1 (n = 33); ≥ 4 = 0 (n = 77)]	0.45	0.18 – 1.13	0.087
Previous pesticide poisoning			
[Yes = 1 (n = 26); No = 0 (n = 84)]	2.01	0.76 – 5.30	0.157
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 33)	1.00		
○ ≤ 28.9 U/g (n = 21)	0.49	0.14 – 1.66	0.250
○ > 28.9 U/g and ≤ 32.6 U/g (n = 23)	0.47	0.15 – 1.53	0.209
○ > 32.6 U/g and ≤ 36.3 U/g (n = 33)	0.72	0.24 – 2.12	0.547

(N = 619)			
A spray person at some time during their working life [Yes = 1 (n = 109); No = 0 (n = 510)]	1.08	0.69 – 1.68	0.736
Potential Covariates			
Age [> 33 =1 (n =324); ≤ 33 =0 (n =295)]	**0.66**	**0.47 – 0.93**	**0.016**
Farm type			
[Table grapes =1(n =481); Wine grapes=0(n =138)]	1.08	0.72 – 1.61	0.722
C.A.G.E. Score	**1.28**	**1.10 – 1.49**	**0.001**
Psychiatric Ilness [Yes =1 (n = 54); No =0 (n =565)]	1.27	0.71 – 2.26	0.426
PPE [≤ 1 =1 (n = 142); ≥ 2 =0 (n = 477)]	1.28	0.86 – 1.89	0.225
SES [< 4 =1 (n = 243); ≥ 4 =0 (n = 376)]	**1.51**	**1.07 – 2.12**	**0.019**
Previous pesticide poisoning			
[Yes = 1 (n = 95); No = 0 (n = 524)]	1.07	0.68 – 1.69	0.760
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 33)	1.00		
○ ≤ 28.9 U/g (n = 142)	0.72	0.45 – 1.15	0.166
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	1.00	0.63 – 1.58	0.990
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	0.99	0.63 – 1.56	0.977

Table C7.2 Aggression associated with Current Occupational Exposure, adjusted for all Potential Covariates

(N = 619)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Current spray person [Yes =1 (n = 98); No =0 (n = 521)]	1.25	0.79 – 1.98	0.343
<u>Potential Covariates</u>			
Age (> 33 = 1, ≤ 33 = 0)	**0.65**	**0.46 – 0.91**	**0.012**
Farm type (Table grapes = 1, Wine grapes = 0)	1.07	0.71 – 1.60	0.751
C.A.G.E. Score	**1.28**	**1.10 – 1.49**	**0.001**
Psychiatric Ilness (Yes =1, No =0)	1.28	0.72 – 2.29	0.400
PPE (≤ 1 = 1, ≥ 2 = 0)	1.30	0.88 – 1.92	0.191
SES (< 4 = 1, ≥ 4 = 0)	**1.52**	**1.08 – 2.14**	**0.017**
Previous pesticide poisoning (Yes = 1, No = 0)	1.06	0.67 – 1.67	0.798
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	0.71	0.44 – 1.15	0.162
○ > 28.9 U/g and ≤ 32.6 U/g	1.00	0.63 – 1.59	0.998
○ > 32.6 U/g and ≤ 36.3 U/g	0.99	0.63 – 1.56	0.965

(N = 619)	Prevalence Odds Ratio	Confidence Interval	p – value
Currently involved in one or more spraying activity			
[Yes = 1 (n = 384); No = 0 (n = 235)]	0.89	0.61 – 1.31	0.545
Potential Covariates			
Gender [Male =1 (n =393); Female =0 (n =226)]	0.88	0.59 – 1.29	0.506
Age (> 33 = 1, ≤ 33 = 0)	**0.67**	**0.48 – 0.94**	**0.022**
Farm type (Table grapes = 1, Wine grapes = 0)	1.04	0.69 – 1.56	0.861
C.A.G.E. Score	**1.28**	**1.10 – 1.49**	**0.001**
Psychiatric Ilness (Yes =1, No =0)	1.21	0.68 – 2.16	0.521
PPE (≤ 1 = 1, ≥ 2 = 0)	1.17	0.78 – 1.76	0.443
SES (< 4 = 1, ≥ 4 = 0)	**1.51**	**1.07 – 2.13**	**0.018**
Previous pesticide poisoning (Yes = 1, No = 0)	1.10	0.70 – 1.74	0.670
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	0.71	0.44 – 1.14	0.153
○ > 28.9 U/g and ≤ 32.6 U/g	0.97	0.61 – 1.55	0.903
○ > 32.6 U/g and ≤ 36.3 U/g	1.00	0.64 – 1.58	0.993

Currently worked in vineyard during spraying			
[Yes = 1 (n = 457); No = 0 (n = 162)]	1.14	0.79 – 1.66	0.482
Potential Covariates			
Gender (Male =1, Female =0)	0.83	0.58 – 1.18	0.294
Age (> 33 = 1, ≤ 33 = 0)	**0.68**	**0.48 – 0.96**	**0.026**
Farm type (Table grapes = 1, Wine grapes = 0)	1.06	0.70 – 1.59	0.798
C.A.G.E. Score	**1.27**	**1.10 – 1.48**	**0.002**
Psychiatric Ilness (Yes =1, No =0)	1.21	0.68 – 2.17	0.516
PPE (≤ 1 = 1, ≥ 2 = 0)	1.20	0.81 – 1.79	0.368
SES (< 4 = 1, ≥ 4 = 0)	**1.50**	**1.06 – 2.11**	**0.021**
Previous pesticide poisoning (Yes = 1, No = 0)	1.08	0.69 – 1.70	0.741
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	0.71	0.44 – 1.15	0.160
○ > 28.9 U/g and ≤ 32.6 U/g	0.98	0.61 – 1.55	0.913
○ > 32.6 U/g and ≤ 36.3 U/g	1.01	0.64 – 1.60	0.957

