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A RESPIRATORY HEALTH SURVEY WITHIN A BREWERY IN SOUTH AFRICA

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DECLARATION

I, Gail Rosamund Irwin, hereby declare that the work on which this thesis is based is my original work (except where acknowledgement indicates otherwise) and that neither the whole work, nor any part of it has been, is being, or is to be submitted for another degree at this or any other University.

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ABSTRACT

Introduction: A brewery worker developed work-related asthma associated with exposure to malt and other grain dust allergens in a brewery over a period. The aim of this study was to determine the prevalence of work-related respiratory symptoms and associated risk factors, within this brewery in South Africa

Study method: Use was made of a cross-sectional analytical study design. Sample method: A stratified opportunistic sampling method was used to select the study sample (n = 251) from a total population of 414 permanent workers in the brewery. The workers were classified into three exposure groups based on a subjective visual assessment of exposure to dusts, chemicals, gases, vapors and fumes reported in different departments. Study tool: A previously validated interviewer-administered questionnaire of the European Community Respiratory Health Survey (ECRHS), adapted for local context, was used. Almost all (251/252) workers selected eventually participated in the study. Analysis: Univariate, bivariate and multivariate logistic regression models were used to investigate the association between upper and lower respiratory symptoms and outcomes, host factors and specific environmental exposures.

Results: The study population was predominantly male (n=95; 78%) with a mean age of 40 years and an average of 10 years employed in the current job. Thirty-five percent (n=88; 35%) of the workforce were smokers, twenty-five percent (n=62; 25%) had a family history of allergy, hay fever and/or asthma and sixteen percent (n=39; 16%) reported doctor-diagnosed asthma. The most common potentially hazardous agents reported included sodium hydroxide (n=123; 49%), carbon dioxide (n=108; 43%), ammonia (n=100; 40%), kieselguhr/silica dust (n=88; 35%) and malt dust (n=83; 33%). Upper respiratory symptoms (n=161; 64%) were more common than lower respiratory symptoms (3% – 28%). Between 2% and 38% of workers reported possible work-related respiratory symptom experiences depending on the definition used. The common respiratory disease phenotypes included general asthma (n=39; 16%), atopic asthma (n=18; 7%), work-related asthma (n=15; 6%), work aggravated asthma (n=7; 3%), possible allergic alveolitis/grain fever (n=63; 25%) and possible chronic bronchitis (n=7; 3%). Host factors strongly associated with respiratory outcomes included age, male gender, previous hospitalization for a lung disease and a family history of allergy, hay fever or asthma. In the adjusted multivariate logistic regression models, hazardous chemical agents such as sodium hydroxide (OR, 2.27: 95%CI, 1.09-4.73) and kiesselguhr/silica (OR, 2.58: 95%CI, 1.22-5.46) were strongly associated with work-related upper airway symptoms.

Workers in the high exposure group were ten times as likely (OR, 10.45: 95%CI 3.08–35.45), compared to the lower exposure group, to have reported a chest problem caused by peak exposures to a large amount of dusts, chemicals, gases, vapors or fumes. Chemicals strongly associated with lower respiratory symptoms in general, and in excessive levels of either dusts, chemicals, gases, vapors or fumes causing a chest problem, included sodium hydroxide (OR, 2.79: 95%CI,1.48 - 5.28), carbon dioxide (OR, 3.92: 95%CI, 2.04 -7.56) and ammonia (OR,3.69: 95%CI, 2.01 – 6.78). In addition, sodium hydroxide (OR, 7.28: 95%CI, 3.41-15.56), carbon dioxide (OR, 2.93: 95%CI, 1.53-5.62) and kiesselguhr/silica (OR, 2.40: 95%CI, 1.27- 4.53) were significantly associated with possible allergic alveolitis. Only sodium hydroxide demonstrated strong associations with possible, probable or confirmed asthma. Among the biological agents, grain dust (OR, 2.16: 95%CI, 1.08-4.33), hops (OR, 2.05: 95%CI, 1.07-3.93) and malt dust (OR, 2.16: 95%CI, 1.17-4.04) were strongly associated with possible allergic alveolitis/grain fever. Grain dust (OR, 13.28: 95%CI, 2.28-77.39), hops (OR, 7.21: 95%CI, 1.33-39.18) and malt dust (OR, 5.83: 95%CI, 1.08-31.55) were significantly associated with possible chronic bronchitis.

Conclusion: Brewery workers exposed to high levels of dusts, chemicals, gases, vapors or fumes are at increased risk of developing work-related respiratory symptoms and developing work-related asthma, chronic bronchitis and possible allergic alveolitis/grain fever. The symptoms are associated with exposure to once-off peak exposures of dusts, chemicals, gases, vapors or fumes. Both hazardous chemical agents (sodium hydroxide, carbon dioxide, ammonia and kiesselguhr/silica) and biological agents (malt dust, hops and other grain dust) are implicated.

Significance to clinical practice: The high prevalence of work-related respiratory symptoms associated with chemical and biological exposures in a brewery were identified. In addition, several host-related factors were also identified. This survey points to the need for appropriate preventative strategies to be undertaken in order to reduce exposures and more targeted respiratory medical surveillance of exposed workers. This, in the long term will reduce the incidence of respiratory problems among brewery workers, and ensure the protection and promotion of the respiratory health of employees in the workplace.

Key words: Brewery workers; respiratory symptoms; asthma; work-related asthma; work-related rhinitis; risk factors; host; environmental; occupational exposure; work-exacerbated asthma; chronic bronchitis; malt dust; dusts; chemicals; gases; vapors; fumes.

OPERATIONAL DEFINITION OF TERMS

Aeroallergen

Any airborne substance, such as malt dust, pollen or spores, which triggers an allergic reaction

Asthma

A chronic inflammatory disorder of the airways in which many cells and cellular elements play a role. The chronic inflammation is associated with airway hyper-responsiveness that leads to recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night or in the early morning. These episodes are usually associated with widespread, but variable, airflow obstruction within the lung, that is often reversible, either spontaneously or with treatment (Tarlo et al. 2008)

Allergen

A substance that causes the immune system to produce antibodies. A non-parasitic antigen may be capable of stimulating a type-1 hypersensitivity reaction in atopic individuals. In atopic individuals, non-parasitic antigens stimulate inappropriate IgE production, leading to type-1 hypersensitivity. Sensitivities vary from one person to another and it is possible to be allergic to an extraordinary range of substances. An antigen may be a foreign substance from the environment such as chemicals, bacteria, viruses, or proteins of animal and plant origin (e.g. pollen)

Antibodies

Also known as immunoglobulins are gamma globulin proteins that are found in blood or other body fluids of vertebrates and are produced in response to an antigen by the immune system to identify and neutralize foreign agents

Atopy

Most humans mount significant Immunoglobulin E (IgE) responses only as a defense against parasitic infections. However, some individuals mount an IgE response against common environmental antigens. This hereditary predisposition is called atopy. It is an allergic hypersensitivity reaction, affecting parts of the body not necessarily in direct contact with the allergen. Atopy is a disease characterized by a tendency to be hyper allergic

Chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease is a disease characterized by airflow limitation, which is generally irreversible, with the presentation of symptoms of a productive cough, airway hyper-responsiveness and breathlessness to differing degrees

Endotoxins

Toxins associated with certain bacteria, secreted only during cell division

Fibrosis (pulmonary)

The formation or development of excess fibrous connective tissue in the lungs, commonly described as 'scarring of the lungs'

Health risk

A factor that raises the probability of adverse health outcomes (World Health Organisation)

Healthy worker survivor effect

This 'effect' occurs when workers who become ill are 'selected out' of employment, through either medical disability or resignation. This would result in reduced risks estimates in a cross-sectional study assessing the relationship between the exposure and the outcome, such as asthma (Joubert & Ehrlich 2007)

Hypersensitivity

A state of altered reactivity in which the body reacts with an exaggerated immune response to what is perceived as a foreign substance

Hypersensitivity (Type 1)

Refers to immediate allergy, sensitivity, and is an allergic reaction provoked by re-exposure to a specific type of antigen referred to as an allergen. Exposure may be by ingestion, inhalation, injection or direct contact

Hypersensitivity Pneumonitis (HP)

The group of diseases caused by pulmonary hypersensitivity to inhaled organic antigens, usually caused by a type-3 allergic reaction to microorganisms (e.g. aspergillus clevatus). Appears to affect the peripheral gas-exchanging tissues of the lung, and is characterized by dysnoea some hours after exposure, a pyrexial reaction, crepitations, diffuse micronodular opacities on radiological examination, and reduction in both forced vital capacity (FVC) and carbon monoxide (CO) transfer factor. In most instances there is no clinical or physiological evidence of obstructive disease of the airways, such as wheezing (Riddle et. al, 1968)

Immunological

The study of all aspects of the immune system

Immunoglobulin E (IgE)

IgE is a type of protein called an antibody. The body's immune system produces antibodies in response to substances it perceives as threats to one's health. When one has allergic asthma one's body is thought to make too much of a natural substance known as IgE in response to certain allergens such as pollen, dust mites, animal dander and cockroaches. This extra IgE may lead to the development and persistence of airway inflammation, which results in asthma symptoms and asthma attack. It is a class of antibody that has only been found in mammals, and plays an important role in allergy, is especially associated with type-1 hypersensitivity and capable of triggering the most powerful immune reactions

In vitro

In an artificial environment outside the living organism, e.g. test done in a laboratory

Irritant

Many substances can aggravate or increase the severity of asthma symptoms in individuals who are sensitive to these allergens or irritants, such as cigarette smoke, ammonia gas

Medical surveillance

A periodic comprehensive review of a worker's health status. Acceptable elements of such surveillance program are listed in legislation pertaining to, for example, Occupational Health

Mycotoxins

The toxic chemical products produced by fungi e.g. mould. One mould species may produce many different mycotoxins

Occupational asthma (OA)

Refers to *de novo* asthma or the recurrence of previously quiescent asthma (i.e, asthma as a child or in the distant past that has been in remission) induced by either sensitization to a specific substance (e.g. an inhaled protein [high-molecular-weight] protein of > 10 kd or a chemical at work [low-molecular-weight agent]), which is termed 'sensitizer-induced OA', and/or by exposure to an inhaled irritant at work, which is termed 'irritant-induced OA' (Tarlo et al. 2008)

Occupational conjunctivitis

Inflammation of the conjunctiva of the eye: Related to ones occupation

Occupational disease

Disease related to an occupation

Organic dust

Aerosols or particulate matter of microbial, plant or animal origin, that may consist of live or dead bacteria, viruses, allergens, bacterial endotoxins, mycotoxins, glucans, pollen, plant fibres

Prevalence

Total number of cases of a disease in the population at a given time, or the total number of cases in the population, divided by the number of individuals within that population. It is used as an estimate of how common a condition is within a population over a certain period of time

Pyrexial

Fever. Elevated body temperature

Reactive Airways Dysfunction Syndrome (RADS)

The most definitive form of irritant-induced asthma which describes an acute onset of asthma after a single, very high irritant exposure (Tarlo et al. 2008)

Rhinitis (occupational rhinitis)

The episodic work-related occurrence of sneezing, nasal discharge, pruritis, and congestion which contribute to distress, discomfort and work inefficiency, and is two to three times more frequent than OA, and often co-exists with OA, frequently preceding development of OA but not developing subsequently to OR

Sensitizer

A chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue, after repeated exposure to the chemical

Sentinel health event

A sentinel event is defined as any unanticipated event in a healthcare setting, resulting in death or serious physical or psychological injury to a patient or patients not related to the natural course of the patient's illness. Sentinel events specifically include loss of a limb or gross motor function, and any event for which a recurrence would carry a risk of a serious adverse outcome

Spirometry

The measurement of the volume and /or flow rate of gas breathed in or out of the lungs under specific conditions of effort, namely maximum effort

Toxins

A poisonous substance produced by the living cells or organisms capable of causing disease

Urticaria (Occupational contact urticaria)

An erythematous, popular, pruritic rash seen in classic hives, specifically associated with occupational exposure. The mechanism is usually an Immunoglobulin-E-mediated (IgE-mediated) process

Work-exacerbated Asthma (WEA)

Asthma triggered by various work-related factors (e.g. aeroallergens, irritants or exercise) in workers who are known to have pre-existing or concurrent asthma. Namely, asthma that is occurring at the same time but is not caused by workplace exposures (Tarlo et al. 2008)

Work-related Asthma (WRA)

A broad term encompassing both occupational asthma (OA*)* and work-exacerbated asthma (WEA) that may coexist in individual workers (Malo et al. 2007)

ABBREVIATIONS

ACCP	American College of Chest Physicians
ACGIH	American Conference of Industrial Hygienists
CO	Carbon monoxide
COID	Compensation for Occupational Injuries and Diseases Act
COPD	Chronic obstructive pulmonary disease
EAA	Extrinsic allergic alveolitis
ECRHS	European Community Respiratory Health Survey
FeNO	Fractional exhaled nitric oxide
FEV1	Forced expiratory volume in one second
FHS HREC	Faculty of Health Sciences Human Research Ethics Committee
FVC	Forced vital capacity
GDP	Gross Domestic Product
Hazchem	Hazardous chemicals
HMW	High molecular weight
HP	Hypersensitivity pneumonitis
IgE	Immunoglobulin-E
IrIA	Irritant-induced asthma
LoD	Limit of detection
LMW	Low molecular weight
MSDS	Material Safety Data Sheet
NO	Nitrous oxide
NIOH	National Institute of Occupational Health
OA	Occupational asthma
OC	Occupational conjunctivitis
OCSA	Occupational Society of South Africa
OD	Occupational dermatitis
OHSA	Occupational Health and Safety Act
OR	Occupational rhinitis
PEFR	Peak expiratory flow rate
PPE	Personal protective equipment
RADS	Reactive airways dysfunction syndrome
TLC	Total lung capacity
WEA	Work-exacerbated asthma
WHO	World Health Organisation
WRA	Work-related asthma

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INTRODUCTION

1.1 Introduction

There have been very few studies that have investigated the prevalence of respiratory symptoms in brewery workers. This study provides a description of the demographic profile of workers in a South African brewery with particular reference to personal and occupational characteristics. The prevalence of work-related respiratory symptoms associated with allergic respiratory outcomes among the workers in different exposure groups are presented. A discussion of the relationship between these symptoms and host and work-related factors, followed by recommendations, concludes the study.

Chapter 1

Introduces the reader to the background to the study within its global, South African and industrial contexts. The problem and scientific rationale are presented, aim and research question identified and research objectives stated.

Chapter 2

Presents the background and literature reviewed. It describes the working population at risk. Properties, characteristics and health effects of malt dust, food dust particulates, chemicals, gases, vapors and fumes are related. Respiratory outcomes, environmental and host risk factors are discussed. An overview of previous studies is given. Significance and relevance for health, and the purpose of the study concludes the chapter.

Chapter 3

Outlines the study design selected and considered most appropriate for this study. The rationale thereof, the study setting, study population, brewing process and methodology employed, is discussed. The sampling approach and recruitment, including inclusion and exclusion criteria, are described. Ethical considerations of the study are related. The collection and management of data and data analysis are included in this chapter.

Chapter 4

Presents the research analysis and findings that are derived from the specific research objectives that address the research question. Univariate, bivariate and multivariate logistical regression models were used to investigate the association between upper and lower respiratory symptoms, host factors and specific chemical and biological agents, and respiratory outcomes. Measures of disease association were evaluated by means of Chi2 test prior to regression models. Results are presented by means of tables and statistical summaries including odds ratios (unadjusted and adjusted) and their confidence intervals.

Chapter 5

Presents a discussion of the findings. Reference is made to relevant and available literature reviewed in Chapter 2, expanding on main trends.

Chapter 6

Concludes the study. Limitations of the study, implications and recommendations will be included in this chapter. A summary of findings and discussion concludes the study.

1.2 Occupational Health: The global context

Work can be hazardous to one's health and to ones safety. Nearly half of the world's population of 6 billion people are workers, of which an estimated 90% live and work in developing countries, contributing greatly to both economic and social development worldwide (WHO 2007). Approximately 40% of these workers are employed in potentially hazardous sectors. Global estimates focusing on the contribution of occupational exposures to ill health, indicates that selected risks at work resulted in the loss of 24 million years of healthy life and caused 850,000 deaths worldwide in 2000 (Adams, Morar, Kolbe-Alexander & Jeebhay 2007).

Hazards in the workplace, together with social and individual factors, and access to health services, may impact on the health and safety of workers. To address these issues, the World Health Organisation and other organisations have come together with strategies, policies and programs to target, in particular, developing countries with occupational initiatives. This is in order to prevent occupational hazards and to protect and promote health at the workplace (World Health Organisation 2007).

National policies and plans for the implementation, monitoring and evaluation of a 'Global Plan of Action on Workers health 2008 – 2017', together with appropriate mechanisms and legal frameworks, is being promoted at both national and international levels. This is in collaboration with workers, employers and their organizations (World Health Organisation 2007). It includes the incorporation of workers health into national policy, the establishment of appropriate evidenced-based health programs, services and surveillance systems in the primary prevention of work-related hazards and diseases, and the development of comprehensive health and non-health strategies to ensure reintegration of sick and injured workers into the mainstream of society (World Health Organisation 2007).

1.3 Occupational health: The South African context

Workers accounted for 17 million of the economically active population in 2006. This figure represented a marked growth and was particularly observed in both the informal sector and women applicants, with women accounting for six in ten of all new labour force entrants (Adams et al. 2007).

Occupational illness and disease pose an enormous cost to the South African economy. A study commissioned by the Department of Labour in 1997 estimated the cost to equate to R17 billion which translated to 3.5% of the Gross Domestic Product (Adams et al. 2007). As Public health care provision in South Africa is influenced by legislative requirements, so too is health care provision in the workplace. There are statutes that govern occupational health and safety, health service provision and compensation for occupational injury and disease (Table 1).

Table 1: South African legislation pertaining to occupational health and safety, health service provision and compensation (Adams et al. 2007)

	Act	Function	Enforcement agency
Occupational health and safety	Occupational Health and Safety Act (Act 85 of 1993).[25]	Ensures that employers provide workers with a healthy and safe work environment	Department of Labour
	Mine Health and Safety Act (Act 29 of 1996).[26]	Ensues a healthy and safe working environment for workers in the mining sector	Department of Minerals and Energy
	National Occupational Health and Safety Bill, 2005.[23]	Allows for the establishment of a National Health and Safety Authority which will act as a forum for policy-making and standard setting in occupational health and safety with overall regulatory responsibility for occupational health and safety in South Africa	Department of Labour
Health care provision and funding	Medicines and Related Substances Act (Act 101 of 1965).[27]	Provides for an authorisation permit to be issued to a nurse to dispense schedule 1-4 substances at workplace health services	Department of Health
	Labour Relations Act (Act 66 of 1995).[28]	Allows for the establishment of bargaining councils that have the right to establish and administer pension, provident funds, sick pay and medical aids for the benefit of the members Outlines procedures for dealing with ill-health causing incapacity in the workplace	Department of Labour
	Medical Schemes Act (Act 131 of 1998).[29]	Allowed the establishment of a Council for Medical schemes to regulate the activities of medical schemes and protect the interests of members of medical aid schemes	Department of Health
	National Health Act (Act 61 of 2003).[30]	Sets out rights and duties of health care providers, health workers, health establishments and users Provides for the provision of occupational health services by provincial departments of health	Department of Health
	Nursing Bill (Bill 26 of 2005).[31]	Outlines the scope of practice, duties and responsibility and level of accountability of nurses within government and other health service organisations	Department of Health
Compensation of occupational injury and disease	Occupational Diseases in Mines and Works Act (Act 78 of 1973).[32]	Provides mainly for the compensation of occupational lung diseases in mines and quarries	Department of Health
	Compensation for Occupational Injuries and Diseases Act (Act of 1993).[33]	Provides for medical cover and compensation of occupational injuries or diseases arising from workplace exposures	Department of Labour

As far as health care financing is concerned, the government, financing 44% of health care, has been identified as the largest source thereof. Other sources include household (making contributions to medical schemes, private insurance or direct out-of-pocket payments for health care services), donors and non-governmental organizations (Adams et al. 2007). Health care in the workplace may be provided by means of contributions to private health insurance companies and employer-funded occupational health services. There is, however, no obligation on employers to do so. As a result thereof, employer-funded workplace-based clinics only service a fraction of workplaces and are limited to the services they offer. This is influenced by legislative requirements, employment patterns, the nature of the industry, associated hazards and availability of and access to health care outside of the workplace (Adams et al. 2007).

1.4 The food and beverage industry in South Africa

The total income generated by the food and beverage industry over the three months ended April 2010 increased by 4.6% to R8.6 billion, compared with the three months ended April 2009 (Statistics South Africa 2010).

Central to this study, is that of the liquor industry which has developed into a major force worldwide. In an independent study, 'The Econex Report 2010' (Econex 2010), it was determined that in the South African economy, this industry and its suppliers provided employment to about 87 000 workers and generated tax revenue in excess of R19-billion during 2009. This study estimated that, including all multiplier impacts (in process of manufacturing, packaging, marketing and delivering alcoholic beverages), the liquor industry contributed R94.2-billion or 4.4% to GDP in 2009, generating in excess of R41-billion in government revenue, and sustained close to 550,000 jobs (Econex 2010).