Table C7.3 Aggression associated with Environmental Exposure, adjusted for all Potential Covariates

(N = 599)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Observed pesticide spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	1.22	0.86 – 1.71	0.264
<u>Potential Covariates</u>			
Gender [Male =1 (n = 379); Female =0 (n = 220)]	0.83	0.58 – 1.20	0.329
Age [> 33 = 1 (n = 313); ≤ 33 = 0 (n = 286)]	**0.64**	**0.45 – 0.90**	**0.011**
Farm type [Table grapes =1 (n = 465); Wine grapes =0 (n = 134)]	1.05	0.70 – 1.60	0.808
C.A.G.E. Score	**1.25**	**1.07 – 1.47**	**0.005**
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 546)]	1.26	0.70 – 2.26	0.451
PPE [≤ 1 = 1 (n = 134); ≥ 2 = 0 (n = 465)]	1.14	0.76 – 1.71	0.536
SES [< 4 = 1 (n = 234); ≥ 4 = 0 (n = 365)]	**1.48**	**1.05 – 2.09**	**0.027**
Previous pesticide poisoning [Yes = 1 (n = 89); No = 0 (n = 510)]	1.13	0.71 – 1.81	0.601
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 138)	0.70	0.43 – 1.14	0.149
○ > 28.9 U/g and ≤ 32.6 U/g (n = 154)	0.93	0.58 – 1.49	0.766
○ > 32.6 U/g and ≤ 36.3 U/g (n = 150)	0.94	0.59 – 1.49	0.779

(N = 612)	Prevalence Odds Ratio	Confidence Interval	p – value
Observed the smell of pesticides in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	**1.41**	**1.00 – 2.00**	**0.053**
<u>Potential Covariates</u>			
Gender [Male =1 (n = 386); Female =0 (n = 226)]	0.84	0.59 – 1.21	0.351
Age [> 33 = 1 (n = 321); ≤ 33 = 0 (n = 291)]	**0.65**	**0.46 – 0.92**	**0.014**
Farm type [Table grapes =1 (n = 475); Wine grapes =0 (n =137)]	1.04	0.69 – 1.58	0.838
C.A.G.E. Score	**1.27**	**1.09 – 1.48**	**0.003**
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 559)]	1.21	0.67 – 2.18	0.535
PPE [≤ 1 = 1 (n = 141); ≥ 2 = 0 (n = 471)]	1.19	0.80 – 1.78	0.400
SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 375)]	**1.49**	**1.05 – 2.10**	**0.025**
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 519)]	1.04	0.66 – 1.65	0.870
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 139)	0.75	0.47 – 1.22	0.245
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	0.97	0.61 – 1.55	0.906
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	1.04	0.66 – 1.65	0.855

Table C8 Adjusted Multivariate Results (Sequential Models)

Table C8.1 Impulsivity associated with Cumulative Years of Occupational Exposure, adjusted for all Potential Covariates

(N = 174)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Years worked as tractor driver [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]	0.57	0.29 – 1.11	0.098
<u>Potential Covariates</u>			
Farm type [Table grapes =1 (n =138); Wine grapes =0 (n = 36)]	1.78	0.79 – 4.03	0.164
C.A.G.E. Score	0.86	0.64 – 1.14	0.291
Psychiatric Sickness[Yes =1 (n =10); No =0 (n=164)]	1.10	0.29 – 4.23	0.889
PPE [≤ 1 = 1 (n = 23); ≥ 2 = 0 (n = 151)]	1.72	0.67 – 4.42	0.264
SES [< 4 = 1 (n = 50); ≥4 = 0 (n = 124)]	1.57	0.78 – 3.15	0.208
Previous pesticide poisoning [Yes = 1 (n = 35); No = 0 (n = 139)]	0.94	0.44 – 2.04	0.882
Cholinesterase Levels (quartiles):			
o > 36.3 U/g (n = 49)	1.00		
o ≤ 28.9 U/g (n = 36)	0.74	0.30 – 1.84	0.517
o > 28.9 U/g and ≤ 32.6 U/g (n = 40)	0.62	0.25 – 1.54	0.305
o > 32.6 U/g and ≤ 36.3 U/g (n = 49)	0.54	0.23 – 1.27	0.156

	Prevalence Odds Ratio	Confidence Interval	p – value
(N = 110)			
Years worked as a head sprayer [> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	0.68	0.29 – 1.59	0.376
Potential Covariates			
Farm type [Table grapes =1 (n = 94); Wine grapes = 0 (n = 16)]	2.69	0.74 – 9.77	0.133
C.A.G.E. Score	0.92	0.61 – 1.36	0.663
Psychiatric Ilness [Yes =1 (n =4); No = 0 (n =106)]	1.22	0.15 – 10.20	0.858
PPE [≤ 1 = 1 (n = 9); ≥ 2 = 0 (n = 101)]	4.07	0.87 – 19.13	0.076
SES [< 4 = 1 (n = 33); ≥ 4 = 0 (n = 77)]	1.13	0.46 – 2.78	0.792
Previous pesticide poisoning [Yes = 1 (n = 26); No = 0 (n = 84)]	1.00	0.39 – 2.55	1.00
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 33)	1.00		
○ ≤ 28.9 U/g (n = 21)	0.62	0.19 – 2.05	0.431
○ > 28.9 U/g and ≤ 32.6 U/g (n = 23)	0.73	0.23 – 2.30	0.588
○ > 32.6 U/g and ≤ 36.3 U/g (n = 33)	0.49	0.16 – 1.47	0.205

(N = 619)			
A spray person at some time during their working life [Yes = 1 (n = 109); No = 0 (n = 510)]	1.02	0.65 – 1.59	0.940
Potential Covariates			
Age [> 33 = 1 (n = 324); ≤ 33 = 0 (n = 295)]	0.79	0.56 – 1.11	0.172
Farm type [Table grapes =1 (n =481); Wine grapes =0 (n =138)]	0.73	0.49 – 1.09	0.123
C.A.G.E. Score	1.03	0.89 – 1.19	0.710
Psychiatric Ilness [Yes =1 (n =54); No =0 (n = 565)]	1.59	0.89 – 2.84	0.120
PPE [≤ 1 = 1 (n = 142); ≥ 2 = 0 (n = 477)]	1.40	0.95 – 2.07	0.090
SES [< 4 = 1 (n = 243); ≥ 4 = 0 (n = 376)]	**1.59**	**1.13 – 2.24**	**0.007**
Previous pesticide poisoning [Yes = 1 (n = 95); No = 0 (n = 524)]	0.81	0.52 – 1.29	0.378
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 33)	1.00		
○ ≤ 28.9 U/g (n = 142)	0.72	0.45 – 1.15	0.167
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	0.74	0.46 – 1.17	0.195
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	0.96	0.61 – 1.51	0.860

Table C8.2 Impulsivity associated with Current Occupational Exposure, adjusted for all Potential Covariates

(N = 619)	Prevalence Odds Ratio	Confidence Interval	p – value
Current spray person [Yes =1(n =98); No =0 (n = 521)]	1.01	0.64 – 1.61	0.954
<u>Potential Covariates</u>			
Age (> 33 = 1, ≤ 33 = 0)	0.79	0.56 – 1.11	0.172
Farm type (Table grapes = 1, Wine grapes = 0)	0.73	0.49 – 1.09	0.124
C.A.G.E. Score	1.03	0.89 – 1.19	0.709
Psychiatric Ilness (Yes =1, No =0)	1.59	0.89 – 2.83	0.121
PPE (≤ 1 = 1, ≥ 2 = 0)	1.40	0.95 – 2.07	0.091
SES (< 4 = 1, ≥ 4 = 0)	**1.59**	**1.13 – 2.24**	**0.007**
Previous pesticide poisoning (Yes = 1, No = 0)	0.82	0.52 – 1.29	0.378
Cholinesterase Levels (quartiles):			
o > 36.3 U/g	1.00		
o ≤ 28.9 U/g	0.72	0.45 – 1.15	0.167
o > 28.9 U/g and ≤ 32.6 U/g	0.74	0.46 – 1.17	0.195
o > 32.6 U/g and ≤ 36.3 U/g	0.96	0.61 – 1.51	0.861

(N = 619)	Prevalence Odds Ratio	Confidence Interval	p – value
Currently involved in one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 235)]	0.77	0.53 – 1.14	0.191
Potential Covariates			
Gender [Male =1 (n = 393); Female =0 (n = 226)]	1.11	0.75 – 1.64	0.601
Age (> 33 = 1, ≤ 33 = 0)	0.78	0.56 – 1.09	0.150
Farm type (Table grapes = 1, Wine grapes = 0)	0.72	0.48 – 1.08	0.107
C.A.G.E. Score	1.03	0.89 – 1.20	0.686
Psychiatric Ilness (Yes =1, No =0)	1.58	0.88 – 2.83	0.126
PPE (≤ 1 = 1, ≥ 2 = 0)	1.33	0.88 – 1.99	0.173
SES (< 4 = 1, ≥ 4 = 0)	**1.62**	**1.15 – 2.27**	**0.006**
Previous pesticide poisoning (Yes = 1, No = 0)	0.82	0.52 – 1.30	0.405
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	0.72	0.45 – 1.16	0.174
○ > 28.9 U/g and ≤ 32.6 U/g	0.74	0.46 – 1.18	0.200
○ > 32.6 U/g and ≤ 36.3 U/g	0.97	0.62 – 1.53	0.899

Currently worked in vineyard during spraying [Yes = 1 (n = 457); No = 0 (n = 162)]	0.85	0.59 – 1.23	0.391
Potential Covariates			
Gender (Male =1, Female =0)	1.01	0.71 – 1.45	0.941
Age (> 33 = 1, ≤ 33 = 0)	0.79	0.56 – 1.10	0.162
Farm type (Table grapes = 1, Wine grapes = 0)	0.72	0.48 – 1.09	0.117
C.A.G.E. Score	1.03	0.89 – 1.20	0.656
Psychiatric Ilness (Yes =1, No =0)	1.58	0.88 – 2.84	0.123
PPE (≤ 1 = 1, ≥ 2 = 0)	1.40	0.94 – 2.08	0.097
SES (< 4 = 1, ≥ 4 = 0)	**1.60**	**1.14 – 2.24**	**0.007**
Previous pesticide poisoning (Yes = 1, No = 0)	0.83	0.53 – 1.31	0.431
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	0.71	0.44 – 1.14	0.156
○ > 28.9 U/g and ≤ 32.6 U/g	0.73	0.46 – 1.17	0.190
○ > 32.6 U/g and ≤ 36.3 U/g	0.94	0.60 – 1.49	0.804