1.5 The brewing process

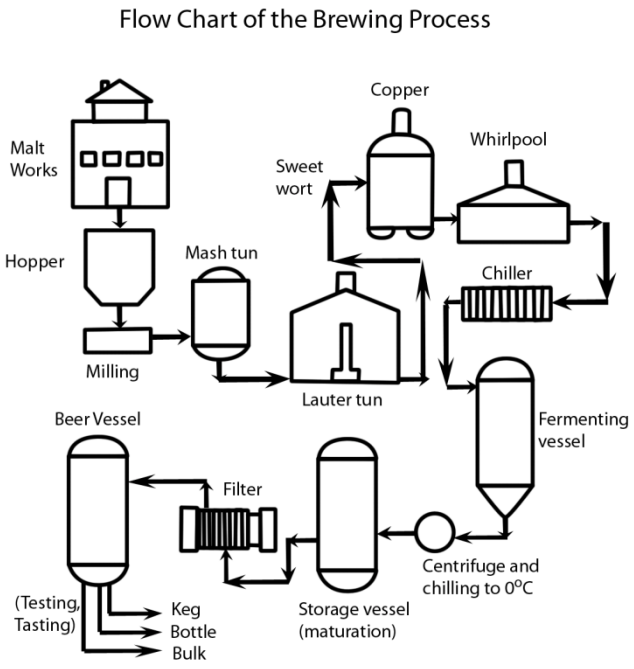

Figure 1: Adapted from 'Stellman, J.M. 1998. *Encyclopaedia of occupational health and safety.*fourth ed.International Labor Office' (Stellman 1998)

Brewing is the production of beer through steeping a starch source, commonly cereal grains such as barley or wheat, in water, and then fermenting the yeast. The basic ingredients of beer include water, malt, maize and hops. As beer is composed mostly of water, and mineral content of regions differ, different regions are suited to make different beers (Nelson 2005). Although brewing can be viewed as an art, there are also several fundamental steps in the brewing process.

Raw materials are received, unloaded and stored. These may include starches (including maize and barley), malt (including malted barley and black malt), hops, liquid adjunct (consisting of maltose, dextrose and sucrose), yeast, calcium sulphate, calcium chloride, oxygen and carbon dioxide.

Malting, the first step in beer making, is a process whereby grain is steeped in water and allowed to soak, allowing it to begin germinating in order to develop enzymes to convert the starch in the grain to sugar. This process is stopped by heating and the drying of the cereal, often in a kiln, the degree of which influences both flavor and colour of the beer. Dust and husks are removed. Milling is the process whereby malt is crushed in order to break open the grain kernels, allowing easier absorption of water which extracts sugar from the malt. A small amount of lactic acid is added to adjust the PH. The milled grain is then dropped into hot water in a large vessel called a 'mash tun' and, by a process known as mashing, mixed to a 'porridge', with time and temperature according to brew. In the Lauter Tun this mixture is laid to rest on a false bottom, and, whilst water sprayed over it, slowly moved with large rakes, in order to remove as much sweet wort as possible.

The wort is then boiled in the Wort Kettle at a specific temperature for a specific time according to the brand. Hops that is responsible for the bitterness and distinct aroma of the beer, is added. Calcium Sulphate is dosed automatically, and Calcium Chloride, salt and liquid adjunct also added. It is within the Whirlpool that the wort is separated from the solid particles, leaving through the sides, the remaining solid particles used for cattle feed. Wort, heated and rapidly cooled in the heat exchanger, passes to the cellars where yeast, added to produce fermentation, converts the fermentable sugars into alcohol and carbon dioxide. After about 2 weeks the 'fermentation' is sent to maturation, where the cold conditioning process, lagering, occurs, with brew stored at subzero temperatures of -1C. Filters remove solid

particles, and, following the testing of carbon dioxide content, colour, aroma and taste, the final product is packaged for distribution far and wide (Stellman et al. 1998).
It is within the context of the food and beverage industrial setting, that of a brewery in South Africa, that this study takes place.

1.6 Background to the study

A brewery worker developed work-related asthma following exposure to inhalable malt dust, despite all precautionary measures taken to remove him from highly exposed areas at the time of his first episode six years previously. Patterns of sensitization to malt dust and other allergens were subsequently identified and occupational asthma diagnosed, for which he was compensated. Due to more frequent episodes of bronchospasm to malt dust and other allergens or irritants, at work and at home, he was granted permanent disability.

A number of the brewery workers in this factory are exposed to various irritants and allergens, including that of malt dust. Annual dust monitoring has revealed varying exposure levels to malt dust these past few years. Exposure levels have been, at times, over the legislated recommended limit of 10 mg/m3, with some malt intakes more 'dusty' than others. Occasional distribution of malt dust is dispersed all over the plant, such as on a very windy day. Engineering control measures to contain the dust and limit the number of employees exposed to this dust, by means of the use of an extractor system and curtains to enclose malt intake area, have been, at times, dysfunctional. This has resulted in greater dispersion of, and over-exposure of employees, to this dust. Although grain is normally emptied into the silos by means of an extractor system from base of the train carts, grain is not always transported to the brewery by train. Tipper trucks are also used. The emptying of grain from tipper trucks generates far more dust than that from the train. Of note, however, is the subsequent enclosure of sides of the malt intake area with metal plates a few months ago. This, together with the re-institution of the extractor system, when in use, has had a positive impact on reducing the dust levels.

1.7 Statement of Problem

The level of exposure to a causative agent at work is the major determinant of risk for the development of occupational asthma (Nicholson, Cullinan, Burge & Boyle 2010). Evidence-based guidelines state that early diagnosis and early avoidance of further exposure are the

cornerstones of patient management for patients with immunological occupational asthma (OA) (Nicholson et al. 2010).

A regular health surveillance program consisting of annual medical, various questionnaires and specified tests are conducted on an annual basis on workers in the brewery exposed to known sensitizers, irritants or allergens in the workplace. Those employees identified as exposed to noise, to certain dusts, chemicals, gases, vapors and fumes, as legislated, are included in this program.

Despite the present surveillance program in place, a sentinel health event resulted in subsequent granting of permanent disability to an employee with asthma exposed to malt dust and other allergens over time. The prevalence of respiratory problems in this brewery setting is, largely, unknown.

1.8 Rationale for the study

Although there have been significant contributions to the knowledge base around asthma and allergens, what will be revealed in the literature review is the paucity of both international and national literature on respiratory health of brewery workers. Whilst a number of studies have described the harmful effects of exposure to grain dust on lung function, namely the development of respiratory disease amongst grain workers, only a few studies have investigated the respiratory health of brewery workers, particularly in relation to malt dust and other chemical agents used in the production process. No studies have documented the prevalence of work-related respiratory problems and associated risk factors within a brewery in South Africa.

1.9 Aim of Study

To conduct a respiratory health survey within a brewery in South Africa in order to document the prevalence of work-related respiratory problems and associated risk factors.

1.10 Research question identified

What is the prevalence of work-related respiratory problems and associated risk factors amongst brewery workers within a brewery in South Africa?

1.11 Research objectives

i. To describe the demographic profile of the workforce in relation to personal and occupational characteristics.

ii. To classify the subjects into 3 exposure groups based on subjective levels of exposure to dusts, chemicals, gases, vapors and fumes in different departments. This was based on the principle investigators prior knowledge and assessment of departmental levels of exposure to chemical and biological dusts, chemicals, gases, vapors and fumes. Prior knowledge of the principle investigator to the levels of these exposures was built on current risk assessments and level of medical surveillance to which each department was currently subjected to, at the brewery. Exposure levels included:
   - High exposure: Brewing (Including Utilities), Logistics.
   - Medium exposure: Packaging, Warehouse, Laboratory (Including QAQC).
   - Low exposure: Administration (Including Sales and Distribution).

iii. To determine the prevalence of work-related respiratory symptoms associated with allergic respiratory outcomes (rhino-conjunctivitis, asthma, extrinsic allergic alveolitis and chronic bronchitis) among workers in these different exposure groups.

iv. To document the relationship between work-related respiratory symptoms reported and potential risk factors for disease with specific reference to:
   - Host factors: Age, gender, smoking status, atopy (allergic tendency), previous family history (of allergy, hay fever or asthma);
   - Work-related factors: Exposure group category (to dusts, chemicals, gases, vapors or fumes)

1.12 Conclusion

The background to this study within its global, South African and industrial contexts has been presented. The problem has been described, aim and research question identified, and research objectives stated.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter will present the background and literature reviewed, with particular reference to the prevalence of respiratory problems, including asthma and allergy. Particular emphasis will be placed on these health outcomes within the brewery setting, and the working population at risk. Properties, characteristics and health effects of malt dust, food dust particulates, chemicals, gases, vapors and fumes will be related. Respiratory outcomes, environmental and host risk factors will be discussed. An overview of previous studies will be given. Significance and relevance for health, and the purpose of the study will conclude the chapter.

2.1.1 Background and review of the literature

A worker developed work-related asthma associated with exposure to malt dust and other grain dust allergens in a brewery over a period. The prevalence of respiratory problems in this brewery setting is unknown.

The aim of the study was to determine the prevalence of respiratory problems, including asthma and allergy, as well as patterns and factors associated with these outcomes, within a brewery setting, in order to identify groups of workers that may be potentially at risk of developing respiratory outcomes. The purpose of this review was to gain a better understanding and insight into respiratory health and risk factors associated with this industry and workforce. The ultimate aim would be the protection and promotion of respiratory health in the workplace.

The literature review included internet searches of both Google and Google Scholar, and electronic databases of CINAHL and Pub Med. Other sources included government gazettes, books, journal articles and articles of interest. All articles that were considered relevant and published in English were included in the study.

The search was limited to the keywords which included: Brewery workers; respiratory symptoms; asthma; work-related asthma; rhinitis, work-related rhinitis; occupational asthma; occupational rhinitis; work-related chest symptoms; immunological sensitization; occupational exposure; occupational allergens; occupational irritants; work-exacerbated asthma; chronic obstructive pulmonary disease; chronic bronchitis; respiratory health; malt dust; food; plants; barley; insects; rhodents; pests; dusts; chemicals; gases; vapours; fumes.

Incidence studies appeared to be uncommon, with prevalence studies remaining the most widely done investigations.

2.1.2 Working population at risk

The food industry employs a large proportion of workers, many of which are exposed to potential allergens capable of occupational allergy and asthma (Van der Walt, Lopata, Nieuwenhuizen & Jeebhay 2010). A variety of food, food additives and food contaminants have been identified as associated with these outcomes.

The primary risk of exposure to food allergens is by means of the inhalation of dust, steam and vapors of aerolized proteins. Those at risk would, therefore, include those involved in the cutting, scrubbing, cleaning, cooking, boiling and drying activities of these products (Cartier 2010).

As in the food industry, the South African liquor industry has developed into a major force in the South African economy, supporting thousands of jobs related to these sectors. Workers are exposed to various products in the production process. Of particular note, is the reporting of exposure, although not excessive, to grains and to malt dust, in the brewing industry, as an important risk factor for the development of respiratory disease amongst brewery workers (Godnic-Cvar, Zuskin, Mustajbegovic, Schachter, Kanceljak, Macan, Ilic, & Ebling 1999). Resultant symptoms may vary from mild local to severe systemic allergic reactions.

As far as breweries and grain dust is concerned, the exact numbers of workers exposed to grain dust is unknown since so many occupations are involved (Chan-Yeung, Ashley, & Grzybowski 1978). Occupational exposure to malt dust, however, occurs mainly at the malt works where malt is processed and at breweries and distilleries where malt is received.

Working populations at risk include farmers, industrial workers exposed to the grain, workers employed in the storing and packing of the grain, malt workers and brewery workers that are involved in malt intake, and workers involved in raw material handling and in the transferring of grain or malt to silos for storage, logistics, maintenance and repairs (Riddle 1974; Grant, Blackadder, Greenberg & Blyth 1976; Chan-Yeung et al. 1978; Ellis & Friend 1981; Stellman et al. 1998; Heaney, McCrea, Buick & MacMahon 1997; Godnic-Cvar et al. 1999 & Bernstein, Bernstein, Chan-Yeung & Malo 2006).

2.2 Grain dust and its characteristics

Grain dust is generated by the abrasive action of the kernels when the grain is being handled (Bernstein et al. 2006) whether whilst harvesting, receiving, grading, weighing, milling, baking, storage, cleaning, transport, loading or offloading. The levels of grain dust is influenced by the type of grain handled, the degree of activity, the extent of enclosure, the efficiency and upkeep of exhaust ventilation provided at transfer points, and work and housekeeping practices (Bernstein et al. 2006).

The physical and chemical composition of grain dust varies according to the geographic site, the type of grain, the wetness of the area, storage temperature and other factors. Grain has variable components including fractured grain kernels, fractured weed seeds, storage mites, insects, bacteria, moulds, silica and chemicals such as pesticides and insecticides, many particles of which are respirable (Bernstein et al. 2006). Certain grains may precipitate certain symptoms in individuals. Barley and oats contain many needle-like fragments compared to other types of grains and many grain workers complain that their symptoms are worse when they handle these grains (Bernstein et al. 2006). The allergenicity of grains are not always comparable. The allergenicity of milled grain, according to Baatjies & Jeebhay (2002), may be greater than unmilled grain (Baatjies & Jeebhay 2002).

The microflora of grain dust also changes during various processes. During harvesting many fungi produce spores which become airborne in large quantities such as Cladasporium and Alternaria. This production of spores, however, changes during storage, depending on water content, the degree of spontaneous heating and the aeration of the grain bulk, where fungi such as Ustilago, Cladasporium and Alternia are also found (Bernstein et al. 2006).

Storage mites, the number of which is directly related to the water content of the dust, are also found in grain dust, together with particles from weevils, insects, rodents, birds, and their excreta (Bernstein et al. 2006). According to Jeebhay, Baatjies & Lopata (2005), allergens from the storage pests, mealworm and cockroach, in grain-mill dust, is a significant predictor of work-related asthma symptoms, particularly evident in atopic workers who demonstrated increased IgE reactivity to mealworm and cockroach associated with work-related asthma symptoms (Jeebhay, Baatjies & Lopata 2005). Other components such as herbicides, aluminium phosphide and other types of pesticides, and chemicals such as fumigants, commonly used in agriculture and storage, can be absorbed through the skin, swallowed, or, more frequently, inhaled. The pathogenicity of all these components, on the respiratory health of workers, is not known (Bernstein et al. 2006).

2.3 Biochemical/Immunological properties of malt dust and allergens

Exposure to malt dust or other types of allergens may lead to the development of acute and chronic respiratory symptoms accompanied by lung function and immunological changes. The routes of exposure to, for example, malt dust, a food-derived protein allergen, are primarily through inhalation and occasionally cross-reactivity through ingestion, inducing allergic or immunologic diseases, that include occupational rhinitis (OR), occupational conjunctivitis (OC), extrinsic allergic alveolitis (EAA), hypersensitivity pneumonitis (HP) or occupational asthma (OA) (Sikora, Cartier, Aresery, Wild & Lehrer 2008).

Malt dust is allergenic and capable of eliciting a type-1, IgE-mediated reaction in sensitive individuals. A worker's initial contact with the antigen, e.g. malted barley, is followed by a latent sensitization period of weeks or years between first exposure and development of symptoms, depending on the allergen type, followed by the development of symptoms on exposure to even very low doses of the allergen and the onset of clinical disease, for example, occupational asthma (Jeebhay 2010). At this stage, exposure to non-specific irritants may even trigger a reaction. It is noted, however, that whilst the latent interval can extend to many years, the risk of occupational asthma appears to be highest in the first few years of exposure (Nicholson et al. 2010).

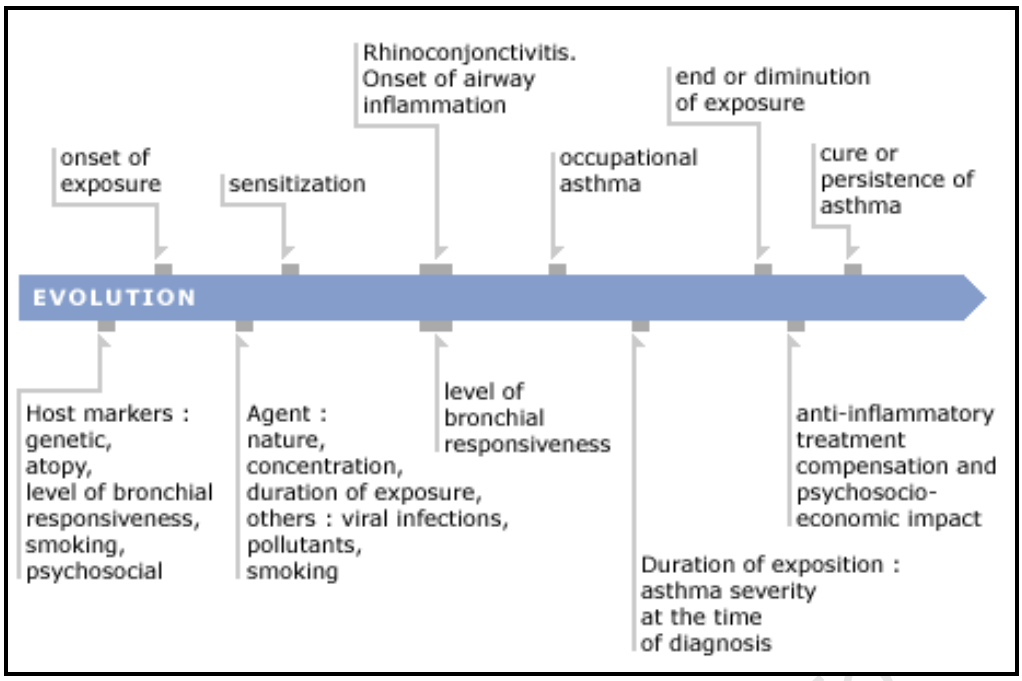

Figure 2: Natural history of occupational asthma, risk factors for disease onset and progression (Source: http://www.asthma-workplace.com/en/information/modelused)

2.4 Health effects of food dust particulates (e.g. grain and malt dust), chemicals, vapors, fumes and gases

Occupational lung diseases, such as asthma, extrinsic allergic alveolitis and chronic obstructive pulmonary disease (COPD) are caused by exposure to airborne particles. These diseases present major health challenges, with significant potential for acute morbidity, long-term disability, and adverse social and economic impacts (Tarlo, Balmes, Balkissoon, Beach, Beckett, Bernstein, Blanc, Brooks, Cowl & Daroowalla 2008) on workers and society as a whole (Malo & Chan-Yeung 2007). Although occupational asthma is the most common occupational lung disease in industrialized countries and the second most common occupational lung disease after pneumoconiosis in developing countries (Table 2), occupational asthma remains under-recognised, poorly managed and inadequately compensated worldwide (Jeebhay & Quirce 2007).

Table 2: Occupational diseases reported to the Compensation Fund for the non-mining sector in South Africa, 2001 – 2006 (Adams et al. 2007)

Occupational disease reported	2001	2002	2003	2004	2005	2006
Noise-induced hearing loss (NIHL)	1 465	1 952	2 549	2 724	1 823	1 276
Post traumatic stress syndrome (PTSD)	970	1 624	1 325	1 297	839	816
Tuberculosis of the lungs (in health care workers)	211	500	384	384	323	293
Dermatitis	217	203	203	227	203	156
Pneumoconiosis	193	182	302	189	109	134
Occupational asthma	104	168	214	165	103	74
Repetitive strain injuries		40	24	82	71	71
Mesothelioma	201	20	17	28	16	12
Irritant induced asthma				7	16	2
Lung cancers				4	1	1
Chronic obstructive airways disease (COAD)				17	13	25
Disease caused by chemical agents				69	15	19
Disease caused by physical agents, excluding noise				5	13	
Disease caused by biological agents, excluding TB				75	228	185
Others				85	49	44
Total	3 361	4 689	5 018	5 358	3 822	3 108

2.5 Work-related asthma

World- wide, an estimated 300 million people of all ages and ethnicities, suffer from asthma, the prevalence of which range from 1% to 18% in various populations (Dykewicz 2009). Estimates of the incidence and prevalence of occupational asthma vary, due partly to inconsistent definitions, diagnostic criteria, and variable work settings as well as limited surveillance data. Although the true frequency of the disease is not known, occupational factors are estimated to account for about one in six cases of asthma in adults of working age. This includes new onset or recurrent disease. The annual population incidence of occupational or work-related asthma ranges from an estimated 12 to 300 cases per million workers (Nicholson et al. 2010). Occupational asthma occurred in 3% to 10% of workers exposed to green coffee beans (Sikora et al. 2008) and in 16% of snow crab processing workers (Cartier, Malo, Forest, Lafrance, Pineau, St-Aubin & Dubois 1984). In a cross-sectional study of 517 supermarket bakery workers in 31 bakeries in South Africa, the presence of probable occupational asthma was 13% (Baatjies, Lopata, Sander, Raulf-Heimsoth, Batemen, Miejster, Heederik, Robins & Jeebhay 2009).

It is generally accepted that between 9% to 16% (Blanc & Toren 1999, Balmes et al. 2003, Henneberger 2007, Tarlo et al. 2008, Dykewicz 2009; & Cartier 2010) of adult onset asthma can be attributed to workplace exposures or occupational factors. This figure is rising, with recent data indicating that 25% or more of de nova asthma may have an occupational basis (Dykewicz 2009). According to Henneberger (2007), 45% of all work-related asthma cases attributable to asthma, is not caused by, but exacerbated by work (Henneberger 2007).

Several hundred agents have been reported to cause occupational asthma, and new cases are being reported regularly (Nicholson et al. 2010). Cartier (2010) states that, in food industries in which the prevalence of occupational asthma is available, rates of occupational asthma do not differ significantly from those found in non-food industries, that both individual and industrial factors are associated with asthma (Cartier 2010). Most frequently reported agents include isocyanates, flour and grain dust, colophony and fluxes, animals, aldehydes, adhesives, metals, resins and wood dust (Nicholson et al. 2010). The workers most commonly reported include animal handlers, bakers and pastry makers, chemical workers, food processing workers, hairdressers, paint sprayers, nurses and other health professionals, timber workers and welders (Nicholson et al. 2010).

Whilst occupational asthma is the most common occupational lung disease in industrialized countries, it is the second most common occupational lung disease reported, after pneumoconiosis, in developing countries (Jeebhay & Quirce 2007). The reported mean annual incidence of occupational asthma in developing countries is less than two per 100 000 population, compared to very high rates of up to 18 per 100 000 population in Scandinavian countries. There are, however, also regional differences in existence in South Africa, with a much higher incidence reported in the highly urbanized Western Cape Province of 2.5 per 100 000 population compared to that of 1.8 per 100 000 population in South Africa (Jeebhay & Quirce 2007).

Work-related asthma (WRA) can be generally defined as, and includes, occupational asthma (OA) or asthma caused by conditions or specific agents in the workplace and work exacerbated asthma (WEA) or pre-existing asthma exacerbated or worsened by work. There are two main forms of OA: Sensitizer-induced OA, caused by sensitizers at work, such as malt dust, is characterized by a latency period required for developing allergic sensitization prior to the development of symptoms. According to Nicholson (2010), almost 90% of cases

of occupational asthma are of the allergic type (Nicholson et al. 2010). According to Douwes, Gibson, Pekkanen & Pearce (2002), however, a substantial proportion of work-related asthma is non-allergic, one type of which is frequently referred to as irritant-induced asthma (Douwes et al. 2002) and relatively common in occupational populations. Causal exposures are diverse, and often present in the general environment. In contrast to allergic asthma, previously unexposed subjects can develop symptoms and reversible airflow obstruction without any prior sensitization or latency period.

Non-allergic occupational asthma is mediated by an acute inflammatory response and the subsequent massive infiltration and activation of neutrophils in the lower and upper airway. This is very similar to the inflammatory response observed in non-eosinophilic asthma in the general population (Douwes et al. 2002). This may follow single or multiple exposures to irritant compounds such as forms of dusts, vapors, fumes or gases (Henneberger 2007).

Most low molecular weight chemicals encountered in the workplace can induce airways disease. Most low molecular weight (LMW) chemicals are irritants. If exposure levels are high enough or if there is extended exposure, these chemicals can cause inflammation of the eyes, respiratory tract and alveolar membrane without antibody production or involvement of cellular mechanisms. Reflex or inflammatory bronchoconstriction may result (O'Neil 1990) At lower concentrations, some of these LMW chemicals are hapenic and induce respiratory symptoms by immune mechanisms. Dose, duration of exposure, physiochemical properties of the agent and host factors influence the effect that a given agent may have on the individual (O'Neil 1990). According to Douwes et al. (2002), the primary agent inducing these inflammatory responses in workers exposed to organic dust is believed to be bacterial endotoxin. Macrophages carry specific endotoxin binding receptors, namely CD14 or TLR4, that play a crucial role in the activation of these cells and the subsequent inflammatory reactions (Douwes et al. 2002). Irritant occupational asthma includes Reactive Airways Dysfunction Syndrome (RADS) which is a syndrome which develops within 24 hours after a single, high dose exposure to high levels of an irritating vapor, fume or smoke. Chemicals involved in this type of asthma, amongst others, include chlorine, sulfur dioxide and ammonia. Due to the initial injury the bronchial epithelium becomes denuded and loses its protective properties, resulting in a tissue remodeling response (Douwes et al. 2002).

Work-exacerbated asthma, on the other hand, is the worsening of asthma due to workplace conditions and can be triggered by physical factors (e.g. extreme temperature and exercise), behavioral states (e.g. strong emotions, stress), odors (e.g. perfume), general irritants and dust, and second hand cigarette smoke (Henneberger 2007) (Fig.3: Classification of work-related asthma).

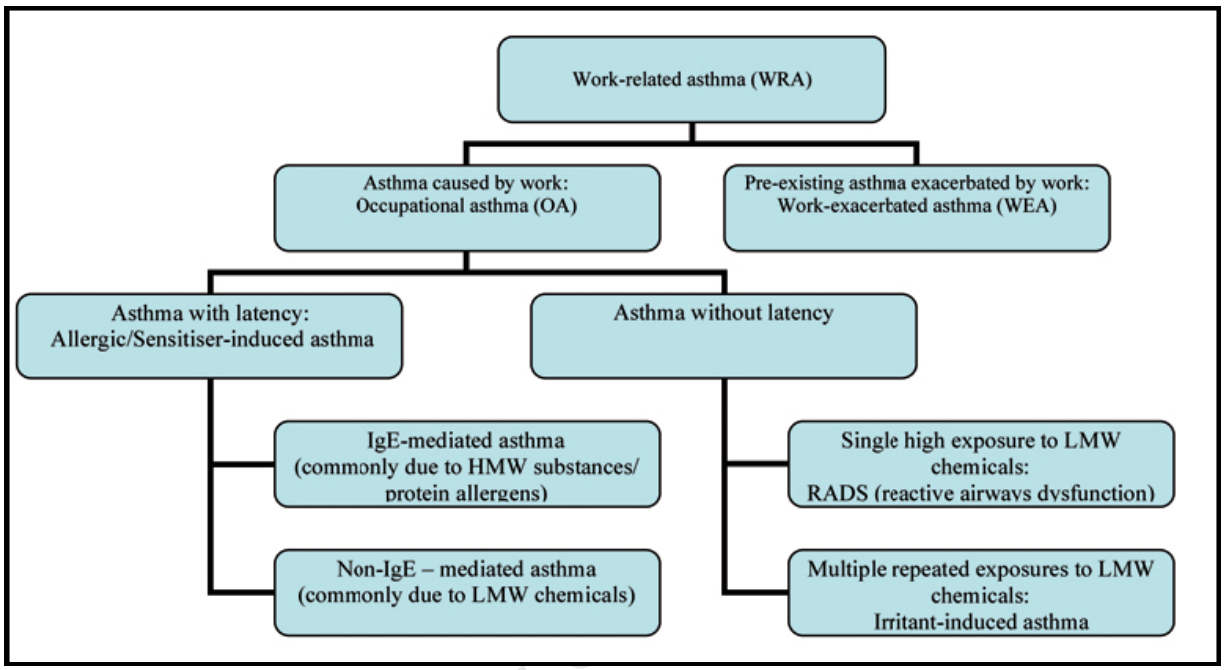

Figure 3: Classification of work-related asthma (Jeebhay 2010)

It has been suggested, generally, that OA has a poor prognosis and is likely to persist and deteriorate unless identified early and managed effectively (Nicholson et al. 2010). The likelihood of improvement or resolution of symptoms, or of preventing deterioration, is greater in workers who avoid further exposure to the causative agent, and who have relatively normal lung function and shorter duration of symptoms at the time of diagnosis (Nicholson et al. 2010).

Reducing airborne exposure by means of substituting the agent with a less harmful agent, engineering and hygiene measures, including use of respiratory protection and worker education and training, can prevent the onset of OA and the numbers of workers who become sensitized, later developing asthma. Redeployment to a low exposure area may lead to improvement or resolution of symptoms or prevent deterioration in some workers, but is, however, not always effective (Nicholson et al. 2010). Likewise, use of respiratory

protective equipment may reduce but not completely prevent occupational asthma, which should be considered in all workers with symptoms of airflow limitation (Nicholson et al. 2010).

In order to detect sensitized individuals or cases of asthma at the very early, reversible stage of the occupational asthma, an adequate health surveillance program, including the use of a respiratory questionnaire, spirometry, and where appropriate, identification of specific Immunoglobulin-E (IgE) by skin prick test or serology, may be used. It has been suggested, however, that screening questionnaires may underestimate the prevalence of occupational asthma, that questionnaires are insensitive. As far as other tests are concerned, depending on the quality of recorded series, the sensitivity and specificity of serial peak flow measurements can be high for the diagnosis of occupational asthma (Nicholson et al. 2010). Both skin prick and serological tests are sensitive for detecting specific IgE and occupational asthma caused by most high molecular weight (HMW) agents but are not specific for diagnosing asthma (Nicholson et al. 2010). Overall, both skin prick and serological tests are less sensitive for detecting specific IgE and occupational asthma caused by low molecular weight (LMW) agents and while specificity may be higher, they are not specific for diagnosing asthma (Nicholson et al. 2010). Carefully controlled specific challenges come closest to a gold standard test for some agents causing occupational asthma (Nicholson et al. 2010). As with a normal exhaled nitric oxide test not excluding the diagnosis of occupational asthma, in the clinical setting the absence of sputum eosinophilia does not exclude a diagnosis of asthma (Nicholson et al. 2010).

It has been related that workers with occupational asthma suffer financially, that approximately one third of workers with occupational asthma are unemployed up to six years after diagnosis (Jeebhay 2010). It has, therefore, been suggested, that in cases of established disease, adequate management including timely reporting and compensation thereof where necessary, is essential, in order to minimize the effects thereof (Nicholson et al. 2010).

2.6 Extrinsic Allergic Alveolitus (Hypersensitivy Pneumonitis)

Extrinsic allergic alveolitis (EAA) is an immunologically mediated inflammatory disease involving the terminal airways of the lung associated with intense or repeated exposure to various inhaled allergens. The result of this exposure is initially a lymphocytic alveolitis

followed by granuloma formation and eventually irreversible pulmonary fibrosis in the untreated patient (Sikora et al. 2008). This disease can progress to a disabling or even fatal end-stage lung disease.

According to Sikora et al. (2008), the incidence of EAA, as compared to WRA, is difficult to determine because of the disease's general low occurrence, problems with differential diagnosis, and the lack of prospective epidemiologic studies. Incidence depends on exposure levels of the offending antigen and varies widely in different industries or even in areas of the same plant. Both industrial and individual factor, such as atopy, genetic predisposition, cigarette smoking and possible pre-existing non-specific bronchial responsiveness, are associated with an increased risk of developing occupational hypersensitivity (Sikora et al. 2008).

2.7 Chronic Obstructive Pulmonary Disease

Cigarette smoking has been identified as the most commonly encountered risk factor for the development of Chronic Obstructive Pulmonary Disease (COPD), accounting for over 75% of the cases of the disease (Naidoo 2010). According to Rabe, Hurd, Anzueto, Barnes, Buist, Calverley, Fukuchi, Jenkins, Rodriquez-Roisin & van Weel (2007), a wide variety of occupational exposures, including that of organic and inorganic dusts such as grain dust, chemical agents and fumes, have the potential to cause COPD if exposure is high and over a long period of time, and account for 10% to 20% of either symptoms or functional impairment consistent with this disease (Rabe et al. 2007, Naidoo 2010). If not the cause, one's occupation, directly or in combination with tobacco smoke, may result in greater severity of the disease, greater disability and acceleration of loss of lung function among those with the disease (Naidoo 2010). However, not all who have similar exposures to smoking, environmental or occupational agents develop the disease. Consideration needs to be taken of other factors in a working population. Genetic components highly implicated in COPD pathogenesis include that of a severe hereditary genetic deficiency of α-1antitrypsin (Naidoo 2010). Other risk factors are ageing, gender, respiratory infections (including Tuberculosis and childhood infections), socio-economic status, and indoor air pollution, such as the use of biomass as a source of energy which has been strongly linked to the development of this disease (Naidoo 2010).

Chronic obstructive pulmonary disease globally, both in developed and developing countries, is associated with increased morbidity and mortality worldwide and is largely preventable (Naidoo 2010). This disease is characterized by airflow limitation associated with abnormal inflammatory response of the lung to exposures such as noxious particles and gases, that is usually progressive and not fully reversible. Other symptoms include the presentation of a chronic productive cough, airway hyper-responsiveness and breathlessness to differing degrees (Naidoo 2010). The pathogenesis of COPD is related to the inflammatory response to noxious inhalants, resulting in the release of destructive proteolytic enzymes from inflammatory cells, eventually resulting in airway remodeling (Rabe et al. 2007).

This multi-factorial and progressive respiratory disease is strongly associated with both occupational and non-occupational exposures. Chronic obstructive pulmonary disease is the sixth leading cause of death in developing countries. This disease is responsible, according to the 2001 World Bank/World Health Organization Global Burden of Disease Report: 2004 update, in 2001, for 4.9% of deaths (Naidoo 2010). It has been predicted, according to the World Health Organisation, Global Burden of disease report: 2004 update, that the non communicable disease burden, which includes COPD, will increase to 66% by the year 2030. This is due to factors such as the increase in an ageing population and increase in cigarette smoking (World Health Organisation 2009).

2.8. Environmental risk factors for work-related asthma: Sensitizing power of the allergen, work processes, dust exposure concentration and duration of exposure

Other than the intrinsic physicochemical and immunogenic properties of agents, and route of exposure, the most important risk for developing OA is the level and duration of exposure to agents capable of causing OA. Industrial hygiene and engineering practices also influence the potential of occupational agents to induce allergic disease (Sikora et al. 2008).

According to Cartier (2010), it is difficult to distinguish between roles of the sensitizing powers of the various foods or allergens and that of certain processes and exposure levels regarding level of exposure and risk afforded to the worker (Cartier 2010). Literature has revealed the high allergenicity of grain dust, with some grains, such as barley and oats, potentially higher than others. Grain dust has been designated a threshold limit value of

10mg/m3 TWA of total inhalable dust (Government Gazette 2005). This standard is, however, less conservative than international standards and not always applicable and acceptable. A 4mg/m3 TWA has been recommended by the American Conference of Industrial Hygienists (ACGIH).

Dust concentration can vary considerably, and can depend on factors such as to whether a ventilation and extractor system is in place and is functional. It is likely that the effect on the respiratory system and/or development of sensitization varies with the concentration, and is dose-dependent (Chan-Yeung et al. 1978; Jeebhay 2010; Nicholson et al. 2010). This has been demonstrated in a number of occupational settings (Nicholson et al. 2010), such as those in bakery, crab, prawn and pilchard (Jeebhay 2010). The quality of the grains too, differs. Some grain has been partly cleaned during its transport which may account for low frequency of effects, such as grain fever, on the grain workers. Whilst a positive correlation between the frequency of respiratory symptoms and the number of years of exposure in non smoking workers in grain elevators has been found, in other studies such a correlation was difficult to establish (Chan-Yeung et al. 1978).

2.9 Host risk factors for work-related asthma

While the concentration and the quality of dust influence the frequency and type of clinical syndrome in grain workers, host factors are also important, as only a small proportion of exposed workers develop occupational reactions (Sikora et al. 2008). These factors may include atopy, genetic predisposition, cigarette smoking, socio-economic and educational factors and the presence of occupational rhinitis or occupational conjunctivitis (Sikora et al. 2008). According to Cartier (2010), the pre-existence of asthma is not a risk factor for the development of Occupational Asthma, unless the individual is atopic (Cartier 2010).

2.9.1 Atopy

Atopy is a state whereby the subject tends to produce specific immunoglobulin IgE on ordinary exposure to common allergens in the subject's environment (Nicholson et al. 2010). Nicholson (2005) states that, as most food allergens are high molecular weight chemicals, atopy is the most important risk factor for the development of occupational asthma (Nicholson 2005). Sikora et al. (2008) confirms that, in general, the association, although not high, between atopy and OA is found consistently in OA caused by HMW agents. Atopic

individuals may often have a personal or family history of hay fever, asthma or atopic dermatitis, and exhibit a greater tendency to develop sensitivity to environmental agents than do normal subjects. Although atopic individuals frequently show elevated total IgE levels, atopy is not always associated with an increased incidence of OA. Skin prick testing is often used along with a suggestive history to establish a diagnosis thereof (Sikora et al. 2008). A number of studies have reported atopy as increasing the risk of developing occupational asthma caused by exposure to many high molecular weight agents that induce the production of specific IgE antibodies (Nicholson et al. 2010). For example, atopy has been found to be associated with an increased risk of developing occupational asthma in workers exposed to flour (Baatjies et al. 2009). However, this association was not confirmed in two snow crab-processing industries (Cartier et al. 1984).

According to Chan-Yeung et al. (1978) the proportion of individuals with atopy in grain workers, as judged from positive reactions to SPT with common antigens, appeared to be about the same in this working population as in the general population (Chan-Yeung et al. 1978). And similarly, atopy was not a major studied factor responsible for the high prevalence of chronic respiratory symptoms in male workers employed in a brewery plant (Godnic-Cvar et al. 1999)

2.9.2 Genetics

It has been suggested that grain workers with intermediate serum concentrations of alpha-1 Antitrypsin (heterozygotes with the MZ phenotype), appear to have, although not confirmed, a greater frequency of lung function abnormalities (Chan-Yeung et al. 1978). He added that, if this were to be established, alpha-antitrypsin phenotyping would be able to be recommended as a pre-employment screening procedure. Individuals with the ZZ phenotype can be expected to experience severe lung function abnormalities. However, the frequency of this phenotype in the general population is so low (approximately 1:2000) that costly screening for the purpose of discovering these individuals would not be justified (Chan-Yeung et al. 1978). According to Sikora et al. (2008), certain genetic factors have recently been identified that may alter risk for OA (Sikora et al. 2008), although very little data exists, in this regard (Sikora et al. 2008; Cartier 2010).

2.9.3 Smoking

Although the role of cigarette smoke, including exposure to second-hand smoke, in the development, exacerbation, or pathogenesis of OA is not clear, cigarette smoking can increase the risk of developing occupational asthma with some sensitizing agents (Nicholson et al. 2010). Tobacco use has been associated with, according to the report of Global Health Risks of exposure to cigarette smoke, globally causing about 71% of lung cancer, 42% of chronic respiratory disease and nearly 10% of cardiovascular disease. It is responsible for 12% of male deaths and 6% of female deaths in the world and estimated to cause approximately 5.1 million deaths globally in 2004 among adults aged 30 years and over (World Health Organisation 2009).

As far as occupational asthma is concerned, conflicting evidence is available regarding the role of cigarette smoking (Nicholson et al. 2010). Cigarette smoke has been found to increase bronchial epithelial permeability. This might potentially allow inhaled antigens increased access to immune-competent cells and an immune response (Sikora et al. 2008). Although tobacco smoking has not been found to be consistently associated with increased risk for OA, reports of an association between smoking and OA from certain agents suggest that the absence or presence of such an association may vary depending on the agent (Dykewicz et al. 2009). According to Chan-Yeung et al. (1978), the effects of cigarette smoking has an additive effect on grain dust exposure and is the most important factor influencing the frequency of chronic bronchitis (Chan-Yeung et al. 1978).

2.9.4 Occupational rhinitis/Occupational conjunctivitis

There is epidemiological evidence from the general population that rhinitis and asthma frequently occur together, possibly as clinical manifestations of a single disorder (Nicholson et al. 2010). Rates of co-morbid rhinitis or rhino-conjunctivitis of between 45% and 100% have been reported in subjects suffering from occupational asthma attributed to various agents (Nicholson et al. 2010).

Occupational rhinitis and/or occupational conjunctivitis is characterized by ocular symptoms, reduced airway caliber and hyper-responsiveness as well as inflammation, and is caused by agents in the workplace (Gautrin & Malo 2010). It has been found that these symptoms are common, and often precede and co-exist with the onset of occupational asthma (Malo et al.

1997; Gautrin & Malo 2010; Nicholson et al. 2010). It is the presence of OR and OC in a sensitized individual that may identify patients at greater risk for developing OA (Nicholson et al. 2005; Dykewicz et al. 2009). This risk is highest in the year after the onset of occupational rhinitis (Nicholson et al. 2010).

As with OA there are two main forms of OR: Sensitizer-induced OR, caused by sensitizers at work. These sensitizers are usually HMW agents or LMW agents. Sensitization by HMW agents such as malt dust, is characterized by a latency period required for developing allergic sensitization prior to the development of symptoms. Irritant-induced OR is usually caused by LMW agents, without latency, characterized by the onset of rhinitis following exposures to irritant compounds, such as chemicals (Gautrin & Malo 2010). As so far as prevalence and intensity of rhino-conjunctivitis is concerned in relation to agents, Malo, Lemiere, Desjardins & Cartier (1997) reported the prevalence of symptoms were not different for HMW and LMW agents, although rhinitis was more intense for HMW than for LMW agents (Malo et al. 1997).

2.10 Previous studies of respiratory health in brewery workers

It was Ramazzini, in 1713, who, observing that workers in granaries and barns, sifting and measuring grain, almost all developed shortness of breath and rarely reached old age, initiated the clinical diagnosis of the occupational nature of asthma (Breathnach 2000).

Many years later the term 'extrinsic allergic alveolitis', was collectively used to describe the diffuse pulmonary hypersensitivity to inhaled organic antigens or spores. This term included diseases such as farmer's lung, bird fancier's lung, bagossis, and many more. Although the prevalence of extrinsic alveolitis in the brewing industry was not large, malt men were potentially at risk. They would be very ill, often leaving the industry on a voluntary basis because they were physically unable to work (Riddle, Channell, blyth, Weir, Lloyd, Amos & Grant 1968). In a study amongst Scottish malt workers, more than half of the malt workers were found to have precipitating antibodies in their serum against antigens from mould spores of Aspergillus Clavatus, Penicillin Citrinum or Rhizopus Stolonifer. No correlation, however, was found, in that study, between sensitization to these and the presence of chronic respiratory disease (Grant et al. 1976). It was the concentration of the spores more than the size, that Riddle et al. (1968) observed to be of importance (Riddle et al. 1968). In his study

amongst Hungarian malt workers respiratory illness was attributed to the physical properties of the dust inhaled rather than to the many mould spores present (Mickolczy 1958 cited in Riddle 1974). It was subsequently suggested that, when conditions were not favorable for malting barley at high ambient temperatures, due to damaged or split corns, or grain contaminated with mould, the malting should be stopped until conditions improve and personal protective equipment (PPE) worn (Riddle 1974). According to Riddle (1974), high quality barley is less liable to fungal contamination than the inferior imported, and often damaged, grain which is more likely to cause respiratory disease (Riddle 1974).

Episodes of bronchospasm in non-atopic subjects having precipitins, with a delay in onset after exposure to antigens, similar to that in allergic alveolitis, is what Pepys drew attention to in industry (Pepys 1969 cited in Riddle 1974). Although, according to Riddle (1974), illness of this nature was not revealed in his present survey (Riddle 1974), many of the workers, complaining of symptoms after work, mentioned wheezing (Riddle 1974). Riddle (1974) suggested that, in addition to the men continuing to work in the malting, a large scale survey would be justified to investigate the reasons that men leave, and the state of their health before and after working in the malting industry (Pepys & Bernstein 1969; Riddle 1974). Riddle (1974) suggested they were leaving the industry on a voluntary basis because they were physically unsuitable (Riddle 1974). This was confirmed in a study of Scottish malt workers and allergic alveolitis, where Grant (1976) noted most cases were mild, as men with more severe disease had possibly left the industry. He also recommended the replacement of old methods by new mechanical processes in order to reduce, if not eliminate altogether, this form of extrinsic allergic alveolitis (Grant et al. 1976).