Table C8.3 Impulsivity associated with Environmental Exposure, adjusted for all Potential Covariates

(N = 599)	**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Observed pesticide spray drift reaching the home [Yes = 1 (n = 352); No = 0 (n = 247)]	0.75	0.53 – 1.05	0.095
<u>Potential Covariates</u>			
Gender [Male =1 (n = 379); Female =0 (n = 220)]	0.96	0.67 – 1.39	0.844
Age [> 33 = 1 (n = 313); ≤ 33 = 0 (n = 286)]	0.80	0.57 – 1.13	0.212
Farm type [Table grapes =1 (n =465); Wine grapes =0 (n =134)]	0.71	0.47 – 1.07	0.103
C.A.G.E. Score	1.06	0.91 – 1.24	0.449
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 546)]	1.61	0.89 – 2.90	0.116
PPE [≤ 1 = 1 (n = 134); ≥ 2 = 0 (n = 465)]	1.26	0.84 – 1.89	0.267
SES [< 4 = 1 (n = 234); ≥ 4 = 0 (n = 365)]	**1.53**	**1.08 – 2.16**	**0.016**
Previous pesticide poisoning [Yes = 1 (n = 89); No = 0 (n = 510)]	0.82	0.51 – 1.31	0.401
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 138)	0.72	0.45 – 1.17	0.188
○ > 28.9 U/g and ≤ 32.6 U/g (n = 154)	0.74	0.46 – 1.19	0.216
○ > 32.6 U/g and ≤ 36.3 U/g (n = 150)	0.96	0.60 – 1.52	0.851

(N = 612)	Prevalence Odds Ratio	Confidence Interval	p – value
Observed the smell of pesticides in the home [Yes = 1 (n = 396); No = 0 (n = 216)]	0.95	0.67 – 1.34	0.759
Potential Covariates			
Gender [Male =1 (n = 386); Female =0 (n = 226)]	0.97	0.68 – 1.39	0.864
Age [> 33 = 1 (n = 321); ≤ 33 = 0 (n = 291)]	0.81	0.58 – 1.14	0.229
Farm type [Table grapes =1(n =475); Wine grapes =0 (n = 137)]	0.72	0.48 – 1.08	0.108
C.A.G.E. Score	1.03	0.89 – 1.20	0.680
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 559)]	1.55	0.86 – 2.80	0.144
PPE [≤ 1 = 1 (n = 141); ≥ 2 = 0 (n = 471)]	1.39	0.94 – 2.08	0.102
SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 375)]	**1.52**	**1.08 – 2.13**	**0.017**
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 519)]	0.83	0.53 – 1.32	0.439
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 139)	0.74	0.46 – 1.19	0.209
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	0.77	0.48 – 1.23	0.277
○ > 32.6 U/g and ≤ 36.3 U/g (n = 157)	1.00	0.64 – 1.58	0.988

Table C9 Adjusted Multivariate Results (Sequential Models)

Table C9.1 Suicidal Ideation associated with Cumulative years of Occupational Exposure, adjusted for all Potential Covariates

(N = 174)		**Prevalence Odds Ratio**	**Confidence Interval**	**p – value**
Years worked as tractor driver [> 13 = 1 (n = 91); ≤ 13 = 0 (n = 83)]		0.52	0.26 – 1.04	0.065
<u>Potential Covariates</u>				
Farm type [Table grapes = 1 (n = 138); Wine grapes =0 (n = 36)]		0.86	0.37 – 1.98	0.724
C.A.G.E. Score		0.95	0.71 – 1.28	0.751
Psychiatric Sickness [Yes =1 (n = 10); No = 0 (n = 164)]		0.97	0.23 – 4.14	0.971
PPE [≤ 1 = 1 (n = 23); ≥ 2 = 0 (n = 151)]		0.65	0.23 – 1.86	0.426
SES [< 4 = 1 (n = 50); ≥4 = 0 (n = 124)]		1.25	0.61 – 2.57	0.537
Previous pesticide poisoning [Yes = 1 (n = 35); No = 0 (n = 139)]		1.10	0.49 – 2.47	0.815
Cholinesterase Levels (quartiles):				
○ > 36.3 U/g	(n = 49)	1.00		
○ ≤ 28.9 U/g	(n = 36)	0.58	0.22 – 1.59	0.291
○ > 28.9 U/g and ≤ 32.6 U/g	(n = 40)	0.97	0.39 – 2.45	0.952
○ > 32.6 U/g and ≤ 36.3 U/g	(n = 49)	0.80	0.33 – 1.94	0.627