Chan-Yeung et al. (1978) reported grain dust to be composed of a large number of materials. These included various types of grain and their disintegration products. These included silica, fungi , insects and mites, hairs and excreta of rodents and pigeons, and chemicals used in agriculture and pest control that could be absorbed through skin, swallowed or inhaled (Chan-Yeung et al. 1978). Both acute and chronic respiratory affects of grain dust exposure in grain elevator workers, including chronic bronchitis, grain dust asthma, extrinsic allergic alveolitis, grain fever, silo-fillers lung, rhinitis and conjunctivitis, has been reported. Lung destruction in a malt worker, initially thought to be extrinsic allergic alveolitis, was found to be a cavitating lung disease as a result of Aspergillus Fumigatous infection. This resulted in mycomata, a vigorous immune response, and granulomatous lung disease, with

reticulonodular shadowing, fibrosis and bullae formation. The lung function revealed a restrictive defect and reduction of transfer factor, resulting in progressive breathlessness on exertion in the affected worker (Ellis & Friend 1981).

As suggested by Chan-Yeung et al. (1978), it was not only the type, quantity (concentration) and quality (some washed and not so dusty) of grain that influenced the frequency, duration and the type of clinical syndrome in grain workers, but also host factors, including smoking, atopy and genetic factors. Chan-Yeung et al. (1978) recommended that studies should provide the scientific background for the determination of appropriate threshold limit concentration for grain dust. What was borne in mind, however, was that allergic reactions such as asthma and alveolitis may occur with exposure to lower concentrations (Chan-Yeung et al. 1978). It was also recognized that respiratory impairment, continuing into the retirement years, was linked with chronic disability (Chan-Yeung et al. 1993).

Although, as far as smoking is concerned, the presence of chronic respiratory symptoms increased with the number of cigarettes smoked, the differences, while suggestive, were not conclusive in earlier studies (Riddle et al. 1974). Cause and effect were not apparent (Channell et al. 1969), quite unlike data in a later study. The suggestion that exposure to agents in the brewery environment may lead to the development of acute and chronic respiratory symptoms accompanied by lung function and immunological changes was made as early as 1999 by Godnic-Cvar et al.1999. Among the 97 male workers employed in a brewery plant, occupational asthma was recorded in 2.1% of the brewery workers exposed to organic dusts such as hops, barley and brewer's yeast. The prevalence of most of chronic respiratory symptoms was also significantly higher ($P < 0.01$) compared to a group of unexposed brewery workers. Suggestive of obstructive changes in smaller airways was the evidence in the decreased lung function compared to predicted reference values. This was thought to be possibly due to workplace exposures (Godnic-Cvar et al. 1999).

Immunological changes were evident in the increased prevalence of positive skin prick tests of brewery workers exposed to tested allergens, including organic dusts such as hops, barley and brewery yeast, compared to controls ($P<0.05$). Indicative, also, of a correlation of immunologic changes with the work environment, was the increased total IgE serum levels ($p<0.01$) found in 45.1% of brewery workers, compared to only 2.7% of control workers (Godnic-Cvar et al. 1999). Exposures were considered multi-factorial. It was smoking together with dust exposures, however, that was stated as the major studied factors

responsible for the high prevalence of respiratory impairment and immunological reactions in workers in the brewing industry (Godnic-Cvar et al. 1999).

Schwartz, Thorne, Yagla, Burmeister, Olenchock, Watt & Quinn (1995) suggested the concentration of endotoxin in grain dust bio-aerosols may be particularly important in the development of grain dust induced airway disease (Schwartz et al. 1995). Deetz, Jagielo, Quinn, Thorne, Bleuer & Schwartz (1997) supported the notion that exposure to malt dust could cause airflow obstruction and lower respiratory tract inflammation in human subjects (Deetz et al. 1997). Pepys & Bernstein (2006) maintained that different types of organic dusts, such as barley and malt, and various other components had the potential to change respiratory function and immunologic status of those exposed (Pepys & Bernstein 2006).
In another study individuals exposed to hops, barley and yeast, and with potential to develop both acute and chronic respiratory problems, were investigated. The effects of brewery dust on guinea pig tracheal smooth muscle were studied. It was suggested that brewery dust extracts cause a dose-related airway smooth muscle constriction by non-immunologic mechanisms involving a variety of airway mediators and, possibly, cholinergic receptors (Schachter, Zuskin, Rienzi, Goswami, Castranova, Whitmer & Siegel 2001). Miedinger, Malo, Cartier, Labrecque & duSacre-Coeur (2009) emphasized that, following a case of occupational asthma to malt and a case of allergic alveolitis in a subject who was initially referred for possible occupational asthma, in workers with respiratory symptoms who were exposed to malt, both occupational asthma as well as allergic alveolitis must be considered (Miedinger et al. 2009).

According to Bernstein (2006), the agent in grain dust mainly responsible for grain dust asthma is unknown, and no information on the true overall prevalence of allergic grain dust-induced asthma is available, as asthmatics are likely to seek alternative employment and leave the industry shortly after starting employment, resulting in a 'healthy worker effect'. It has also been suggested that a cross-shift decline of lung function observed in grain workers, is directly related to the level of dust exposure or endotoxin, and not due to age, smoking habit, duration of employment, or atopic status skin reactivity to grain dust antigens. Grain dust-induced asthma may possibly be due to a non-allergic response to some constituents in the grain that is not IgE-mediated. It has also been suggested that the prevalence of grain dust-induced asthma is likely to be low, that atopic status does not appear to be an important determinant of airflow obstruction, and that the physiological response to grain dust is

primarily mediated by an acute inflammatory response and airway obstruction in the respiratory tract, in a dose-dependent manner. This is thought to be primarily due to bacterial endotoxin in the grain dust releasing chemical mediators directly in the airways. This acute illness, identified as Grain Fever, was reported in 6% - 32% of exposed workers in different studies (Bernstein et al. 2006) Studies suggest, however, that workers exposed to levels of dust less than 1mg/m3 are not at risk of developing rapid decline in lung function (Bernstein et al. 2006).

2.11 Significance and relevance for health and purpose of this study

A review of the literature has revealed that a number of studies have described the harmful effects of exposure to grain dust on lung function, namely the development of respiratory disease amongst grain workers or workers handling grain products (Williams, Skoulas & Merriman 1964; Chan-Yeung et al. 1978; Yap, Chan & Wang 1994; Schwartz et al. 1995; Vidal & Gonzalez-Quintela 1995; Deetz et al. 1997; Jeebhay, Stark, Fourie, Robins & Ehrlich 2000; Sigsgaard & Schlunssen 2004; Jeebhay, Baatjies & Lopata et al. 2005; Sikora et al. 2008; Baatjies et al. 2009;). Only a few studies, (Riddle et al. 1968; Riddle 1974; Grant et al. 1976; Ellis et al. 1981; Heaney et al. 1997; Godnic-Cvar et al. 1999; Schachter et al. 2001 & Miedinger et al. 2009), have investigated the respiratory health of brewery workers, particularly in relation to dusts, chemicals, gases, vapors and fumes. No studies have documented the prevalence of work-related respiratory problems and associated risk factors within a brewery in South Africa.

Central to this study is the recent identification of an individual with the diagnosis of OA, which represents a potential sentinel health event. Evaluation of the workforce, in order to identify and prevent other cases of OA in the same setting, is considered best practice to follow (Tarlo et al. 2008). Despite dust exposures in this brewery recently being below threshold limit values for non-specific dust, this does not take into account the fact that allergic reactions such as occupational asthma and extrinsic allergic alveolitis may occur with exposure to lower concentrations (Chan-Yeung et al. 1978). This survey was to assist in determining the prevalence of work-related respiratory health problems within this brewery setting, identify groups of workers that are potentially at risk of developing respiratory health problems and provide greater insight into the risk factors for respiratory health problems among brewery workers. The information obtained could contribute to enriching the

knowledge base of respiratory problems and associated risk factors among brewery workers, informing policy so as to develop effective intervention and preventative strategies, as health of workers is an important consideration for both economical and ethical reasons (Chan-Yeung et al. 1978). The implementation of appropriate preventative strategies to be undertaken in order to reduce exposures and more targeted medical surveillance of exposed workers could reduce the incidence of respiratory health problems among brewery workers, improve health and lower the cost to the individual, to business and to society as a whole (Tarlo et al. 2008).

2.12 Summary

An overview of the literature with particular reference to the prevalence of respiratory problems, including asthma and allergy, and patterns and associated factors has been provided.

Significance and relevance for health and purpose of this study concluded this chapter. Chapter three will describe the research design and methodology chosen including details of the research process.

CHAPTER 3
METHODOLOGY

3.1 Introduction

3.1.1 Study setting and population

The study took place within a South African brewery. This brewery was centrally situated and conveniently accessible by both rail and road. Over 500 brewery workers, including 414 permanent employees were responsible for the brewing, packaging, distribution, security, administration and marketing of its products. The brewing process necessitated 24 hour coverage, and a worker's ability to acclimatize to shift work and tight schedules, and to noisy, hot, humid, wet conditions. Hard work was encouraged and driven by incentives to perform and meet demands of this progressive, multi-ethnic, multi-cultural company.

3.2 Study design and rationale

A cross-sectional, analytical study design was used. A comparative rather than a simple survey design was chosen as three groups were being compared to see if there were any similarities or differences on selected variables (Brink 2002; de Vos, Strydom, Fouche & Delport 2005).

3.3 Study frame and sample size

The study population size (n=414) was determined by means of lists generated of all current permanent, full-time brewery workers. These lists constituted the study frame. This included 358 permanently employed brewery workers involved in the production process and a further 56 employees responsible for the administration, sales and distribution of the product.

An accurate sample size calculation using the Raosoft statistical calculator, based on the prevalence and required precision of the estimate was done. This was based on the study population size, included a measure of error one can accept of 5%, an aim of a confidence level of 95% and a minimal response distribution of 50%. Based on previous studies of the literature (Godnic-cvar 1999), a 38-45% prevalence of IgE reactivity, a 30% prevalence of asthma-related symptoms and 2% prevalence of occupational asthma was found in brewery workers. Taking into consideration the heterogeneity of the population, the available

resources (including money, time available to conduct the research and personnel available), and the number of variables in which the data were grouped, a sample size of at least 200 was proposed. This sample was to be drawn from the sample frame.

3.4 Inclusion criteria

Workers, male and female, aged 18-65 years and employed by the brewery in a permanent, full time capacity, at the time of the study, were invited to participate. This was on a voluntary, informed basis only and independent of the length of employment at the brewery.

3.5 Exclusion criteria

All contract workers were excluded from the study. No permanent, full-time brewery workers were excluded from the study. This was to minimize the introduction of bias into the study and accommodate findings, such as the prevalence of work-aggravated asthma.

3.6 Recruitment

The nature, procedure and importance of the proposed study was related to the manager of the brewery in relevant meetings by the Occupational Health Nurse that headed the brewery clinic, and related to Department Heads on a one-to-one basis by the principal researcher. This was supported by a written explanation, a 'Memorandum of Understanding' between the principal investigator and the brewery, of the proposed study. It included an introduction to and purpose of the study, the proposed sample frame and size, and an explanation of the procedure. Emphasis was placed, in this 'memorandum of understanding,' on the granting of ethical approval by the Faculty of Health Sciences Human Research Ethics Committee in order for the study to take place (Addendum 1: Ethical approval). This included rights and confidentiality of employer and employees. Implications including expected risks and benefits, costs or compensation related to participation in the study were explained. Commitment of the researcher to the brewery ensuring protection of information collected and the objective and accurate interpretation and dissemination of findings according to academic practice was related. Thereafter, both permission and co-operation were obtained from the management of the brewery, signified by the signing of this agreement, the 'Memorandum of Understanding', by both principal investigator and the brewery manager (Addendum 2: Memorandum of Understanding).

Notification of the study, describing and explaining the aim, purpose and objectives of the study to the potential study participants, within the identified population, was communicated via meetings and emails, or on an individual basis, inviting them to participate.

Those workers who, at the time of the study, were employed by the brewery in a permanent, full time capacity, were invited to participate in the study. Participation was to be independent of length of employment at the brewery. No worker was excluded from the study. This was to ensure bias was not introduced and all findings were accommodated, such as that of the prevalence of work-aggravated asthma.

Participation was entirely voluntary and on an informed basis only. If a worker did not wish to take part in the study, the researcher would not have access to their information. In order to prevent selection bias, however, full participation was encouraged by means of communication of the study verbally and by email, and on a personal basis. Benefits to employees, to business and to society as a whole, was related to the workers, as too the availability of the researcher to explain any queries that may have arisen. These were possible contributing factors to such a high participation rate in this voluntary study. Maximum participation was encouraged. One worker declined the opportunity to participate in the study. All remaining workers selected agreed to participate in the study.

3.7 Sampling technique

An opportunistic stratified sampling method was used. This was linked to annual medicals in order to ensure all workers in the 3 exposure groups were represented. The study population was classified into 3 exposure groups based on subjective levels of exposure to dusts, chemicals, gases, vapors and fumes in different departments. This was based on the principle investigators prior knowledge and assessment of departmental level of exposure to chemical and biological dusts, gases, vapors and fumes. Prior knowledge of the principle investigator, to the level of exposure, was built on current risk assessments and level of medical surveillance to which each department was currently subjected to, at the brewery.

In order to ensure adequate representation of each exposure group, which was of unequal size, an attempt was made to include all subjects in the high exposure group and a proportion of subjects in the medium and low exposure group, in the study:

- High exposure: Brewing (Including Utilities), Brewing Engineering, Logistics.
- Medium exposure: Packaging, Warehouse, Laboratory (Including QAQC).
- Low exposure: Administration, Sales and Distribution.

Data collection was linked to the routine annual medical examinations and/or surveillance program that was currently in place. All employees in the medium exposure groups and high exposure groups who presented to the clinic for their annual medicals, for follow-up procedures linked to their annual medicals, or for administrative purposes, were included in the study. The study was not linked to the presentation of the worker to the clinic for other reasons, such as pertaining to primary health care matters, as it was thought that this may introduce bias towards workers who were unwell. Although the principal investigator completed the routine annual medicals, it was the supervisor and not the principal investigator who scheduled who would be attending the medicals. All persons whose medicals where scheduled with the principal investigator were, therefore, invited to participate in the study. Those whose medicals were not scheduled with the principal investigator did not participate in the study. The principal investigator was 'blinded' as to who would be scheduled to arrive for a medical, and who would not be scheduled to arrive for a medical.

As far as the lower exposure group is concerned, as no medicals were performed, data collection was linked to clinic visits, other than clinic visits for primary health care purposes, or by phone call if necessary. Each employee in this group received either an email or phone call inviting them, on a voluntary, informed basis, to participate during normal working hours. The principal investigator would, as per other exposure groups, interview the participants upon arrival at clinic or by means of phone call if necessary.

3.8 Method of data collection: Interview-administered questionnaire

The study took the form of an interviewer-administered questionnaire, either face-to-face or by means of a phone call if necessary, which took no longer than 15 minutes of the subjects time. It was decided that the study tool to be used would be a previously validated interview-

administered questionnaire of the European Community Respiratory Health Survey (ECRHS), specifically designed for the investigation of work-related asthma and respiratory problems. This would be adapted for local context and the brewing industry. Prior to use thereof, coding of the proposed questionnaire took place (Addendum 3: Coding of questionnaire).

Permission was sought from authors of the European Community Respiratory Health Survey (ECRHS) (Burney et al. 1993) to use and adapt their questionnaire to the brewery setting. Affirmative response was received (Addendum 4: Covering letter requesting use of ECRHS questionnaire & response received). Of the two hundred and fifty two workers invited to participate in the study, two hundred and fifty one workers consented to participate verbally and in writing (Addendum 5: Consent form).

Thereafter, it was requested of each participant to respond to a standard questionnaire. A previously validated interview-administered questionnaire of the European Community Respiratory Health Survey (ECRHS) (Burney et al. 1993) specifically designed for the investigation of work-related asthma and respiratory problems, and adapted for local context and the brewing industry, was used (Addendum 6). The questionnaire addressed acute and chronic work-related respiratory symptoms, current and previous employment, prevalence of exposure to dusts (including that of malt dust), gases, vapors and fumes, and to tobacco smoke. All questionnaires were administered by the principal investigator herself as she was an experienced occupational health nurse. The questionnaire was administered in English.

The questionnaire was administered in privacy, face-to-face, on a one-to-one basis, or by telephone if necessary, and was ideally linked to the annual medical examination or clinic visits or appointment. It took approximately 15 minutes to complete, and was administered during normal working hours. Smoking status was classified into three categories viz. non-smoker as lifelong abstinence from smoking; ex-smoker if ceased smoking more than a month before the survey; and current smoker. A worker's description of job (Addendum 7: job descriptions) in a specific work area, including subjective exposure to dusts, gasses, vapors and fumes, use of personal protective equipment (PPE) e.g. respirators, goggles and gloves, in the questionnaire, assisted in assessing environmental exposure and temporal relationship between respiratory problems and allergy symptoms and work. This was in

order to determine whether there could have been previous exposures to agents similar to those in the current workplace.

Past medical history, with regard to respiratory problems, prior to and after employment in the brewing industry, was assessed by the presence of any one of the following: history of allergy, hay fever, asthma, tuberculosis of the lungs or hospitalization for a serious lung problem. Acute and chronic upper and lower respiratory symptoms were evaluated for prevalence of rhino-conjunctivitis, asthma, extrinsic allergic alveolitis and chronic bronchitis and for temporal relation to work. Specific symptoms related to the clinical endpoints, namely, those pertaining to asthma (wheeze, tight chest, cough and shortness of breath); those pertaining to allergic alveolitis (dysnoea, cough, feverish, night sweats, pyrexial reaction occurring some hours after exposure to malt dust); those pertaining to chronic bronchitis (coughing most days or nights for as much as three or more months in each of the last 2 years), and those pertaining to rhino-conjunctivitis (itchy watery red eyes, hay fever, runny nose, blocked nose, stuffy nose), were addressed.

The medical history detailed any precipitating events, including whether there was a personal history of allergies or a family history of asthma and allergies. The characterization of asthma symptoms (e.g. shortness of breath, chest tightness, cough, and/or wheezing), triggers in the work environment, and, for example, whether condition worsened by exercise, or at night, in support of the diagnosis of asthma was included. In addition to providing information on respiratory symptoms present in work-related asthma patients, and whether it did accompany or was preceded by symptoms of rhinitis and/or conjunctivitis, specific inquiry was made to determine any relationship between the workplace and symptoms. The use of protective devices or equipment, the onset and timing of symptoms, reported medication needs, and temporal relationship to periods at and away from work, were also included in the history (Addendum 8: Operational definitions of respiratory symptoms).

3.9 Ethical considerations

3.9.1 Institutional approvals

Ethical approval for the study was sought from the Faculty of Health Sciences Human Research Ethics Committee, University of Cape Town. Upon ethical approval (Addendum 1), permission was sought from the manager of the brewery. A Memorandum of Understanding (Addendum 2: Memorandum of Understanding) cleared by the contracts

office, University of Cape Town, was signed by the manager of the brewery and the principal investigator.

3.9.2 Autonomy

As individuals are autonomous, and have the right to self-determination and the right to be respected (Brink 2002), participation in the study was entirely voluntary, on an informed basis. All physiological, psychological, social, political, religious, cultural and economic consequences were considered throughout the study.

All participants had the right to fair selection and treatment and the right to decide whether they would participate in the study. They had the right to refuse to answer a question and the right to withdraw from the study at any time, without any negative consequences to the participant.

3.9.3 Beneficence and non-maleficence

Beneficence obliges the researcher to do good. Non-maleficence refers to the obligation of the researcher not to cause harm (Brink 2002). In order to secure the wellbeing of the person in this study, effort was made to protect participants from discomfort and harm by ensuring every possible precaution was taken to apply good ethical principles throughout the research process. Any possible risks as a result of completing the questionnaire were explained to the participant. That there would be no compensation or remuneration and no costs as a result of participating in the study was also emphasized to the participant.

It was explained that what was hoped to be gained from this study would be the prevalence of brewery workers that suffer from respiratory problems and associated risk factors. It was hoped that this would assist in the identification of appropriate preventative strategies that could be used in order to reduce the incidence of respiratory problems among brewery workers, with ultimate aim of the protection and promotion of the respiratory health of employees in the workplace. It was emphasized though, that although the study would recommend changes, it could not implement changes, as the principal researcher could not guarantee that management would act on any recommendations.

3.9.4 Justice

The principle of justice includes the right to fair selection and treatment and the right to privacy and confidentiality (Brink 2002). Selection of participants was directly linked to routine annual medicals in both medium and high exposure groups. All were invited to participate in low exposure group. Care was taken to ensure the interview took place on a one-to-one basis in a private room. Only appropriate questions and no invasive questions were asked in the study.

In order to ensure confidentiality, referring to the researcher's responsibility to protect all data gathered within the scope of the project from being divulged or made available to any other person (Brink 2002), all information collected during the course of the study was kept strictly confidential to the extent permitted by law, and was safely stored in a locked cupboard accessible only to the Principal Investigator or research team.

Anonymity refers to the act of keeping participants nameless in relation to their participation in the research (Brink 2002). Information relating to the participants was not linked to the participants personally and individual names were not included in the analysis of the findings. No identifying information, such as name, was included on the questionnaire. Each individual who agreed to participate was assigned a unique 3-digit code. The data collection instruments reflected this. All questionnaires were stored in confidential files, in a locked cupboard, until the completion of the study (All questionnaires will be retained in a locked, fireproof cupboard for 24 months post study for reference purposes. Thereafter, the research co-ordinator will ensure that all questionnaires be suitably destroyed, in order to protect confidentiality of participants).

Individual results were treated as confidential and personal information was only released with the worker's consent as the need arose. Anonymity was assured. All workers with abnormal outcomes were to be, upon written consent, referred to their own general practitioner, their local clinic or the brewery occupational health clinic, for further evaluation and management, or to the Occupational Medicine Clinic at the relevant hospital, if indicated. It was also emphasized that should it be recommended that a participant be referred for further assessment and management; no referral would be made without the consent of the participant.

3.9.5 Informed consent

Verbal consent was initially sought from recruited participants. Voluntary, informed written consent was sought from each participant prior to administration of the questionnaire. This was achieved by means of a covering letter and consent (Addendum 5: English consent form), explaining the purpose of the research, the requirements of the research project, ethical considerations, and expected completion time resulting from participation in the study.

To voluntarily agree to take part in the study, it was requested of the participant to sign a consent form (Addendum 5: English consent form). It was emphasized that the participant would not be giving up any of his/her legal rights by signing this form. The signature would indicate that the participant had read, or had read to him/her, the entire consent form, including the risks and benefits, and had all questions answered. The participant was given a copy thereof.

3.9.6 Management of data

The questionnaire was administered free of charge on an informed, voluntary basis during working hours. Good faith was expected of the researcher to ensure the findings were interpreted objectively and as accurately as possible, and presented as such, ensuring the importance of scientific honesty in disclosing sufficient, correct and understandable information, disclosing shortcomings and acknowledging input, was ensured. It was related to management that a draft final report would be presented to the brewery management upon completion of the study.

3.10 Validity and reliability

Validity refers to the ability of an instrument to measure the variable that it is intended to measure (Brink 2002). Reliability refers to the consistency and dependability of a research instrument to measure a variable, including stability, equivalence and internal consistency (Brink 2002).

3.10.1 The pilot study

In order to test the research design for the prospective study, prior to the study, a pilot study (small-scale study), and a second pilot study, was carried out on a small population who had similar characteristics to the target population (de Vos 2005). The measuring instrument, the

interview-administered questionnaire was administered to a total of 30 brewery contractors working in similar environments as those of the proposed study participants. Errors were identified and controlled where necessary. An opportunistic stratified sampling method was used, in order to ensure all workers in the three exposure groups were represented.

The purpose of the pilot study was to identify and control any errors, such as instrument errors, and reduce it to its lowest possible level. This would ensure data would be as meaningful and as accurate as possible. This would increase the precision of the instrument, the questionnaire (de Vos 2005).

3.10.2 Content stability

The questionnaire to be used was compiled from the ECRHS, the reliability of which had already been tested (Burney et al. 1994).

3.10.3 Bias

It was suggested that certain bias may be present: Data in this study applied only to the brewery being studied and was not representative of any other brewery or form of private home brewing practice. It was felt that effects of selection may bias results of this study, as misclassification of subjects could be operative. Close linkage of interviews with annual medicals was a possible drawback and could have resulted in some degree of 'over-reporting'. There could be information bias introduced as data collected at one point in time does not necessarily reflect the symptoms experienced throughout the year, which may vary. There may have been potential recall bias, as information collected may have resulted in inaccuracies arising due to information having to be recalled over a period of time. Furthermore, only permanent, full time employees, who may have been healthier than non permanent employees, participated in this study. This may have represented the 'healthy worker effect'. As this study was a cross-sectional analyses of the current workforce, this study may have reflected the resulting survivor effects. Workers who had recently left the company or changed jobs in order to safeguard their health may also have contributed to the 'healthy worker effect'. Attempts were made to account for this latter effect by collecting data and analysing for those who had changed their jobs on the basis of their symptoms.

3.10.4 Generalization

It was thought that the results of this study, although applicable to the brewery studied, would be able to be generalized to other brewery settings. It was also thought that the possibility existed that results may suggest that further studies may be required.

3.11 Data analysis

3.11.1 Statistical analysis

STATA statistical package was utilized for data management and analysis. The entire database and questionnaire responses were analysed using STATA version 10. Independent checks of range, validity, consistency and missing data were performed. Logic check programs were run to ensure that each value found in the data fell within the expected range or corresponded to possible values in the codebook. All discrepancies were addressed. Descriptive statistics such as means and proportions were used to summarize the data. Key associations of interest involved investigating relationships between exposure groups (low, medium and high), occupational agents (chemical, and biological), host factor attributes (e.g age, gender, family history of allergy, hay fever or asthma, smoking, or history of a lung problem for which the participant had to be hospitalized) and respiratory health outcomes (e.g. work-related upper and lower respiratory symptoms). Univariate, bivariate and multivariate logistic regression models were used to investigate the association between upper and lower respiratory symptoms, host factors and specific chemical and biological agents, and respiratory outcomes (Tredoux & Durrheim 2002). Measures of disease association were evaluated by means of chi-squared test prior to the development of regression models (Tredoux & Durrheim 2002). Strength of association was expressed as an odds ratio (OR) or p-value, with a p-value of ≤ 0.05 considered significant. Results were presented by means of tables and statistical summaries (Katzenellenbogen 2004).

3.11.2 Outcome variables

The key outcome variables of interest (Please refer to definitions below) included:

Self-reported upper respiratory symptoms, general and work-related, suggestive of rhinoconjunctivitis

- Self-reported lower respiratory symptoms, general and work-related
- Self-reported asthma (based on symptoms and doctor diagnosis)

- Self-reported work-aggravated asthma
- Self-reported atopic asthma
- Self-reported work-related asthma
- Possible extrinsic allergic alveolitis symptom complex
- Possible chronic bronchitis symptom complex

3.11.3 Definitions: Outcome variables

Words/Phrases	Definition
Work-related ocular-nasal symptoms suggestive of Rhino-conjunctivitis	Nasal allergies in the last 12 months Nasal allergies worse with work Nasal allergies after starting at the brewery
Asthma	Doctor-diagnosed asthma Asthma attack in past 12 months OR Use of asthma medication in past 12 months
Work-aggravated asthma	Asthma attack in last 12 months OR asthma medicine in last 12 months AND work-related chest symptoms, OR job change due to work-related symptoms, OR increase in medication use
Atopic asthma	Family history of asthma, allergy or hay fever AND definition of Asthma
Work-related asthma	Definition of Asthma AND one or more work-related chest symptoms, as follows: Chest symptoms after starting at the brewery Change of work processes preceding onset of chest symptoms Change of job because of chest problems Increase in medication use Symptoms worse when working in current job Symptoms improve after changing job or during extended time away from job
Possible extrinsic allergic alveolitis	Fever, chills, cough, difficulty in breathing following exposure to product or certain work activity
Possible chronic bronchitis	Cough most days, nights for 3 or more months in each of past 2 years

3.11.4 Exposure variables

The primary measures of exposure included:

Exposure group: Subjects were classified into 3 exposure groups. This was based on the principle investigators prior knowledge and assessment of departmental levels of exposure to chemical and biological dusts, gases, vapors and fumes. Prior knowledge of the principle investigator to the levels of these exposures, was built on current risk assessments and level of medical surveillance to which each department was currently subjected to, at the brewery.

Exposure levels included:

- High exposure: Brewing (Including Utilities), Logistics.
- Medium exposure: Packaging, Warehouse, Laboratory (Including QAQC).
- Low exposure: Administration (Including Sales and Distribution) based on visual inspection of levels of exposure to dusts, gases, vapours and fumes in different departments.

Chemical agents: The most important chemical agents used in the analysis were sodium hydroxide, carbon dioxide, ammonia and kiesselguhr/silica (Addenda 10 and 11).

Biological agents: The most important biological agents used in the analysis were grain dust, hops and malt dust (Addendum 9).

3.11.5 Covariates

Covariates included:

Age

Gender

Family history of allergy, hay fever or asthma

Current smoking status

Previous history of a serious lung problem for which participant had to be hospitalized.

3.12 Chapter summary

Use was made of a cross-sectional analytical study design, using a stratified opportunistic sampling method to select the study sample (n = 251) from a total population of 414 permanent workers in the brewery. A previously validated interview-administered questionnaire of the European Community Respiratory Health Survey (ECRHS), adapted for

local context, was used to interview workers divided in 3 exposure groups. Ethical principals were considered throughout the study in the collection and management of data and data analysis. This included the use of univariate, bivariate and multivariate logistic regression models to investigate the association between respiratory symptoms and outcomes, host factors and specific environmental exposures.

CHAPTER 4

RESULTS

4.1 Introduction

A cross sectional analytical study was conducted within a brewery in South Africa in order to document the prevalence of work-related respiratory problems and associated risk factors.
This chapter presents the research analysis and findings that were derived from the specific research objectives that addressed the research question. Univariate, bivariate and multivariate analyses used to investigate the association between upper and lower respiratory symptoms and outcomes, and host factors and specific chemical and biological agents, is presented. Measures of disease association are evaluated by means of Chi-squared test prior to the development of regression models. Strength of association is expressed by means of odds ratio or p-value. Results are presented by means of tables, and statistical summaries.

4.2 Demographic, employment and health-related characteristics

A total of two hundred and fifty-one (n=251; 61%) permanently employed brewery workers (n=414) were selected to participate in the survey. The mean age of this study sample was 40 years, and ranged from 20 years to 62 years of age. The majority of the participants were male 195 (78%). Only thirty-five percent (n=88; 35%) of the study population reported to be smoking at the time of the study, the majority of which smoked less than 10 cigarettes per day. Of those currently smoking, eight percent (n=7; 8%) reported smoking more than 20 cigarettes per day (Table 3).

The years of service in current jobs of participants averaged 10 years. Job categories varied quite substantially (Addendum 7). Of interest, twenty-five percent (n=62; 25%) of participants reported a family history of allergy, hay fever or asthma. A total of five percent (n=13; 5%) of workers reported a past history of a serious lung problem for which the participant had to be hospitalized. These included hospitalization for asthma, pneumonia, tuberculosis, a viral lung infection, a collapsed lung, pulmonary embolism and pleural effusion. Only two percent (n=5; 2%) of participants reported a history of tuberculosis for which they did not need to be hospitalized (Table 3).

Table 3: Demographic, employment and health-related characteristics of workers in a South African brewery (n = 251)

Demographic characteristics	Prevalence n (%)
Age (years)	40 ± 10
Age < 30 years	55 (22%)
Age 31 - 40 years	78 (31%)
Age 41 - 50 years	77 (31%)
Age > 50 years	41 (16%)
Gender: Female: Male (%)	22 : 78
Smoking status	
Current smokers	88 (35%)
Number of cigarettes smoked per day: currently	
1 – 10 cigarettes	57 (65%)
11-20 cigarettes	24 (27%)
More than 20 cigarettes	7 (8%)
Employment History	
Duration of employment in brewery (years)	12 ± 9
Duration of employment in current job (years)	10 ± 8
Past History of allergy	
Family history of allergy, hay fever, asthma	62 (25%)
Past history of serious lung problem for which had to be hospitalized	13 (5%)
Past history of Tuberculosis of the lung (not hospitalized)	5 (2%)

Note: Data presented as number (%) or mean ± standard deviation, unless otherwise stated

4.3 Self-reported exposure to particulate dust agents

A large proportion of workers were exposed to various hazardous agents. Table 4 lists common hazardous particulate dust agents identified through self-reported exposure histories of the brewery workers interviewed. A high proportion of workers were exposed to kieselguhr and silica dust (n=88; 35%), and to malt dust (n=83; 33%). (Addendum 9: Self-reported exposure to particulate dust agents.

Table 4: Top 10 hazardous particulate dust agents identified through self-reported exposure histories of workers in a South African brewery (n = 251)

Dusts	Number (%)
Kieselguhr (diatomaceous earth, crystalline silica, quartz) and silica dust (crystalline silica, quartz)	88 (35%)
Malt dust	83 (33%)
Hops	67 (27%)
Grain dust(maize)	52 (21%)
General dust (Surfaces of crates, cases, trays, machines, including dust generated by air hoses/blowers)	42 (17%)
Diesel particulates	38 (15%)
Calcium sulphate /calcium chloride	33 (13%)
Activated carbon	28 (11%)
Lucilite (silica aerogels)	20 (8%)
Glass dust (bottle washer; empty bottle inspection; glass crusher; depallitizer; glass under machines; recycle of glass)	5 (2%)

Note: Data presented as number (%) or mean ± standard deviation, unless otherwise stated

4.4 Self-reported hazardous chemical agents

Table 5 lists the more common hazardous chemical agents, including gases, vapors and fumes, identified through self-reported exposure histories of workers in this brewery. The most common hazardous chemical agent to which the brewery workers reported to have been exposed to was sodium hydroxide (n=123; 49%), followed by carbon dioxide (n=108; 43%) and ammonia (n=100; 40%). Please refer to Addendum 10: Self-reported hazardous chemical agents. (Addendum 11: Self-Reported Exposure to Gases, Vapors, fumes).

Table 5: Top 10 hazardous chemical (including gases, vapors and fumes) agents identified through self-reported exposure histories of workers in a South African brewery (n = 251)

Chemicals	Number (%)
Caustic soda (sodium hydroxide)	123 (49%)
Carbon dioxide	108 (43%)
Ammonia	100 (40%)
Sterilant (hydrogen peroxide aqueous solution)	55 (22%)
Carbon monoxide	48 (19%)
Fumes from welding, soldering, cutting	30 (12%)
Videojet make-up fluid (2-Butanone, methanol, Propylene glycolmonomethylether	25 (10%)
Chlorine dioxide	23 (9%)
Lactic acid	20 (8%)
Sulphurs (sulphur; sulphuric acid; sulphur dioxide)	17 (7%)

Note: Data are presented as number (%), unless otherwise stated

Those chemicals cited as causing respiratory problems as a result of peak exposure experiences included ammonia (n=45; 18%), carbon dioxide (n=19; 8%), malt dust (n=16; 6%), caustic (n=3; 1%) and kieselguhr/silica (n=3; 1%).

4.5 Self-reported respiratory symptom history

4.5.1 Upper respiratory symptoms

A high prevalence of upper respiratory symptoms was reported with sixty-four percent (n=161; 64%) of participants reporting nasal allergies including ocular-nasal symptoms in the last 12 months. Up to half of those reporting these symptoms, reported ocular-nasal symptoms commencing after starting at the brewery and twenty-three percent (n=58; 23%) reported these symptoms worse at work (Table 6).

4.5.2 Lower respiratory symptoms

A range of between three percent (n=8; 3%) and twenty-eight percent (n=71; 28%) of workers reported lower respiratory symptoms which could be indicative of possible, probable or confirmed asthma. A prevalence of sixteen percent (n=39; 16%) reported doctor-diagnosed asthma. Of those participants reporting doctor-diagnosed asthma, only one third (n=12; 5%) were currently using asthma medication (Table 6).

4.5.3 Work-related respiratory symptoms

A range of between two (n=4; 2%) and thirty-eight percent (n=95; 38%) of workers reported possible work-related respiratory symptom experiences. Just over one third of the participants (n=95; 38%) reported experiencing chest symptoms after starting at the brewery. Almost a third (n=69; 27%) reported peak exposure experiences, namely exposure to a large amount of a dust, chemical, gas, vapor or fume, causing a chest problem. A total of four percent (n=11; 4%) reported changing a job because of a chest problem. Reasons cited for changing of job as a result of exposure to either dusts, chemicals, gases, vapors or fumes causing a respiratory problem included exposures to dust, malt, kieselguhr, caustic, carbon dioxide and vapors emanating whilst running a particular brand of beer.

Table 6: Self-reported upper and lower respiratory symptom history of workers (n = 251) in a South African brewery

SYMPTOM	PREVALENCE(%) (n = 251)
UPPER RESPIRATORY SYMPTOMS	
Ocular-Nasal symptoms:	
Ocular-nasal symptoms in the last 12 months	161 (64%)
Work-related ocular -nasal symptoms:	
Ocular-nasal symptoms after starting at the brewery	75 (30%)
Ocular-nasal symptoms worse at work	58 (23%)
LOWER RESPIRATORY SYMPTOMS	
Possible/probable/confirmed asthma:	
Wheezing or whistling within the last 12 months	71 (28%)
Wheeze or whistling in chest and breathlessness past 12 months	36 (14%)
Wheeze or whistling without a cold	31 (12%)
Woken up with tight chest in past 12 months	39 (16%)
Attack of shortness of breath at rest in past 12 months	21 (8%)
Shortness of breath at night or woken by shortness of breath past	24 (10%)
Doctor-diagnosed asthma	39 (16%)
Attack of asthma in last 12 months	8 (3%)
Current use of asthma medication in past 12 months	12 (5%)
Possible work-related respiratory symptom experiences	
Chest symptoms present after starting at the brewery	95 (38%)
Changes in work processes preceding onset of chest symptoms	25 (10%)
Chest symptoms worse when working in current job	8 (3%)
Chest symptoms improve during extended times away from work	12 (5%)
Increase in medicine while working in current job	4 (2%)
Change in job because of chest problem	11 (4%)
Large amount of dust, chemical, gas, vapor, fume causing chest problem	69 (27%)

Note: Data are presented as number (%) unless otherwise stated

4.6 Respiratory disease and asthma phenotypes

Referring to Table 7, possible allergic alveolitis was the most common respiratory disease phenotype (n=63; 25%) Among asthma phenotypes, almost half of asthmatics (n=39; 16%) had atopic asthma, (n=18; 7%), suggesting a larger proportion with non-atopic asthma.

Table 7: Prevalence of respiratory disease and asthma phenotypes among brewery workers (n = 251) in a South African brewery

Phenotype	Prevalence n (%)
Asthma	39 (16%)
Probable atopic asthma	18 (7%)
Work-related asthma	15 (6%)
Work-aggravated asthma	7 (3%)
Possible allergic alveolitis	63 (25%)
Possible chronic bronchitis	7 (3%)

Note: Data are presented as number (%) unless otherwise stated

4.7 Demographic, employment and health-related characteristics in relation to exposure

In relation to exposure category, males were more likely to be employed in the medium and high exposure category jobs ($p<0.001$). No other demographic and health-related characteristics (age, smoking, employment duration, past history of allergy, previous hospitalization for a lung disease) appeared to be significantly different over exposure categories (Table 8).

Table 8: Demographic, employment and health-related characteristics of workers in a South African brewery (n = 251) in relation to exposure group

Characteristics	Overall Prevalence (%) (n = 251)	Low Exposure (n = 57)	Medium Exposure (n = 129)	High Exposure (n = 65)	Chi-Square/ T-test p-value
Age (years)	40 ± 10	37±9	42±11	37±9	0.648
Age category					
Age < 30 years	55 (22%)	17 (30%)	19 (15%)	19 (29%)	
Age 31 -40 years	78 (31%)	19 (33%)	33 (26%)	26 (40%)	
Age 41 -50 years	77 (31%)	15 (26%)	46 (36%)	16 (25%)	
Age > 50 years	41 (16%)	6 (11%)	6 (11%)	4 (6%)	
Gender: Female: Male (%)	22 : 78	61:39	10:90	10:90	<0.001
Smoking status					
Current smokers	88 (35%)	17 (30%)	45 (35%)	26 (40%)	0.240
Number cigarettes smoked/day					
1 – 10 cigarettes	57 (23%)	14 (25%)	28 (22%)	15 (23%)	
11-20 cigarettes	24(10%)	3 (5%)	12 (9%)	9 (14%)	
More than 20 cigarettes	7 (3%)	-	5 (4%)	2 (3%)	
Employment History					
Permanent employee	251 (100%)	57 (23%)	129 (51%)	65 (26%)	-
Duration of employment in brewery (yrs)	12 ± 9	9±7	15±9	10±8	0.787
Duration of employment in current job	10 ± 8	8±6	12±8	8±7	0.842
Past History of allergy					
Family history of allergy, hay fever, asthma	62 (25%)	13 (23%)	37 (29%)	12 (18%)	0.497
Past history of serious lung problem for which had to be hospitalized	13 (5%)	5 (9%)	6 (5%)	2 (3%)	0.163
Past history of Tuberculosis of the lung (not hospitalized)	5 (2%)	0 (0%)	5 (4%)	0 (0%)	0.918

Note: Categorical values – chi-squared test for trend
Low exposure group = Administration, Sales and Distribution departments
Medium exposure group= Packaging, Warehouse, Laboratory and QAQC departments
High exposure group= Brewing (including Utilities) and Logistics departments

4.8 Respiratory symptoms in relation to exposure group using bivariate analysis

Self-reported upper and lower respiratory symptom history in relation to exposure group (Table 9) demonstrated an association of upper airway symptoms in relation to work. The reporting of ocular-nasal symptoms after starting at the brewery was associated (P=0.036), and the reporting of ocular-nasal symptoms worse with work was strongly associated (P<0.001) with exposure category.

For lower airway symptoms, doctor-diagnosed asthma demonstrated association (P=0.011), and varied across the exposure groups with a higher prevalence in the lower group, (n=17; 30%).

Chest symptoms significantly associated with work-relatedness included the experiencing of chest symptoms after starting at the brewery (p=0.001), changes in work processes preceding the onset of chest symptoms (p= 0.001), and the reporting of inhaling a large amount of dust, chemical, gas, vapor or fume causing a chest problem (P<0.001). Less strongly associated was the reporting of chest symptoms worse when working in current job (p=0.079) and chest symptoms improving during extended times away from work (p=0.085). Among the respiratory disease phenotypes, the increasing prevalence of possible allergic alveolitis across exposure groups demonstrated a strong association (P<0.001). Less strongly associated was asthma (p=0.011) and atopic asthma (p=0.021) (Please refer to Table 9).