	Prevalence Odds Ratio	Confidence Interval	p – value
(N = 110)			
Years worked as a head sprayer			
[> 13 = 1 (n = 57); ≤ 13 = 0 (n = 53)]	0.75	0.32 – 1.78	0.502
<u>Potential Covariates</u>			
Farm type [Table grapes =1 (n = 94); Wine grapes = 0 (n = 16)]	0.33	0.10 – 1.04	0.058
C.A.G.E. Score	0.94	0.62 – 1.41	0.760
Psychiatric Ilness [Yes = 1 (n = 4); No = 0 (n = 106)]	2.06	0.25 – 17.05	0.504
PPE [≤ 1 = 1 (n = 9); ≥ 2 = 0 (n = 101)]	0.49	0.09 – 2.72	0.413
SES [< 4 = 1 (n = 33); ≥ 4 = 0 (n = 77)]	1.01	0.41 – 2.50	0.991
Previous pesticide poisoning [Yes = 1 (n = 26); No = 0 (n = 84)]	0.85	0.32 – 2.23	0.739
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 33)	1.00		
○ ≤ 28.9 U/g (n = 21)	0.86	0.25 – 2.93	0.806
○ > 28.9 U/g and ≤ 32.6 U/g (n = 23)	1.09	0.34 – 3.52	0.880
○ > 32.6 U/g and ≤ 36.3 U/g (n = 33)	0.68	0.23 – 2.05	0.499

(N = 618)			
A spray person at some time during their working life [Yes = 1 (n = 109); No = 0 (n = 509)]	1.54	0.97 – 2.44	0.066
<u>Potential Covariates</u>			
Age [> 33 = 1 (n = 323); ≤ 33 = 0 (n = 295)]	**0.69**	**0.48 – 0.99**	**0.043**
Farm type [Table grapes = 1 (n = 480); Wine grapes = 0 (n = 138)]	**0.61**	**0.41 – 0.92**	**0.019**
C.A.G.E. Score	1.01	0.86 – 1.17	0.947
Psychiatric Ilness [Yes =1 (n = 54); No =0 (n = 564)]	1.08	0.58 – 2.01	0.801
PPE [≤ 1 = 1 (n = 142); ≥ 2 = 0 (n = 476)]	0.98	0.65 – 1.48	0.925
SES [< 4 = 1 (n = 243); ≥ 4 = 0 (n = 375)]	1.13	0.79 – 1.62	0.501
Previous pesticide poisoning [Yes = 1 (n = 95); No = 0 (n = 523)]	0.73	0.44 – 1.19	0.205
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 161)	1.00		
○ ≤ 28.9 U/g (n = 142)	0.79	0.48 – 1.30	0.351
○ > 28.9 U/g and ≤ 32.6 U/g (n = 159)	0.91	0.56 – 1.47	0.688
○ > 32.6 U/g and ≤ 36.3 U/g (n = 156)	0.85	0.52 – 1.36	0.491

Table C9.2 Suicidal Ideation associated with Current Occupational Exposure, adjusted for all Potential Covariates

(N = 618)	Prevalence Odds Ratio	Confidence Interval	p – value
Current spray person [Yes =1 (n = 98); No =0 (n = 520)]	1.53	0.95 – 2.47	0.079
Potential Covariates			
Age (> 33 = 1, ≤ 33 = 0)	**0.70**	**0.49 – 1.00**	**0.047**
Farm type (Table grapes = 1, Wine grapes = 0)	**0.61**	**0.41 – 0.93**	**0.020**
C.A.G.E. Score	1.01	0.86 – 1.18	0.927
Psychiatric Ilness (Yes =1, No =0)	1.07	0.58 – 1.99	0.822
PPE (≤ 1 = 1, ≥ 2 = 0)	0.98	0.65 – 1.48	0.918
SES (< 4 = 1, ≥ 4 = 0)	1.13	0.79 – 1.62	0.503
Previous pesticide poisoning (Yes = 1, No = 0)	0.73	0.45 – 1.20	0.217
Cholinesterase Levels (quartiles):			
o > 36.3 U/g	1.00		
o ≤ 28.9 U/g	0.78	0.48 – 1.29	0.336
o > 28.9 U/g and ≤ 32.6 U/g	0.91	0.56 – 1.47	0.689
o > 32.6 U/g and ≤ 36.3 U/g	0.85	0.53 – 1.37	0.497

(N = 618)	Prevalence Odds Ratio	Confidence Interval	p – value
Currently involved in one or more spraying activity [Yes = 1 (n = 384); No = 0 (n = 234)]	0.68	0.46 – 1.01	0.058
Potential Covariates			
Gender [Male =1 (n =393); Female =0 (n = 225)]	1.15	0.76 – 1.74	0.498
Age (> 33 = 1, ≤ 33 = 0)	0.72	0.51 – 1.03	0.073
Farm type (Table grapes = 1, Wine grapes = 0)	**0.61**	**0.40 – 0.93**	**0.020**
C.A.G.E. Score	1.02	0.87 – 1.19	0.844
Psychiatric Ilness (Yes =1, No =0)	1.02	0.55 – 1.89	0.962
PPE (≤ 1 = 1, ≥ 2 = 0)	0.85	0.56 – 1.31	0.459
SES (< 4 = 1, ≥ 4 = 0)	1.13	0.79 – 1.61	0.515
Previous pesticide poisoning (Yes = 1, No = 0)	0.78	0.48 – 1.27	0.313
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	0.79	0.48 – 1.31	0.362
○ > 28.9 U/g and ≤ 32.6 U/g	0.90	0.55 – 1.46	0.672
○ > 32.6 U/g and ≤ 36.3 U/g	0.87	0.54 – 1.41	0.578