Table 9: Self-reported upper and lower respiratory symptom history among workers (n = 251) in a South African brewery in relation to exposure group

SYMPTOM	Overall Prevalence (%) (n = 251)	Low Exposure (n = 57)	Medium Exposure (n = 129)	High Exposure (n = 65)	Chi-Square/ Trend (p-value)
UPPER RESPIRATORY SYMPTOMS					
Ocular-Nasal symptoms:					
Ocular-nasal symptoms in the last 12 months	161 (64%)	34 (60%)	4 (65%)	43 (66%)	0.466
Work-related ocular -nasal symptoms:					
Ocular-nasal symptoms after starting at the brewery	75 (30%)	5 (9%)	51 (40%)	19 (29%)	0.036
Ocular-nasal symptoms worse with work	58 (23%)	1 (2%)	36 (28%)	21 (32%)	<0.001
LOWER RESPIRATORY SYMPTOMS					
Possible/probable/confirmed asthma:					
Wheezing or whistling within the last 12 months	71 (28%)	14 (25%)	37 (29%)	20 (31%)	0.453
Wheeze or whistling in chest and breathlessness past 12 months	36 (14%)	8 (14%)	19 (15%)	9 (14%)	0.483
Wheeze or whistling when no cold	31 (12%)	6 (11%)	15 (12%)	10 (15%)	0.633
Woken up with tight chest in past 12 months	39 (16%)	9 (16%)	16 (12%)	14 (22%)	0.348
Attack of shortness of breath at rest in past 12 months	21 (8%)	5 (9%)	10 (8%)	6 (9%)	0.914
Short of breath at night/woken by shortness of breath past 12 months	24 (10%)	4 (7%)	14 (11%)	6 (9%)	0.704
Doctor-diagnosed asthma in past 12 months	39 (16%)	17 (30%)	14 (11%)	8 (12%)	0.011
Attack of Asthma in last 12 months	8 (3%)	3 (5%)	3 (2%)	2 (3%)	0.666
Current use of asthma medication in past 12 months	12 (5%)	6 (11%)	3 (2%)	3 (5%)	0.918
Possible work-related respiratory symptom experiences					
Chest symptoms after starting at the brewery	95 (38%)	7 (12%)	58 (45%)	30 (46%)	0.001
Changes in work processes preceding onset of chest symptoms	25 (10%)	1 (2%)	10 (8%)	14 (22%)	0.001
Chest symptoms worse when working in current job	8 (3%)	-	4 (3%)	4 (6%)	0.079
Chest symptoms improve during extended times away from work	12(5%)	-	7 (5%)	5 (8%)	0.085

Table 9: Self-reported upper and lower respiratory symptom history among workers (n = 251) in a South African brewery in relation to exposure group (continued)

SYMPTOM	Overall Prevalence (%) (n = 251)	Low Exposure (n = 57)	Medium Exposure (n = 129)	High Exposure (n = 65)	Chi-Square/ Trend (p-value)
Possible work-related respiratory symptom experiences (continued)					
Increase in medicine while working in this job	4 (2%)	1 (2%)	2 (2%)	1 (2%)	0.480
Change in job because of chest problem	11 (4%)	1 (2%)	6 (5%)	4 (6%)	0.242
Large amount of dust, chemical, gas, vapor, fume causing a chest problem	69 (27%)	5 (9%)	31 (24%)	33 (51%)	<0.001
RESPIRATORY DISEASE PHENOTYPES					
Asthma	39 (16%)	17 (31%)	14 (11%)	8 (12%)	0.011
Work-aggravated asthma	7 (3%)	2 (4%)	3 (2%)	2 (3%)	0.902
Atopic asthma	18 (7%)	9 (16%)	6 (6%)	3 (5%)	0.021
Work-related asthma	15 (6%)	3 (5%)	5 (4%)	7 (11%)	0.179
Possible allergic alveolitis	63 (25%)	2 (4%)	35 (27%)	26 (40%)	<0.001
Possible chronic bronchitis	7 (3%)	1 (2%)	3 (2%)	3(5%)	0.329

Note: Categorical values – chi-squared test for trend
Low exposure group = Administration, Sales and Distribution departments
Medium exposure group= Packaging, Warehouse, Laboratory and QAQC departments
High exposure group= Brewing (including Utilities) and Logistics departments

4.9 Host factors associated with respiratory symptoms using unadjusted models.

In the unadjusted logistic regression models (Table 10), increasing age was significantly associated with chest symptoms after starting at the brewery (OR,1.06; 95%CI, 1.02-1.10) and inhaling a large amount of dust, chemical, gas, vapor, fume causing a chest problem (OR,1.82; 95%CI, 1.00-1.05).

Male gender was significantly associated with work-related ocular nasal symptoms (OR, 5.46; 95%CI, 2.00-14.88), experiencing chest symptoms after starting at the brewery (OR, 4.80; 95%CI, 2.11-10.94) and the reporting of a large amount of dust, chemical, gas, vapor, fume causing a chest problem (OR, 3.98, 95%CI,1.62 – 9.77) (Table 10).

Similarly a family history of allergy, hay fever and asthma was strongly and positively associated with both upper and lower respiratory symptoms, and in relation to work, the association being strong for reporting of ocular-nasal symptoms in the past 12 months (OR, 3.85; 95%CI, 1.85-8.04) and doctor-diagnosed asthma (OR, 3.25; CI, 1.60-6.63). Those reporting lower respiratory chest symptoms were between 2 and 4 times more likely to have reported a family history of allergy, hay fever or asthma (OR, 2.18, 95%CI, 1.06-4.49 to OR, 3.52; 95%CI, 1.28-9.65). The strongest association was that of reporting current use of medication in the past 12 months. These workers were 12 times more likely to have reported a family history of allergy (OR, 11.80; 95%CI, 2.11-66.87). In relation to work, those who reported a change of job because of a chest problem were almost 6 times more likely to have reported a family history of allergy, hay fever or asthma (OR, 5.86; 95%CI, 1.65-20.74) (Table 10).

Hospitalization for a serious lung problem in the past was strongly and significantly associated with doctor-diagnosed asthma (OR, 5.32; 95%CI, 1.68-16.83) and change in job because of a chest problem (OR, 8.63; 95%CI, 1.98-37.52). Of borderline significance, was improvement of chest symptoms during extended times away from work (OR, 5.4; 95%CI, 0.93-31.42). There was no significant association between ‘currently smoking’ and any of the respiratory outcomes (Table 10).

Host factors strongly associated with the general asthma phenotypes was family history of allergy (OR, 3.25; 95%CI 1.60-6.63), and hospitalization for a serious lung problem (OR, 5.32; 95% CI 1.68-16.83). Hospitalization for a serious lung problem was significantly associated with atopic asthma (OR, 7.11; 95%CI, 1.95-25.98) and work-related asthma (OR,9.17; 95%CI, 2.44-34.48), but not positively associated with possible allergic alveolitis or possible chronic bronchitis. Other factors strongly associated with work-aggravated asthma was the reporting of a family history of allergy (OR,8.16, 95%CI 1.54-43.18) and hospitalization for serious lung problem (OR, 17.55; 95%CI, 3.45-89.15) (Table 10).

Table 10: Unadjusted logistical regression models for host factors associated with upper and lower respiratory symptoms of brewery workers (n = 251) in a South African brewery

SYMPTOM	AGE	GENDER (MALE VS FEMALE)	FAMILY HISTORY OF ALLERGY	CURRENT VS NON-SMOKER	HOSPITALISATION FOR SERIOUS LUNG PROBLEM IN PAST
			Odds ratio (Confidence Interval)		
UPPER RESPIRATORY SYMPTOMS					
Ocular-Nasal symptoms:					
Ocular-nasal symptoms in the last 12 months	0.96 (0.93 – 0.98)	0.65 (0.34 – 1.25)	3.85 (1.85 – 8.04)	0.90 (0.49 – 1.67)	0.63 (0.21 – 1.95)
Work-related ocular -nasal symptoms:					
Ocular-nasal symptoms after starting at the brewery	0.95 (0.92 – 0.98)	0.34 (0.15 – 0.74)	1.80 (0.91 – 3.55)	0.94 (0.46 – 1.93)	1.17 (0.25 – 5.41)
Ocular-nasal symptoms worse with work	1.03 (0.99 – 1.06)	5.46 (2.00 – 14.88)	0.79 (0.40 – 1.59)	0.77 (0.37 – 1.61)	0.28 (0.03 – 2.42)
LOWER RESPIRATORY SYMPTOMS					
Possible/probable/confirmed asthma:					
Wheezing or whistling within the last 12 months	1.01 (0.99 – 1.04)	0.71 (0.37 – 1.34)	2.60 (1.42 – 4.77)	1.30 (0.74 – 2.30)	1.13 (0.34 – 3.80)
Wheeze or whistling in chest and breathlessness last 12 months	1.01 (0.99 – 1.04)	0.71 (0.37 – 1.34)	2.60 (1.42 – 4.77)	1.29 (0.68 – 2.44)	3.09 (0.31 – 31.24)
Wheeze or whistling without a cold	0.99 (0.94 – 1.04)	81 (0.28 – 2.34)	3.52 (1.28 – 9.65)	0.74 (0.28 – 1.96)	1.31 (0.17 – 9.86)
Woken up with tight chest in past 12 months	0.99 (0.96 – 1.02	0.69 (0.32 – 1.48)	2.18 (1.06 – 4.49)	2.18 (1.06 – 4.49)	1.68 (0.44 – 6.42)
Attack of shortness of breath at rest in past 12 months	0.98 (0.94 – 1.03)	0.34 (0.14 – 0.86)	3.09 (1.24– 7.69)	0.41 (0.14 – 1.22)	2.10 (0.43 – 10.15)
Short of breath at night or woken by shortness of breath past 12 months	1.01 (0.97 –1.06)	1.49 (0.49 – 4.54)	1.28 (0.50 – 3.25)	0.73 (0.26 – 2.00)	0.78 (0.10 – 6.27)
Doctor-diagnosed asthma in past 12 month	0.97 (0.94 – 1.01)	0.33 (0.16 – 0.69)	3.25 (1.60– 6.63)	0.49 (0.20 – 1.20)	5.32 (1.68 – 16.83)
Attack of Asthma in last 12 months	0.97 (0.89 –1.05)	0.33 (0.07 – 1.65)	4.75 (0.82 – 27.50)	1.8 (0.29 – 11.16)	2.25 (0.33 – 15.26)
Current use of asthma medication in last 12 months	1.03 (0.96 – 1.10)	0.36 (0.09 – 1.45)	11.80 (2.11 – 66.87)	1.32 (0.22 – 7.82)	2.67 (0.45 – 15.72)

Table 10: Unadjusted logistical regression models for host factors associated with upper and lower respiratory symptoms of brewery workers (n = 251) in a South African brewery (continued)

SYMPTOM	AGE	GENDER (MALE VS FEMALE)	FAMILY HISTORY OF ALLERGY	CURRENT VS NON-SMOKER	HOSPITALISATION FOR SERIOUS LUNG PROBLEM IN PAST
			Odds ratio (Confidence Interval)		
Possible work-related respiratory symptom experiences					
Chest symptoms after starting at the brewery	1.06 (1.02 – 1.10)	4.80 (2.11 – 10.94)	0.83 (0.40 – 1.70)	0.74 (0.34 – 1.60)	0.79 (0.17 – 3.67)
Changes in work processes preceding onset of chest symptoms	1.00 (0.96 – 1.05)	1.55 (0.49 – 4.89)	1.18 (0.47 – 2.97)	0.53 (0.21 – 1.36)	2.12 (0.39 – 11.61)
Chest symptoms worse when working in current job	1.03 (0.96 – 1.10)	2.00 (0.24 –16.86)	1.49 (0.34 – 6.53)	0.13 (0.02 – 1.12)	0.30 (0.03 – 2.89)
Chest symptoms improve during extended times away from work	0.96 (0.90 – 1.02)	3.26 (0.41 – 26.21)	2.66 (0.81 – 8.75)	0.28 (0.06 – 1.34)	5.4 (0.93 – 31.42)
Increase in medicine while working in this job	0.10 (0.90 – 1.11)	0.33 (0.02 – 4.74)	0.43 (0.02 – 9.36)	-	1.0 (0.06 – 15.99)
Change in job because of chest problem	1.01 (0.95 – 1.07)	0.76 (0.19 – 2.95)	5.86 (1.65 – 20.74)	0.70 (0.19– 2.56)	8.63 (1.98 – 37.52)
Large amount of dust, chemical, gas, vapor, fume causing chest problem	1.82 (1.00 – 1.05)	3.98 (1.62 – 9.77)	0.64 (0.32 – 1.28)	1.37 (0.71 – 2.63)	0.78 (0.21 – 2.93)
RESPIRATORY DISEASE PHENOTYPES					
Asthma	0.97 (0.94 – 1.01)	0.33 (0.16 – 0.69)	3.25 (1.60 – 6.63)	0.43 (0.19 – 0.97	5.32 (1.68 – 16.83)
Work-aggravated asthma	1.02 (0.95 – 1.10)	0.11 (0.02 – 0.56)	8.16 (1.54 – 43.18)	0.73 (0.14 – 3.87)	17.55 (3.45 – 89.15)
Atopic asthma	0.96 (0.91 – 1.01)	0.20 (0.07 – 0.53	-	0.51 (0.16 – 1.59)	7.11 (1.95 – 25.98)
Work-related asthma	1.02 (0.97 – 1.07)	0.40 (0.14 – 1.19)	2.86 (0.99 – 8.5)	0.44 (0.12 – 1.62)	9.17 (2.44 – 34.48)
Possible allergic alveolitis	1.01 (0.98 – 1.04)	2.82 (1.20 – 6.60)	1.78 (0.95 – 3.34)	1.56 (0.87 – 2.80)	0.53 (0.11 – 2.45
Possible chronic bronchitis	0.97 (0.90 – 1.05)	0.71 (0.13 – 3.76)	1.22 (0.23 – 6.45)	0.30 (0.04 – 2.54)	3.20 (0.36 – 28.94)

Each OR represents a separate logistic regression model
OR not determinable where dash

4.10 Environmental exposure group categories in relation to respiratory symptoms.

In the unadjusted logistic regression models with exposure group as a predictor of self-reported upper and lower respiratory symptoms of brewery workers (Table 11), a strong association was observed between exposure status and ocular nasal symptoms. A very strong association was also observed between work-related ocular-nasal symptoms for medium versus low (OR, 24.75: 95%CI, 3.23-189.54) and high versus low (OR, 31.50; 95%CI 3.95-251.46) exposure categories in a dose-dependant manner.

Similarly, a strong association was also observed between exposure category and increased asthma medication usage while working in this job, in a dose-dependant manner: Workers in the high exposure group was 11 times more likely to have reported having an increase in medicine usage while working in the job, in a dose-dependant manner [medium versus low (OR,3.29; 95%CI, 1.21-8.97) and high versus low (OR, 10.73; 95%CI, 3.80-30.30)].

The association with exposure status was generally stronger for work-related upper than for lower respiratory outcomes. Positive associations included the reporting of chest symptoms after starting at the brewery, changes in work processes preceding the onset of symptoms and peak exposure (the reporting of a large amount of dust, chemical, gas, vapor or fume causing a chest problem). A very strong association was also observed between exposure groups of possible allergic alveolitis [medium versus low (OR, 10.24: 95%CI, 2.37-44.24) and high versus low (OR, 18.33; 95%CI 4.11-81.80)].

Table 11: Adjusted logistical regression with exposure group as a predictor of self-reported upper and lower respiratory symptoms of brewery workers (n = 251) in a South African brewery

SYMPTOM	Overall (n = 251)	Low Exposure (n = 57)	Medium Exposure (n = 129)	High Exposure (n = 65)	Medium vs Low	High vs Low
	Prevalence (%)				Odd ratio (Confidence Interval)	
UPPER RESPIRATORY SYMPTOMS						
Ocular-Nasal symptoms:						
Ocular-nasal symptoms in the last 12 months	161 (64%)	34 (60%)	84 (65%)	43 (66%)	1.26 (0.67 – 2.40)	1.32 (0.63 – 2.76)
Work-related ocular -nasal symptoms:						
Ocular-nasal symptoms after starting at the brewery	75 (30%)	5 (9%)	51 (40%)	19 (29%)	0.11 (0.04 – 0.32)	0.22 (0.07 – 0.67)
Ocular-nasal symptoms worse with work	58 (23%)	1 (2%)	36 (28%)	21 (32%)	24.75(3.23–189.54)	31.50(3.95-251.46)
LOWER RESPIRATORY SYMPTOMS						
Possible/probable/confirmed asthma:						
Wheezing or whistling within the last 12 months	71 (28%)	14 (25%)	37 (29%)	20 (31%)	1.24 (0.61 – 2.52)	1.37 (0.61 – 2.52)
Wheeze or whistling in chest and breathlessness past 12 months	36 (14%)	8 (14%)	19 (15%)	9 (14%)	0.79 (0.23 – 2.73)	0.61 (0.15 – 2.43)
Wheeze or whistling when no cold	31 (12%)	6 (11%)	15 (12%)	10 (15%)	0.91 (0.26 – 3.16)	1.33 (0.34 – 5.27)
Woken up with tight chest in past 12 months	39 (16%)	9 (16%)	16 (12%)	14 (22%)	0.76 (0.31 – 1.83)	1.46 (0.58 – 3.69)
Attack of shortness of breath at rest in past 12 months	21 (8%)	5 (9%)	10 (8%)	6 (9%)	0.87 (0.28 – 2.68)	1.06 (0.30 – 3.67)
Short of breath at night or woken by shortness of breath past 12 months	24 (10%)	4 (7%)	14 (11%)	6 (9%)	1.61 (0.51 – 5.13)	1.35 (0.36 – 5.04)
Doctor-diagnosed asthma in past 12 months	39 (16%)	17 (30%)	14 (11%)	8 (12%)	0.29 (0.13 – 0.63)	0.33 (0.13 – 0.84)
Attack of Asthma in last 12 months	8 (3%)	3 (5%)	3 (2%)	2 (3%)	1.27 (0.21 – 7.58)	1.56 (0.20– 11.83)
Current use of asthma medication in past 12 months	12 (5%)	6 (11%)	3 (2%)	3 (5%)	0.50 (0.10 – 2.52)	1.10 (0.19 - 6.29)

Table 11: Adjusted logistical regression with exposure group as a predictor of self-reported upper and lower respiratory symptoms of brewery workers (n = 251) in a South African brewery (continued)

SYMPTOM	Overall (n = 251)	Low Exposure (n = 57)	Medium Exposure (n = 129)	High Exposure (n = 65)	Medium vs Low	High vs Low
	Prevalence (%)				Odd ratio (Confidence Interval)	
Possible work-related respiratory symptom experiences						
Chest symptoms after starting at the brewery95 (38%)	95 (38%)	7 (12%)	58 (45%)	30 (46%)	5.33 (1.99 – 14.23)	7.01(2.30–21.35)
Changes in work processes preceding onset of chest symptoms	25 (10%)	1 (2%)	10 (8%)	14 (22%)	3.16 (0.38 – 25.95)	12.44(1.52–1.82)
Chest symptoms worse when working in current job	8 (3%)	-	4 (3%)	4 (6%)	-	-
Chest symptoms improve during extended times away from work	12(5%)	-	7 (5%)	5 (8%)	-	-
Increase in medicine while working in this job	4 (2%)	1 (2%)	2 (2%)	1 (2%)	3.29 (1.21 -8.97)	10.73 (3.80– 30.30)
Change in job because of chest problem	11 (4%)	1 (2%)	6 (5%)	4 (6%)	2.73 (0.32 – 23.23)	3.67 (0.40 – 33.85)
Large amount of dust, chemical, gas, vapor, fume causing chest problem	69 (27%)	5 (9%)	31 (24%)	33 (51%)	3.29 (1.21 – 8.97)	10.73 (3.80 –30.30)
PHENOTYPES OF ASTHMA:						
Asthma	39 (16%)	17 (31%)	14 (11%)	8 (12%)	0.29 (0.13 – 0.63)	0.33 (0.13 – 0.84)
Work-aggravated asthma	7 (3%)	2 (4%)	3 (2%)	2 (3%)	0.65 (0.11 – 4.03)	0.87 (0.19 – 6.41)
Atopic asthma	18 (7%)	9 (16%)	6 (6%)	3 (5%)	0.26 (0.88 – 0.77)	0.26 (0.07 – 1.00)
Work-related asthma	15 (6%)	3 (5%)	5 (4%)	7 (11%)	0.73 (0.17 – 3.15)	2.17 (0.53 – 8.83)
Possible allergic alveolitis	63 (25%)	2 (4%)	35 (27%)	26 (40%)	10.24 (2.37 – 44.24)	18.33(4.11 –81.80)
Possible chronic bronchitis	7 (3%)	1 (2%)	3 (2%)	3(5%)	1.33 (0.14 – 13.10)	2.71(0.27 – 26.81)

Each OR represents a separate logistic regression model adjusted for age, gender, smoking, family history of allergy and past history of hospitalisation for lung problems
OR not determinable where dash
Low exposure = Administration, Sales and Distribution departments
Medium exposure = Packaging, Warehouse, Laboratory and QAQC departments
High exposure = Brewing (including Utilities) and Logistics departments

4.11. Adjusted logistical regression: Exposure group and respiratory symptoms

After adjusting for potential confounders (Age, gender, family history of allergy, hay fever or asthma, smoking and past history of hospitalization for a lung problem) the association between exposure categories and respiratory outcomes was generally stronger for upper than for lower respiratory outcomes (Table 12). There was a strong association between exposure status and work-related ocular nasal symptoms (Medium versus low (OR, 15.89: 95%CI, 1.95-129.87) and high versus low (OR, 21.42; 95%CI 2.53-181.04). Positive associations were also observed with reporting of chest symptoms after starting at the brewery [medium versus low (OR, 3.93: 95%CI, 1.03-15.01) and high versus low (OR, 8.28; 95%CI 2.00-34.12)], and changes in work processes preceding the onset of symptoms, high versus low (OR, 15.12; 95%CI 1.42-161.52). Similarly, positive associations were also observed for peak exposure, high versus low (OR, 10.45; 95%CI 3.08-35.45), work-related asthma, high versus low (OR, 10.88; 95%CI 1.50-76.76), and possible allergic alveolitis [(Medium versus low (OR, 7.63: 95%CI, 1.60-36.32) and high versus low (OR, 16.64; 95%CI 3.39-81.65)].