Currently worked in vineyard during spraying [Yes = 1 (n = 457); No = 0 (n = 161)]	0.75	0.51 – 1.11	0.151
Potential Covariates			
Gender (Male =1, Female =0)	1.01	0.69 – 1.47	0.961
Age (> 33 = 1, ≤ 33 = 0)	0.73	0.51 – 1.04	0.083
Farm type (Table grapes = 1, Wine grapes = 0)	**0.62**	**0.41 – 0.94**	**0.023**
C.A.G.E. Score	1.02	0.88 – 1.19	0.783
Psychiatric Ilness (Yes =1, No =0)	1.03	0.55 – 1.90	0.938
PPE (≤ 1 = 1, ≥ 2 = 0)	0.92	0.61 – 1.41	0.711
SES (< 4 = 1, ≥ 4 = 0)	1.11	0.78 – 1.58	0.570
Previous pesticide poisoning (Yes = 1, No = 0)	0.79	0.48 – 1.29	0.351
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g	1.00		
○ ≤ 28.9 U/g	0.77	0.47 – 1.28	0.315
○ > 28.9 U/g and ≤ 32.6 U/g	0.89	0.55 – 1.45	0.641
○ > 32.6 U/g and ≤ 36.3 U/g	0.84	0.52 – 1.35	0.463

Table C9.3 Suicide Ideation associated with Environmental Exposure, adjusted for all Potential Covariates

(N = 598)	Prevalence Odds Ratio	Confidence Interval	p – value
Observed pesticide spray drift reaching the home [Yes = 1 (n = 351); No = 0 (n = 247)]	0.94	0.66 – 1.35	0.748
<u>Potential Covariates</u>			
Gender [Male =1 (n = 379); Female =0 (n = 219)]	0.97	0.66 – 1.43	0.889
Age [> 33 = 1 (n = 312); ≤ 33 = 0 (n = 286)]	0.72	0.50 – 1.04	0.079
Farm type [Table grapes =1 (n = 464); Wine grapes =0 (n = 134)]	**0.62**	**0.40 – 0.94**	**0.025**
C.A.G.E. Score	1.05	0.89 – 1.24	0.569
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 545)]	1.13	0.60 – 2.12	0.701
PPE [≤ 1 = 1 (n = 134); ≥ 2 = 0 (n = 464)]	0.82	0.53 – 1.27	0.370
SES [< 4 = 1 (n = 234); ≥ 4 = 0 (n = 364)]	1.12	0.78 – 1.61	0.538
Previous pesticide poisoning [Yes = 1 (n = 89); No = 0 (n = 509)]	0.77	0.46 – 1.27	0.301
Cholinesterase Levels (quartiles):			
○ > 36.3 U/g (n = 157)	1.00		
○ ≤ 28.9 U/g (n = 138)	0.75	0.45 – 1.25	0.273
○ > 28.9 U/g and ≤ 32.6 U/g (n = 154)	0.84	0.51 – 1.37	0.475
○ > 32.6 U/g and ≤ 36.3 U/g (n = 149)	0.77	0.47 – 1.26	0.297

(N = 611)	Prevalence Odds Ratio	Confidence Interval	p – value
Observed the smell of pesticides in the home [Yes = 1 (n = 395); No = 0 (n = 216)]	1.14	0.79 – 1.65	0.483
Potential Covariates			
Gender [Male =1 (n = 386); Female =0 (n = 225)]	0.99	0.68 – 1.44	0.952
Age [> 33 = 1 (n = 320); ≤ 33 = 0 (n = 291)]	0.74	0.52 – 1.06	0.099
Farm type [Table grapes =1 (n = 474); Wine grapes =0 (n = 137)]	**0.64**	**0.42 – 0.97**	**0.035**
C.A.G.E. Score	1.01	0.86 – 1.18	0.935
Psychiatric Ilness [Yes =1 (n = 53); No =0 (n = 558)]	1.04	0.56 – 1.95	0.892
PPE [≤ 1 = 1 (n = 141); ≥ 2 = 0 (n = 470)]	0.94	0.62 – 1.44	0.783
SES [< 4 = 1 (n = 237); ≥ 4 = 0 (n = 374)]	1.08	0.76 – 1.55	0.659
Previous pesticide poisoning [Yes = 1 (n = 93); No = 0 (n = 518)]	0.74	0.45 – 1.21	0.226
Cholinesterase Levels (quartiles): ○ > 36.3 U/g (n = 157) ○ ≤ 28.9 U/g (n = 139) ○ > 28.9 U/g and ≤ 32.6 U/g (n = 159) ○ > 32.6 U/g and ≤ 36.3 U/g (n = 156)	 1.00 0.81 0.91 0.89	 0.49 – 1.33 0.56 – 1.49 0.55 – 1.44	 0.401 0.710 0.631

APPENDIX D

ADDENDUM TO CHAPTER 2

(Additional information for Literature Review)

D1 Symptoms of Acute Cholinergic Neurotoxicity (Section 2.3.3.1)

The severity of the symptoms of neurotoxicity depends on the route of exposure, age of the exposed person and the specific agrichemical. According to (Hayes et al, 1980; Minton & Murray, 1988; Mearns et al, 1994; O'Malley, 1996; Dyro, 2003; Abou Donia, 2003; Antonijevic & Stojiljkovic, 2007) the signs and symptoms of acute OP toxicity are