Table 12: Adjusted logistical regression with exposure group as a predictor of self-reported upper and lower respiratory symptoms of brewery workers (n = 251) in a South African Brewery

SYMPTOM	Overall (n = 251)	Low Exposure (n = 57)	Medium Exposure (n = 129)	High Exposure (n = 65)	Medium vs Low	High vs Low
	Prevalence (%)				Odds Ratio (Confidence Interval)	
UPPER RESPIRATORY SYMPTOMS						
Ocular-Nasal symptoms:						
Ocular-nasal symptoms in the last 12 months	161 (64%)	34 (60%)	84 (65%)	43 (66%)	2.03 (0.88-4.69)	1.82 (0.74 – 4.47)
Work-related ocular -nasal symptoms:						
Ocular-nasal symptoms after starting at the brewery	75 (30%)	5 (9%)	51 (40%)	19 (29%)	0.09 (0.02 – 0.31)	0.17 (0.04 - 0.68)
Ocular-nasal symptoms worse with work	58 (23%)	1 (2%)	36 (28%)	21 (32%)	15.89(1.95–129.87)	21.42(2.53-181.04)
LOWER RESPIRATORY SYMPTOMS						
Possible/probable/confirmed asthma:						
Wheezing or whistling within the last 12 months	71 (28%)	14 (25%)	37 (29%)	20 (31%)	1.65 (0.66 – 4.10)	2.28 (0.86 – 6.10)
Wheeze or whistling in chest and breathlessness past 12 months	36 (14%)	8 (14%)	19 (15%)	9 (14%)	0.90 (0.16 – 5.04)	0.78 (0.14 – 4.46)
Wheeze or whistling when no cold	31 (12%)	6 (11%)	15 (12%)	10 (15%)	0.94 (0.16 – 5.36)	1.64 (0.27 – 9.79)

Table 12: Adjusted logistical regression with exposure group as a predictor of self-reported upper and lower respiratory symptoms of brewery workers (n = 251) in a South African Brewery (continued)

SYMPTOM	Overall (n = 251)	Low Exposure (n = 57)	Medium Exposure (n = 129)	High Exposure (n = 65)	Medium vs Low	High vs Low
	Prevalence (%)				Odds Ratio (Confidence Interval)	
Possible/probable/confirmed asthma (continued)						
Woken up with tight chest in past 12 months	39 (16%)	9 (16%)	16 (12%)	14 (22%)	0.82 (0.29 – 2.36)	1.84 (0.63 – 5.39)
Short of breath at night or woken by shortness of breath past 12 months	24 (10%)	4 (7%)	14 (11%)	6 (9%)	1.28 (0.33 – 4.93)	1.21 (0.28 – 5.22)
Doctor-diagnosed asthma in past 12 months	39 (16%)	17 (30%)	14 (11%)	8 (12%)	0.31 (0.12 – 0.85)	0.42 (0.14 – 1.25)
Attack of Asthma in last 12 months	8 (3%)	3 (5%)	3 (2%)	2 (3%)	1.57 (0.14 – 17.12)	3.12 (0.19 – 51.17)
Current use of asthma medication in past 12 months	12 (5%)	6 (11%)	3 (2%)	3 (5%)	0.79 (0.08 – 7.87)	4.13 (0.31 – 54.83)
Possible work-related respiratory symptom experiences	95 (38%)	7 (12%)	58 (45%)	30 (46%)	3.93 (1.03 – 15.01)	8.28 (2.00 – 34.12)
Changes in work processes preceding onset of chest symptoms	25 (10%)	1 (2%)	10 (8%)	14 (22%)	2.94 (0.27 – 32.04)	15.12(1.42–161.52)
Chest symptoms worse when working in current job	8 (3%)	-	4 (3%)	4 (6%)	2.48 (0.13 – 45.74)	0.31 (0.02 – 4.34)
Increase in medicine while working in this job	4 (2%)	1 (2%)	2 (2%)	2 (2%)	-	-

Table 12: Adjusted logistical regression with exposure group as a predictor of self-reported upper and lower respiratory symptoms of brewery workers (n = 251) in a South African Brewery (continued)

SYMPTOM	Overall (n = 251)	Low Exposure (n = 57)	Medium Exposure (n = 129)	High Exposure (n = 65)	Medium vs Low	High vs Low
	Prevalence (%)				Odds Ratio (Confidence Interval)	
Possible work-related respiratory symptom experiences (continued)						
Change in job because of chest problem	11 (4%)	1 (2%)	6 (5%)	4 (6%)	5.23 (0.36 – 75.23)	11.71(0.36 – 75.43)
Large amount of dust, chemical, gas, vapor, fume causing chest problem	69 (27%)	5 (9%)	31 (24%)	33 (51%)	2.57 (0.77 – 8.60)	10.45(3.08 – 35.45)
RESPIRATORY DISEASE PHENOTYPES:						
Asthma	39 (16%)	17 (31%)	14 (11)	8 (12)	0.31 (0.12 – 0.85)	0.42 (0.14 – 1.25)
Work-aggravated asthma	7 (3%)	2 (4)	3 (2)	2 (3)	5.42 (0.35 – 82.79)	13.17(0.70–247.82)
Atopic asthma	18 (7%)	9 (16)	6 (6)	3 (5)	0.05 (0.01 – 0.40)	0.07 (0.01 – 0.76)
Work-related asthma	15 (6%)	3 (5)	5 (4)	7(11)	1.86 (0.27 – 12.67)	10.88 (1.5 – 76.76)
Possible allergic alveolitis	63 (25%)	2 (4%)	35 (27%)	26 (40%)	7.63 (1.60 – 36.32)	16.64 (3.39– 81.65)
Possible chronic bronchitis	7 (3%)	1 (2%)	3 (2%)	3(5%)	2.64 (0.19 – 36.37)	5.19 (0.36 – 73.92)

Each OR represents a separate logistic regression model adjusted for age, gender, smoking, family history of allergy and past history of hospitalisation for lung problems
OR not determinable where dash
Low exposure = Administration, Sales and Distribution departments
Medium exposure = Packaging, Warehouse, Laboratory and QAQC departments
High exposure = Brewing (including Utilities) and Logistics departments

4.12 Multivariate logistic regression models for chemical agents associated with respiratory symptoms

In the adjusted multivariate logistic regression models for chemical agents associated with upper and lower respiratory symptoms (Table 13), chemical agents associated with work-related upper airway ocular-nasal symptoms included sodium hydroxide (OR, 2.27: 95%CI, 1.09-4.73) and kiesselguhr/silica (OR, 2.58: 95%CI, 1.22-5.46). The main chemicals associated with lower respiratory symptoms included sodium hydroxide, carbon dioxide, ammonia and kiesselguhr/silica. Among the four chemicals, only sodium hydroxide appeared to be significantly associated with possible, probable or confirmed asthma, with experiencing an attack of shortness of breath (OR,3.83;95%CI, 1.22 - 12.00), and short of breath at night or woken by shortness of breath (OR, 2.88; 95%CI, 1.07 – 7.77). All these chemicals however, and in particular sodium hydroxide, were significantly associated with possible work-related respiratory experiences, such as inhaling a large amount of dust, chemical, gas, vapor or fume causing a chest problem. In addition, sodium hydroxide (OR, 7.28: 95%CI, 3.41-15.56), carbon dioxide (OR, 2.93: 95%CI, 1.53-5.62) and kiesselguhr/silica (OR, 2.40: 95%CI, 1.27-4.53) were significantly associated with possible allergic alveolitis (Table 13).

Table 13: Adjusted multivariate logistic regression models for specific chemical agents associated with upper and lower respiratory symptoms among workers (n = 251) in a South African brewery

SYMPTOM	SODIUM HYDROXIDE	CARBON DIOXIDE	AMMONIA	KIESSELGUHR/ SILICA
	Odds Ratio (Confidence interval)			
UPPER RESPIRATORY SYMPTOMS				
Ocular-Nasal symptoms:				
Ocular-nasal symptoms in the last 12 months	1.34 (0.75 – 2.40)	1.42 (0.78 – 2.56)	1.17 (0.67 – 2.06)	0.61 (0.34 – 1.12)
Work-related ocular -nasal symptoms:				
Ocular-nasal symptoms after starting at the brewery	0.69 (0.34 – 1.39)	0.79 (0.39 – 1.56)	0.44 (0.22 – 0.86)	0.53 (0.26 – 1.08)
Ocular-nasal symptoms worse with work	2.27 (1.09 – 4.73)	1.66 (0.82 – 3.36)	1.27 (0.64 – 2.53)	2.58 (1.22 – 5.46)
LOWER RESPIRATORY SYMPTOMS				
Possible/probable/confirmed asthma:				
Wheezing or whistling within the last 12 months	1.47 (0.79 – 2.74)	1.28 (0.69 – 2.39)	1.41 (0.79 – 2.55)	0.99 (0.53 – 1.84)
Wheeze or whistling in chest and breathlessness last 12 months	1.94 (0.61 – 6.15)	1.19 (0.41 – 3.41)	2.39 (0.81 – 7.00)	1.05 (0.35 – 3.11)
Wheeze or whistling when no cold	1.37 (0.44 – 4.32)	1.72 (0.60 – 5.00)	1.26 (0.44 – 3.60)	0.59 (0.19 – 1.82)
Woken up with tight chest in past 12 months	2.12 (0.97 – 4.64)	1.44 (0.67 – 3.07)	1.51 (0.75 – 3.07)	1.06 (0.50 – 2.24)
Attack of shortness of breath at rest in past 12 months	3.83 (1.22 – 12.00)	1.74 (0.61 – 4.91)	1.78 (0.69 – 4.56)	1.54 (0.58 – 4.07)
Short of breath at night or woken by shortness of breath past 12 months	2.88 (1.07 – 7.77)	0.70 (0.28 – 1.75)	2.02 (0.85 – 5.54)	1.00 (0.40 – 2.50)
Doctor-diagnosed asthma in past 12 month	0.78 (0.35 – 1.73)	0.58 (0.25 – 1.34)	0.84 (0.39 – 1.81)	1.09 (0.49 – 2.38
Attack of Asthma in last 12 months	1.03 (0.14 – 7.47)	3.94 (0.34 – 46.37	2.18 (0.30 – 15.59)	1.46 (0.20 – 10.45)
Current use of asthma medication in last 12 months	0.85 (0.14 – 5.30)	6.23 (0.56 – 69.75)	1.87 (0.27 – 12.86)	2.64 (0.41 – 17.20)

Table 13: Adjusted multivariate logistic regression models for specific chemical agents associated with upper and lower respiratory symptoms among workers (n = 251) in a South African brewery (continued)

SYMPTOM	SODIUM HYDROXIDE	CARBON DIOXIDE	AMMONIA	KIESSELGUHR/ SILICA
	Odds Ratio (Confidence Interval)			
Possible work-related respiratory symptom experiences				
Chest symptoms after starting at the brewery	2.46 (1.12 – 5.39)	2.31 (1.04 – 5.14)	2.81 (1.25 – 6.31)	1.93 (0.85 – 4.41)
Changes in work processes preceding onset of chest symptoms	3.77 (1.27 – 11.19)	2.98 (1.12 – 11.19)	3.40 (0.97 – 5.94)	2.63 (1.03 – 6.71)
Chest symptoms worse when working in current job	-	1.26 (0.27 – 5.80)	1.11 (0.24 - 5.20)	2.98 (0.64 – 13.97)
Chest symptoms improve during extended times away from work	13.67 (1.10 – 169.63)	3.79 (0.85 – 16.90)	1.10 (0.29 – 4.19)	1.24 (0.31 – 4.98)
Increase in medicine while working in this job	-	-	-	0.09 (0.00 – 95.20)
Change in job because of chest problem	2.68 (0.58 – 12.31)	0.80 (0.19 – 3.31)	1.10 (0.29 – 4.20)	1.45 (0.36 – 5.82)
Large amount of dust, chemical, gas, vapor, fume causing chest problem	2.79 (1.48 – 5.28)	3.92 (2.04 – 7.56)	3.69 (2.01 – 6.78)	4.04 (2.12 – 7.67)
RESPIRATORY DISEASE PHENOTYPES:				
Asthma	0.78 (0.35 – 1.73)	0.58 (0.25 – 1.34)	0.84 (0.39 – 1.81)	1.09 (0.49 - 2.38
Work-aggravated asthma	3.72 (0.43 – 32.43)	7.41 (0.70 – 78.45)	2.76 (0.44 – 17.30)	1.52 (0.20 – 11.57)
Atopic Asthma	0.50 (0.13 – 1.86)	0.64 (0.17 – 2.48)	1.32 (0.35 – 4.90)	0.79 (0.20 – 3.06)
Work-related asthma	2.26 (0.62 – 8.20)	1.57 (0.44 – 5.56)	1.28 (0.41 – 4.00)	2.97 (0.87 – 10.17)
Possible allergic alveolitis	7.28 (3.41 – 15.56)	2.93 (1.53 – 5.62)	1.65 (0.90 – 3.03)	2.40 (1.27 – 4.53)
Possible chronic bronchitis	3.54 (0.54 - 23.27)	3.54 (0.54 - 23.27)	2.15 (0.45 – 10.26)	2.67 (0.52 – 13.58)

Each OR represents a separate logistic regression model adjusted for age, gender, smoking, family history of allergy and past history of hospitalisation for lung problems
OR not determined where dash

4.13 Multivariate logistic regression models for specific biological agents associated with respiratory symptoms

It is evident that malt dust is associated with work-related ocular-nasal symptoms (OR, 2.06: 95%CI, 1.00-4.25) (Table 14). This was not evident in the unadjusted logistic regression models (data not shown). Grain dust was also associated with lower respiratory symptoms after joining the brewery (OR, 3.16: 95%CI, 1.15 – 8.63). Both hops and malt dust demonstrated borderline association with development of chest symptoms after starting at the brewery. Grain dust, hops and malt were all significantly associated with changes in work processes preceding onset of symptoms and peak exposure causing a chest problem (Table 14). Furthermore, grain dust (OR, 2.16: 95%CI, 1.08-4.33), hops (OR, 2.05: 95%CI, 1.07-3.93) and malt dust (OR, 2.16: 95%CI, 1.17-4.01) were positively associated with possible allergic alveolitis. In addition, grain dust (OR, 13.28: 95%CI, 2.28-77.39), hops (OR, 7.21: 95%CI, 1.33-39.18) and malt dust (OR, 5.83: 95%CI, 1.08-31.55) were significantly associated with possible chronic bronchitis (Table 14)

Table 14: Adjusted multivariate logistic regression models for specific biological agents associated with upper and lower respiratory symptoms among workers (n = 251) in a South African brewery

SYMPTOM	GRAIN DUST	HOPS	MALT DUST
	Odds ratio (Confidence interval)		
UPPER RESPIRATORY SYMPTOMS			
Ocular-Nasal symptoms:			
Ocular-nasal symptoms in the last 12 months	1.42 (0.71 – 2.85)	1.15 (0.61 – 2.16)	1.31 (0.73 – 2.35)
Work-related ocular -nasal symptoms:			
Ocular-nasal symptoms after starting at the brewery	0.44 (0.19 – 1.01)	0.42 (0.20 -0.89)	0.61 (0.30 – 1.22)
Ocular-nasal symptoms worse with work	1.67 (0.73 – 3.81)	2.06 (0.96 – 4.40)	2.06 (1.00 – 4.25)
LOWER RESPIRATORY SYMPTOMS			
Possible/probable/confirmed asthma:			
Wheezing or whistling within the last 12 months	1.21 (0.60 – 2.47)	1.27 (0.67 – 2.43)	1.17 (0.64 – 2.14)
Wheeze or whistling in chest and breathlessness last 12 months	1.54 (0.44 – 5.38)	1.06 (0.35 – 3.18)	0.88 (0.31 – 2.56)
Wheeze or whistling when no cold	0.88 (0.25 – 3.08)	1.23 (0.40 – 3.76)	1.05 (0.36 – 3.08)
Woken up with tight chest in past 12 months	1.54 (0.67 – 3.52)	1.11 (0.51 – 2.43)	1.20 (0.58 – 2.49)
Attack of shortness of breath at rest in past 12 months	3.79 (1.34 – 10.67)	1.98 (0.75 – 5.26)	1.47 (0.85 – 5.54)
Short of breath at night or woken by shortness of breath past 12 months	1.38 (0.51 – 3.73)	1.88 (0.77 – 4.60)	1.61 (0.67 - 3.82)
Doctor-diagnosed asthma in past 12 month	1.70 (0.71 – 4.13)	1.26 (0.57 – 2.86)	1.06(0.48 – 2.30)
Attack of Asthma in last 12 months	2.89 (0.32 – 26.29)	3.51 (0.39 – 31.59)	4.87 (0.52 – 45.24)
Current use of asthma medication in last 12 months	5.94 (0.64 – 55.08)	4.35 (0.49 – 3.43)	5.64 (0.62 – 51.67)
Possible work-related respiratory symptom experiences			
Chest symptoms after starting at the brewery	3.16 (1.15 – 8.63)	2.16 (0.91 – 5.12)	2.11 (0.92 – 4.87)
Changes in work processes preceding onset of chest symptoms	3.17 (1.22 – 8.26)	3.96 (1.58 – 9.96)	4.09 (1.61 – 10.39)

Table 14: Adjusted multivariate logistic regression models for specific biological agents associated with upper and lower respiratory symptoms among workers (n = 251) in a South African brewery (continued)

SYMPTOM	GRAIN DUST	HOPS	MALT DUST
	Odds ratio (Confidence Interval)		
Possible work-related respiratory symptom experiences (continued)			
Chest symptoms worse when working in current job	1.58 (0.28 – 9.02)	3.79 (0.82 – 17.51)	3.41 (0.74 – 15.85)
Chest symptoms improve during extended times away from work	1.74 (0.42 – 7.11)	1.36 (0.34 – 5.36)	1.23 (0.31 – 4.86)
Increase in medicine while working in this job	0.46 (0.01 – 14.33)	0.46 (0.01 – 14.33)	0.46 (0.01 – 14.33)
Change in job because of chest problem	1.21 (0.26 – 5.64)	2.21 (0.59 – 8.25)	2.72 (0.75 – 9.96)
Large amount of dust, chemical, gas, vapor, fume causing chest problem	3.41 (1.74 – 6.67)	2.52 (1.34 – 4.74)	4.04 (2.18 – 7.47)
RESPIRATORY DISEASE PHENOTYPES:			
Asthma	1.71 (0.71 – 4.13)	1.26 (0.56 – 2.86)	1.06 (0.48 – 2.30)
Work-aggravated asthma			
Atopic asthma	2.06 (0.25 – 16.65)	0.99 (0.13 – 7.54)	1.94 (0.32 – 11.61)
Work-related asthma	2.35 (0.68 – 8.07)	1.94 (0.60 – 6.25)	2.20 (0.71 – 6.80)
Possible allergic alveolitis	2.16 (1.08 – 4.33)	2.05 (1.07 – 3.93)	2.16 (1.17 – 4.01)
Possible chronic bronchitis	13.28 (2.28 – 77.39)	7.21 (1.33 – 39.18)	5.83 (1.08 – 31.55)

Each OR represents a separate logistic regression model adjusted for age, gender, smoking, family history of allergy and past history of hospitalisation for lung problems
OR not determined where dash

4.14 Conclusion

The reporting of upper respiratory symptoms (n=161; 64%) were more common than the reporting of lower respiratory symptoms which ranged between three percent (n=8; 3%) and twenty-eight percent (n=71; 28%). Between two percent (n=4; 2%) and thirty-eight percent (n=95; 38%) of workers reported possible work-related respiratory symptom experiences depending on the definition used. The common respiratory disease phenotypes included general asthma (n=39; 16%), atopic asthma (n=18; 7%), work-related asthma (n=15; 6%), work aggravated asthma (n=7; 3%), possible allergic alveolitis / grain fever (n=63; 25%) and possible chronic bronchitis (n=7; 3%). Both hazardous chemical agents (sodium hydroxide, carbon dioxide, ammonia and kiesselguhr/silica) and biological agents (malt dust, hops and other grain dust) were implicated in this study.

CHAPTER 5
DISCUSSION

5.1 Introduction

This epidemiological study allowed for the determination of the prevalence of work-related respiratory problems and associated risk factors within a brewery in South Africa, using self-reported symptoms and self-reported exposures obtained from a questionnaire.

Although there have been significant contributions to the knowledge base around asthma and allergens, there was the paucity of both international and national literature on respiratory health of brewery workers. Whilst a number of studies had described the harmful effects of exposure to grain dust on lung function, namely the development of respiratory disease amongst grain workers, only a few studies had investigated the respiratory health of brewery workers, particularly in relation to malt dust and other chemical agents used in the production process. No studies had documented the prevalence of work-related respiratory problems and associated risk factors within a brewery in South Africa.

The demographic profile of the workforce (n=251) in relation to personal and occupational characteristics has been described. The prevalence of work-related respiratory symptoms associated with respiratory outcomes amongst workers in different exposure groups has been determined. The relationship between symptoms reported and potential risk factors for disease, with specific reference to host and work-related factors, documented. In order to gain greater insight into the risk factors for respiratory health, problems amongst the various exposure groups will be discussed. It is hoped that these findings may contribute to enriching the knowledge base of respiratory problems and associated risk factors among these brewery workers.

5.2 Discussion of findings

In this study a higher prevalence of upper respiratory symptoms (n=161, 64%), compared to lower respiratory symptoms [within a range of between three percent (n=8, 3%) and twenty-eight percent (n=71, 28%)], was reported. Work-related exposure was specifically shown to be associated with ocular-nasal symptoms. Although it is possible that the high prevalence of

ocular-nasal symptoms, namely rhino-conjunctivitis, could be attributed to other non-occupational factors in addition to work exposures, almost half of the participants reporting prevalence of upper respiratory symptoms (n=161, 64%), reported ocular-nasal symptoms after starting at the brewery (n=75, 30%) and ocular-nasal symptoms worse with work (n=58, 23%). This was reported in a dose-dependent manner, in that the odds of ocular-nasal symptoms being worse with work was higher (OR, 31.50: 95%CI, 3.95 – 251.46) in the high versus low exposure group, compared to the medium versus low exposure group (OR, 24.75: 95%CI 3.23 – 189.54).