Muscarinic effects, of which the main effects are captured in the acronyms MUDDLES (or SLUDGE) , i.e. meiosis; (increased) urination; diarrhoea; diaphoresis (excessive perspiration); lacrimation; excitation of the CNS; salivation; emesis. Other muscarinic effects are:

- Wheezing, increased bronchial secretions, bronchoconstriction
- Cyanosis, pulmonary oedema
- Increased pulmonary and oropharyngeal secretions
- Bradycardia, hypotension and heartblock

Nicotinic effects, which may include

- Muscle fasciculation, including diaphragmatic muscle
- Respiratory muscle weakness
- Diminished respiratory effort
- Tachycardia, hypertension
- Fatigue, paralysis

CNS (nicotinic) effects, which may include

- Acute psychological effects like, restlessness, anxiety, depression, irritability
- Neuropsychological effects like, poor concentration, memory impairment, decreased alertness, word finding problems
- Confusion, headache, tremor, ataxia, dysarthria (slurred speech)
- Convulsions and coma
- Central respiratory paralysis

Bradycardia and excessive secretions occur more commonly in dermal and ingestion overexposure, rather than inhalation exposure (Abou Donia, 2003) Mild and moderate intoxication will result in a range of muscarinic and nicotinic symptoms varying in severity, depending on the extent of the overexposure. Severe intoxication will present with muscarinic, nicotinic and CNS symptoms, particularly respiratory failure and coma (Minton & Murray, 1988; Antonijevic & Stojiljkovic, 2007).

D2 Risk Control Measures (Section 2.3.4)

OHSAS 18001 entails implementation of the following hierarchy of risk control measures: (1) elimination of the hazard at the source (2) reduce the hazard by substituting with a less hazardous substance (3) contain the hazard by engineering controls (4) administrative controls by signage / warnings and reducing employee exposure, e.g. 4 persons exposed for two hours each instead of one person exposed for 8 hours (5) PPE.

D3 Agricultural Regulatory Organisations

The co-operatives and farms that supply the different supermarkets in Europe, the United Kingdom and the USA, are required to be certified and compliant with specified exporter and national codes (e.g. EUREPGAP, British Retail Consortium, HACCP, Nature's Choice, ISO9002), and national legislation. The provision of PPE and protective clothing are included in these codes. Hence, farm owners and managers requiring accreditation with the exporter code(s), have had to provide their farm workers with the necessary PPE, protective clothing and improve the protection of the workers regarding pesticide handling (personal observations while executing health and safety audits for the Wine and Agricultural Industry Ethical Trade Association (WIETA), South Africa, 2004 – 2007).

D4 Association of Somatising Tendencies with Depression (Section 2.4.1.2)

Agricultural studies have found a positive association between somatising tendencies and depressive symptoms (Booth et al 2000; Patel et al 2001; Gregoire 2002). Similarly, Malmberg et al (1997 and 1999) found that depression and physical illness, as determined by frequent attendance of a general practitioner in the last three months, were common and important factors in suicide deaths of farmers in England and Wales. Hence, it was suggested by Booth et al (2000) that when farmers present with recurrent physical problems, general practitioners should consider depression and suicidal intent. A study conducted by Rosenstock et al (1991) however found a borderline increase in somatic (physical health) symptoms amongst their pesticide exposed group of participants but there were no differences in psychiatric symptoms between the exposed and unexposed study groups.

D5 Criteria for self-administered instruments to screen for Depression (Section 2.4.3)

- Is the conceptual basis on which the instrument was developed, sound and credible?
- Is it intended to detect solely depression or other emotional problems, as well?
- Does it measure the severity of depression?
- Has it been tested across a broad spectrum of patients, especially those in primary care or in the community?
- Is it feasible and easy to apply in a clinical setting?
- Is there evidence to support its sensitivity to changes in clinical status?
- Is there evidence to support its reliability?
- Is there evidence that it is a valid measure for the early detection of depression?

D6 Psychometric Characteristics of the Neuropsychiatric Instruments used in the study (Section 2.4.3)

D6.1 General Heath Questionnaire (GHQ)

The original full-length version of the GHQ requires „any 12 symptoms from a set of 60 symptoms to identify a probable case' (Goldberg & Hillier 1979). The internal consistency of the GHQ-60 has been from 80% to 90%, and the coefficients of correlation with global clinical assessments of psychopathology

0.55 to 0.83. The overall sensitivity of the GHQ has been about 68% and the specificity 81% (Feightner et al, 1990).

The shortened 28-item GHQ consists of 4 sub-scales, which are not independent of each other. The highest correlation coefficient of +0.90 between the B scale and the GHQ total score supports the opinion that „anxiety is a core phenomenon which underlies the common syndromes of psychiatric disorder' (Goldberg & Hillier 1979). The other three scales allow for the investigation of other symptoms. The correlation coefficients for the other scales and the GHQ total score are: A scale +0.79, C scale +0.75, and D scale +0.69.

D6.2 Beck Depression Inventory (BDI)

The BDI has been subjected to intensive psychometric evaluation since its inception in 1961. Reliability studies have shown high internal consistency for the BDI / BDI-1A ranging from .73 to .92 with alpha coefficients of .86 for psychiatric populations and .81 for non-psychiatric populations (Beck et al 1988 cited in Groth-Marnat 1990), meaning that the items on the inventory are highly correlated with each other. The BDI is sensitive to change over time with treatment. Test-retest reliabilities for the BDI-1A range from .48 to .86 depending on the interval between retesting and the type of population (Beck et al 1988 cited in Groth-Marnat 1990). Concurrent validity studies that compared the BDI-1A with clinician ratings of depression range from .62 to .66. The BDI-II has also been shown to have high one week test-retest reliability (Pearson r = 0.93), and demonstrated high internal consistency with an alpha coefficient of .91 (Anonymous, 2008).

D6.3 Brief Symptom Inventory (BSI)

The BSI was developed in response to the results of an evaluation of the item-dimension correlation of the SCL-90-R, which found that loading five to six items of each subscale of the SCL-90-R was sufficient to sustain the effectiveness of each syndrome construct. (Derogatis & Cleary 1977a cited in Derogatis 1993).The items of the SCL-90-R that loaded highest on each symptom dimension were selected to form the BSI.

The BSI primary symptom dimensions are highly correlated with the comparable dimensions of the SCL-90-R (Derogatis 1993), and ranges from .92 (on PSY) to .99 (on HOS) for the primary symptom dimensions.

Internal consistency reliability coefficients of the primary symptom dimensions range from .71 (on PSY) to .85 (on DEP), which indicates the extent of the homogeneity of selected items in their representation of the symptom construct. Test-retest reliability coefficients of primary symptom dimensions range from .68 (on SOM) to .91 (on PHOB), and for the global indices from .80 (on PST) to .90 (on GSI), which indicates the extent to which measurement remains stable across time.

D6.4 Aggression Questionnaire (AQ)

The 29-item AQ incorporates three measurement models (Ang 2007)

- A unidimensional model that assumes all items reflect a single global aggression factor
- A multidimensional model that assumes that there are four interrelated first-order factors of aggression, viz. physical aggression, verbal aggression, anger and hostility.
- A hierarchical model that assumes a single , global second-order factor (global aggression) underlies the covariation among the four correlated first-order factors

For both the 29-item and refined 12-item AQ models, the Physical Aggression and Anger factors showed the strongest evidence of convergent and discriminant validity, whereas the Verbal Aggression factor showed the weakest'. In contrast, the Hostility factor had stronger discriminant validity in its refined than in its original form (Bryant & Smith 2001).
Bryant and Smith (2001) concluded that because dispositional aggression is multidimensional, it was best to measure the four separate subtraits of aggression than rely on a pooled total score. Thus the 29-item total score should not be the only measure of quantifying responses to the AQ.

D6.5 Barratt Impulsiveness Scale (BIS)

The development of the BIS-11 subfactors was carried out by Patton et al (1995), who conducted a study to revise the BIS-10, identify the factor structure of the items among normals (college undergraduates), and compare their scores on the revised form (BIS-11) with psychiatric inpatients and prison inmates. It was hypothesized that prison inmates would score higher than other groups on the BIS-11 based on their general lack of impulse control as demonstrated in a study of the „impulsivist personality' (Stanford & Barratt 1992 cited in Patton et al

1995). Psychiatry patients, especially those with substance abuse disorder, were hypothesized to score higher than normals (O'Boyle & Barratt 1993 cited in Patton et al 1995).

Among the college undergraduates, all first-order factor scores of the BIS-11 were significantly intercorrelated from .15 to .42 ($p < 0.0001$). All second-order factor scores were significantly correlated with one another from .46 to .53 ($p < 0.0001$). The BIS-11 total score was significantly correlated with all first- and second-order factor scores. Total scores on the 34-item BIS-10 and 30-item BIS-11 were significantly correlated ($r = 0.98$; $p < 0.0001$) (Patton et al 1995). Crohnbach's alpha coefficients for the total BIS-11 score were within acceptable limits across all groups in the study (.79 to .83).

D7 Alcohol Use: Screening Alcohol Tests

Tests that are similar to or include CAGE questions are the T – ACE Test, TWEAK Test and Rapid Alcohol Problems Screen (RAPS4) Test

The **Michigan Alcohol Screening Test (MAST)** consists of 22 yes/no questions, with six positive responses indication a drinking problem. The test results have shown it to be one of the most accurate alcohol screening instruments, but it is too lengthy and time-consuming to be administered in primary care or emergency setting. This test can be used with adults and adolescents.

Other alcohol screening tests are the **Paddington Alcohol Test** (designed for use in the emergency room); **FAST Test** (a four item questionnaire designed for use in emergency and urgent care settings); A**lcohol Use Disorders Identification Test (AUDIT) (**developed by the World Health Organization) and **Five-Shot Questionnaire** (combination of AUDIT test and the CAGE questionnaire).

A study assessing the diagnostic performance of the CAGE and AUDIT questionnaires in a region of 69 primary care general practices in Belguim, was conducted by Aertgeerts et al (2001). The study found that the past year prevalence of alcohol abuse or dependence for this population was 8.9% (178/1992). Amongst the males, the AUDIT questionnaires had reasonable sensitivities between 68% and 93% at lower cut-points than recommended. The sensitivity of the CAGE was 62% at its lowest cut-point of greater than or equal to one (≥ 1). Sensitivities for female patients were lower. The study concluded that the AUDIT questionnaire was appropriate for use with male and female patients in that population.