Occupational rhinitis and/or occupational conjunctivitis are characterized by ocular symptoms, reduced airway caliber, hyper-responsiveness and inflammation, and is caused by agents in the workplace (Gautrin & Malo 2010). These symptoms are common, and often precede and co-exist with the onset of occupational asthma (Malo et al. 1997; Gautrin & Malo 2010; Nicholson et al. 2010). It is the presence of occupational rhinitis (OR) and occupational conjunctivitis (OC) in a sensitized individual that may identify patients at greater risk for developing OA (Nicholson et al. 2005; Dykewicz et al. 2009). The risk of developing this respiratory outcome is highest in the year after the onset of occupational rhinitis (Nicholson et al. 2010).

As with OA there are two main forms of occupational rhinitis (OR). Sensitizer-induced OR is caused by sensitizers (usually HMW agents) at work, such as malt dust, and is characterized by a latency period required for developing allergic senisitization prior to the development of symptoms. Irritant-induced OR (usually LMW agents), without latency, is characterized by the onset of rhinitis following exposures to irritant compounds, such as chemicals (Gautrin & Malo 2010). It has been well documented that symptoms of rhino-conjunctivitis are often associated with high molecular weight agents such as grain dust (Chan-Yeung et al. 1978, Malo et al. 1997). In this study malt dust was associated with ocular-nasal symptoms being worse with work (OR, 2.06: 95%CI, 1.00-4.25). According to Malo et al. (1997), the prevalence of ocular-nasal symptoms was found to be no different for high molecular weight than for low molecular weight agents (Malo et al. 1997). In the case of exposure to high molecular weight agents, however, rhino-conjunctivitis was often more pronounced, often appearing before occupational asthma (Malo et al. 1997), compared to low molecular agents. The literature has revealed rates of co-morbid rhinitis or rhino-

conjunctivitis of between 45% and 100% in subjects suffering from occupational asthma attributed to various agents (Nicholson et al. 2010).

It has been reported that the primary risk of occupational exposure to food allergens, such as grain dust, hops and malt dust, is by means of the inhalation of dust, steam and vapor of aerolised proteins (Cartier 2010), which may cause occupational lung diseases, such as asthma, extrinsic allergic alveolitis and chronic obstructive pulmonary disease (Tarlo et al. 2008).

The common respiratory disease phenotypes that were identified in this study included possible allergic alveolitis/grain fever (n=63; 25%), general asthma (n=39; 16%), atopic asthma (n=18; 7%), work-related asthma (n=15; 6%), work-aggravated asthma (n=7; 3%) and possible chronic bronchitis (n=7; 3%).

This implies that a large proportion of workers (n=63; 25%) had possible allergic alveolitis (grain fever). This is consistent with the literature that reveals that this acute illness was reported in 6% - 32% of exposed workers in different studies (Bernstein et al. 2006).

In this study, the prevalence of lower respiratory symptoms associated with asthma ranged between 3%-28%. The high prevalence of doctor diagnosed asthma (n=39, 16%) is consistent with previous reports of prevalence of asthma ranging from 1% to 18% in various populations (Dykewicz et al. 2009). However, of those participants reporting doctor-diagnosed asthma, only one third were currently using asthma medication. Interestingly, the prevalence of doctor-diagnosed asthma varied across exposure groups with a significantly higher prevalence (p=0.011) in the lower exposure group (n=8, 30%) compared to the high exposure group (n=8, 12%). The relatively low prevalence of asthma in the higher exposure groups, and lower proportion of older workers in the higher exposure group suggests that asthmatics are likely to change jobs and seek alternative employment in lowly exposed jobs, or leave the industry shortly after starting employment (Chan-Yeung 2006). This would result in the 'healthy worker survivor effect'. This 'effect' occurs when workers become ill are 'selected out' of employment, through either medical disability or resignation. This would result in reduced risks estimates in a cross-sectional study assessing the relationship between the exposure and the outcome, such as asthma (Joubert & Ehrlich 2007). The 'healthy worker effect' generally relates to the fact that the working population is generally young or

middle-aged. Most exposed workers are generally healthy, at least when they start working. This could indicate that the working population has a lower total morbidity and mortality than the population as a whole (Beaglehole, Bonita, Kjellstrom 2005).

Lower respiratory symptoms reported in this study, were often related to work, with over a third of the participants (n=95, 38%) reporting possible work-related respiratory symptoms. Interestingly, aside from a large proportion of participants reporting exposure to high molecular weight protein allergens, such as malt (n=83, 33%), hops (n=67, 27%) and grain dust (n=52, 21%), a large proportion of participants also reported exposure to low molecular weight chemicals capable of causing allergic as well as irritant induced asthma. These reported chemical exposures included sodium hydroxide (n=123, 49%), carbon dioxide (n=108, 43%) and ammonia (n=100, 40%).

As far as the possible relation of respiratory symptoms to work is concerned, unlike doctor diagnosed asthma, respiratory symptoms were strongly associated with work-related asthma in the high exposure group. A range of between two percent (n=4, 2%) and thirty-eight percent (n=95, 38%) of participants reported possible work-related respiratory symptom experiences. Thirty-eight percent (n=95, 38%) of workers reported experiencing chest symptoms after starting at the brewery.

This study reported that a slightly larger proportion of brewery workers with probable asthma (56%) had non-atopic (irritant induced) asthma (n=21; 9%), compared to the proportion of workers with probable asthma (44%) who had atopic (sensitizer-induced) asthma (n=18, 7%). This is consistent with the literature that shows that at least fifty percent (50%) of asthma is of non atopic nature (Douwes et al. 2002). The overall prevalence of work-related asthma was six percent (n=15; 6%) and that of work-aggravated asthma three percent (n=7; 3%). This suggests that the 37.5% proportion of work-related asthma in this population (n=15; 6%) with a sixteen percent (n=39; 16%) overall prevalence of general asthma is quite high. In previous studies it has generally been accepted that between 9% - 15% of adult onset asthma could be attributed to workplace exposures or occupational factors (Balmes et al. 2003, Henneberger et al. 2007, Tarlo et al. 2008 & Dykewicz et al. 2009).

With regard to the prevalence of possible chronic bronchitis (n=7; 3%), inconsistencies with regard to the definition may contribute to variations in reports of prevalence thereof. The

prevalence of COPD, however, which includes the definition adopted in this study for bronchitis, varies between 5% and 22% globally, 10% - 20% of which can be attributed to workplace exposures such as vapors, gases, dusts and fumes, by itself and through interaction with other risk factors (Naidoo 2009).

It is well-known that the level of exposure to a causative agent at work is the major determinant of risk for the development of occupational asthma (Nicholson, Cullinan, Burge & Boyle 2010). Almost a third of this workforce (n=69, 27%) reported peak exposure experiences, namely exposure to a large amount of a dust, chemical, gas, vapor or fume, causing a chest problem.

It has been stated that reduced airway caliber and hyper responsiveness, as well as an inflammatory response is caused by agents in the workplace (Gautrin & Malo 2010). This is followed by subsequent massive infiltration and activation of neutrophils in the upper and lower airway which is very similar to the inflammatory response observed in non-eosinophilic asthma in the general population (Douwes et al. 2002). This may follow single or multiple exposures to irritant compounds such as forms of dusts, vapors, fumes or gases (Henneberger 2007).

This was evident in the adjusted multivariate logistic regression models, where hazardous chemical agents such as sodium hydroxide (OR, 2.27: 95%CI, 1.09-4.73) and kiesselguhr/silica (OR, 2.58: 95%CI, 1.22-5.46) were strongly associated with work-related upper airway symptoms and possible rhinitis. In the form of a liquid or a spray mist, sodium hydroxide is a hazardous corrosive and irritant chemical. It may produce tissue damage particularly with regard to mucous membranes of eyes, nose, mouth and respiratory tract, with subsequent redness, watering and itching thereof. According to Shakeri, Dick & Ayres (2008), sodium hydroxide is one of the many chemical agents identified and reported as being associated with RADS (Shakeri, Dick & Ayres 2008). This chemical, when present in very high concentrations, has irritant qualities to its nature. Linked to RADS, sudden onset of respiratory symptoms may simulate asthma, with coughing, wheezing, chest tightness and dysnoea (Shakeri et al. 2008).

A respirable dust, Kieselguhr/silica contains quartz and crystalline silica, and is an irritant to the eyes, nose and throat. Following exposure, congestion and an inflammatory response of the upper airway may occur. Kieselguhr/silica is also a human carcinogen, may cause silicosis, a non-cancerous lung disease, bronchitis, emphysema and asthma. Silicosis, a chronic lung disease initiated by cellular mechanisms that initiate and propagate a process of inflammation and scarring of lung tissue, continues to be a common cause of chronic lung diseases (Rimal, Greenberg & Rom 2005). The variability of pathogenic potential of different varieties of silica has been well recognized, such as potential of silica quartz to cause Silicosis (Rimal et al. 2005). These diseases can be prevented by environmental dust control.

In the adjusted multivariate logistic regression models, a hazardous biological agent strongly associated with work-related upper airway symptoms and possible rhinitis, was malt dust. According to Douwes et al. (2002), the primary agent inducing these inflammatory responses in workers exposed to organic dust is believed to be bacterial endotoxin. Macrophages carry specific endotoxin binding receptors (CD14, TLR4) that play a crucial role in the activation of these cells and the subsequent inflammatory reactions (Douwes et al. 2002).

In order to avoid contamination, one essential factor in the food and beverage industry is the cleaning and disinfection of the equipment used in processing of the product it produces. Sodium hydroxide, a cleaner, disinfectant and a sterilant, is widely used in the brewing industry. An irritant and corrosive, this chemical may produce severe burns or irritation to eyes, and, upon inhalation, to the respiratory system. Following severe overexposure, the subsequent inflammatory response, characterized by coughing, choking, or shortness of breath, may ultimately result in death.

Carbon dioxide is the fourth most common gas in the earth's atmosphere and the most common by-product of living organisms. As a result, many individuals who have an occupational exposure to carbon dioxide, believe it to be harmless. While this is true that carbon dioxide is harmless at normal atmospheric levels, it can be absolutely deadly at high concentrations (Scott, Kraemar and Keller 2009). Carbon dioxide is produced and used by many industries in its solid, liquid or gaseous states. In addition to its cooling properties, the brewery encounters carbon dioxide during the fermentation process, when it is produced from yeast. A stable, colorless and odourless gas, it is heavier than oxygen and tends to settle at

the bottom of enclosed spaces, where, in sufficient concentration, it can act as an asphyxiant due to oxygen displacement. Carbon dioxide is extremely soluble in tissue fluid. It is carried by the blood, either in solution or in combination with haemoglobin. An increase in carbon dioxide levels in the blood results in a decreased affinity of haemoglobin for oxygen. At lower levels, carbon dioxide is a simple asphyxiant, an irritant and a powerful cerebral vasodilator (Scott et al. 2009).

Ammonia, widely used in the brewing industry is an extremely irritating and noxious gas. Injury may be thermal as well as chemical to skin, eyes, airways and lungs. When inhaled, ammonia is capable of producing severe damage to all levels of the respiratory tract, including laryngotracheitis, pulmonary edema and haemorrhage, bronchopneumonia, bronchiectasis and fibrous obliteration of small airways (Montague & Macneil 1980). Present in high concentrations, ammonia is one of the chemicals linked to RADS, symptoms of which may simulate asthma, including cough, wheeze, tight chest and dysnoea (Shakeri et al. 2008).

Both airway inflammation and constriction of the smooth muscles of the airway are known to be part of the pathophysiologic events that accompany occupational airway disease (Schacter et al. 2000). In this study, a dose-dependant association was found between self-reported level of exposure and lower respiratory symptoms triggered by excessive/peak exposure to a dust or chemicals. Workers in the high exposure group were 10 times as likely (OR, 10.45: 95%CI 3.08–35.45), compared to the lower exposure group, to have reported a chest problem caused by peak exposures to a large amount of dust, chemical, dust or fumes (Table 11). Chemicals strongly associated with peak exposures included sodium hydroxide (OR, 2.79:95%CI,1.48 - 5.28), carbon dioxide (OR, 3.92:95%CI, 2.04 -7.56), ammonia (OR,3.69:95%CI, 2.01 – 6.78) and kiesselguhr/silica (OR, 4.04:95%CI 2.12 – 7.67) (Table 13). Only sodium hydroxide demonstrated strong associations with possible, probable or confirmed asthma (Table 13). Although not strongly associated with the reporting of a change of job because of chest problems, chemical work processes cited as the reason for necessitating a change of job because of a chest or nasal problem included a need to change from processes such as the filler, washer, empty bottle inspection, depallitiser, the kieselguhr store and silo block.

Relatively strong associations were found between chemicals and dusts and the development of possible allergic alveolitis/grain fever.

Reasons cited for the development of fever, chills, following exposure to a product or process included exposures to ammonia, carbon dioxide (bright beer tank room, filler, cellars), malt dust, kieselguhr/silica and carbon monoxide from forklifts. Among the biological agents, grain dust (OR, 2.16: 95%CI, 1.08-4.33), hops (OR, 2.05: 95%CI, 1.07-3.93) and malt dust (OR, 2.16: 95%CI, 1.17-4.04) were strongly associated with possible allergic alveolitis/grain fever (Table 14). Among the chemical agents, sodium hydroxide (OR,7.28; 95%CI, 3.41-15.56), carbon dioxide (OR, 2.93; 95%CI, 1.53-5.62) and silica (OR, 2.40; 95%CI, 1.27-4.53) were strongly associated with this respiratory outcome.

Ventilation in these areas were reported by participants to be either inadequate, non-operational, ineffective or reduced as a result of an energy-saving initiative at the time of the self-reported exposures.

As far as possible chronic bronchitis is concerned, grain dust (OR, 13.28: 95%CI, 2.28-77.39), hops (OR, 7.21: 95%CI, 1.33-39.18) and malt dust (OR, 5.83: 95%CI, 1.08-31.55) were also significantly associated with possible chronic bronchitis (Table 14).

The reporting of harmful effects of grain dust on lung function, namely the development of respiratory disease amongst grain workers or workers handling grain products is well recognized (Williams et al. 1964; Chan-Yeung et al. 1978; Yap et al 1994; Schwartz et al. 1995; Vidal & Gonzalez-Quintela 1995; Deetz et al. 1997; Jeebhay et al. 2000; Sigsgaard & Schlunssen 2004; Jeebhay et al. 2005; Sikora et al. 2008; Baatjies et al. 2009). A few studies (Riddle et al. 1968; Riddle 1974; Grant et al. 1976; Ellis & Friend 1981; Heaney et al. 1997; Godnic-Cvar et al. 1999; Schachter et al. 2001 & Miedinger et al. 2009), have investigated the respiratory health of brewery workers, particularly in relation to dusts, gasses, vapours and fumes. A number of studies have recognized that, as only a small proportion of exposed workers develop occupational reactions, host as well as industrial factors may be associated with respiratory outcomes (Chan-Yeung et al. 1978, Nicholson et al. 2005, Sikora et al 2008, Dykewicz 2009, Cartier 2010, Nicholson et al. 2010).

Exposure to malt dust and other allergens may lead to the development of acute and chronic respiratory symptoms, accompanied by lung function and immunological changes, including occupational rhinitis, occupational conjunctivitis, extrinsic allergic alveolitis/grain fever, or occupational asthma (Sikora et al. 2008).

Not all exposures cause respiratory problems only at high levels. The level of grain dust is influenced by a number of factors including the type of grain handled, the extent of enclosure, the efficiency and upkeep of the exhaust ventilation provided at transport points, and work and housekeeping practices (Bernstein et al. 2006). Although grain is normally emptied into the silos by means of an extractor system from base of the train carts, grain is not always transported to the brewery by train. Tipper trucks are also used. It has been observed by workers in this brewery, that the emptying of grain from tipper trucks generates far more dust than that from the train. Annual dust monitoring in this plant has revealed varying exposure levels to malt dust during these past few years, which at times have been over the legislated recommended limit for total inhalable dust of 10 mg/m3. It has been observed by workers that some malt intakes are more 'dusty' than others with the distribution of malt/grain dust dispersed all over the plant, such as on a very windy day. Futhermore, it has been reported by participants that engineering control measures to contain the dust and limit the number of employees exposed to this dust, such as the use of an extractor system and curtains to enclose malt intake area, have been, at times, dysfunctional. This has resulted in greater dispersion of, and over-exposure of employees, to this dust. Subsequent enclosure, however, of the sides of the malt intake area with metal plates a few months ago, together with the re-institution of the extractor system, when in use, has had a positive impact on reducing the dust levels.

Dust exposures in this brewery have recently reported as being below the threshold limit values. Occupational asthma and extrinsic allergic alveolitis may, however, occur with exposure to lower concentrations due to the allergic basis for these symptoms (Chan-Yeung et al. 1978). This implies that general particulate dust levels are a poor index of exposure to allergens and cannot be used as a basis for determining the risk of developing allergic respiratory disease. The occupational exposure control limit for silica has been amended in Table 1 of the Hazardous Chemical Substances Regulations from 0.4mg/m3 to 0.1mg/mg3. The specific standards presently being suggested for a number of allergens include the occupational exposure control limit for grain dust, 10mg/m3 (although 4mg/m3 is suggested

by ACGIH), for ammonia, 17mg/m3, for carbon dioxide, 9000mg/m3 (although 4mg/m3 is suggested by ACGIH), and for sodium hydroxide, 2mg/m3. It is to be noted that international variation of limits set, vary.

Personal protective equipment is worn. This, however, is not mandatory for all processes, as expected levels of exposure are minimal or engineering control measures, such as extractor fans, are in place. It has been reported by participants, however, that ventilator systems are not always functional or adequate, that these may, at times, be absent, ineffective or not in use.

In this study, in addition to environmental factors, several host-related factors were also identified. Among the host factors, age (OR 1.06, 95%CI, 1.02 – 1.10) and the male gender (OR 4.80, 95%CI 2.11 – 10.94) where associated with the experiencing of chest symptoms after starting at the brewery. The male gender, the reporting of previous hospitalization for a lung disease, and a family history of allergy, hay fever or asthma was strongly associated with the respiratory symptom outcomes (Table 10).

The study found a strong association between exposure and the gendered distribution of work. Consistent with brewery populations in previous studies, in this study, the study population was predominantly male (n=195, 78%) (Table 3). Males were, therefore, more likely to have adverse respiratory outcomes as they were more likely to be found in the higher and medium exposure groups rather than the lower exposure group. Ninety percent (90%) of workers in the high exposure group were males (n=58, 23%). Ninety percent (90%) of workers in the medium exposure group were male (n=116, 46%). Only thirty-nine percent (39%) of workers in the low exposure group were male (n=22, 9%). The female gender, mainly employed in administration, sales and marketing of the product, predominated the low exposure group (61% female gender) (Table 8).

With regard to atopy, the association between atopy and the development of occupational asthma caused by high molecular weight agents is well recognized (Nicholson et al. 2005, Sikora et al. 2008, Baatjies et al. 2009 & Nicholson et al. 2010). Atopic individuals commonly have a family history of allergy. In this study a relatively high percentage (n=62, 25%) of participants reported a family history of allergy, hay fever, asthma (Table 3). This characteristic was strongly associated with adverse respiratory outcomes, such as asthma (OR

3.25, 95%CI, 1.60 – 6.63) and work-aggravated asthma (OR 8.16, 95%CI 1.54 – 43.1) (Table 10). This was unlike a study of grain workers where the proportion of individuals with atopy in grain workers appeared to be about the same in that working population as the general population (Chan-Yeung et al. 1978). The previous study of male workers in a brewery plant, demonstrated that atopy was not a major factor responsible for the high prevalence of chronic respiratory symptoms in this population (Godnic-Cvar et al. 1999).

Tobacco use has been associated with 42% of chronic respiratory disease (World Heath Organisation 2009). Conflicting evidence is available, however, regarding the role of cigarette smoking as far as occupational asthma is concerned (Nicholson et al. 2010). Cigarette smoke has been found to increase bronchial epithelial permeability, potentially allowing inhaled allergens increased access to immune-competent cells and an immune response (Sikora et al. 2008). According to Chan-Yeung et al. (1978), the effects of cigarette smoking has an additive effect on grain dust exposure and is the most important factor influencing the frequency of chronic bronchitis (Chan-Yeung et al. 1978). Interestingly, smoking was not found to be a significant factor associated with the respiratory outcomes of interest in this study. Although a substantial proportion of the workforce studied (35%) were smokers (n=88, 35%), the majority of smokers (n=57, 65%) reported smoking less than 10 cigarettes per day. Only eight percent (n=7, 8%) of participants reported having smoked more than 20 cigarettes per day (Table 3).

In this study five percent (n=13, 5%) of workers reported a previous history of a serious lung problem for which the participant had to be hospitalized. Two percent (n=5, 2%) of the participants reported a past history of tuberculosis for which they did not need to be hospitalized (Table 3). Our study showed that previous hospitalization for a serious lung problem was strongly associated with adverse respiratory symptom outcomes. These included asthma (OR, 5.32, 95%CI, 1.68-16.83), work-aggravated asthma (OR,17.55, 95%CI, 3.45 – 89.15), atopic asthma (OR, 7.11, 95%CI 1.95 – 25.98) and work-related asthma (OR, 9.17, 95%CI 2.44 – 34.48) (Table 10). Other studies have documented a strong association between respiratory infections and lung infections. Tuberculosis and childhood infections has been significantly associated to all asthma outcomes and strongly linked to the development of chronic obstructive pulmonary disease (Naidoo 2010).

5.3 Significance to clinical practice

The high prevalence of work-related respiratory symptoms associated with chemical (Table 13) and biological (Table 14) exposures in a brewery were identified. In addition, several host-related factors were also associated with work-related respiratory symptoms (Table 10) . This study points to the need for appropriate preventative strategies to be undertaken in order to reduce exposures and more targeted respiratory medical surveillance of exposed workers. A more targeted respiratory medical surveillance of exposed workers in the long term will reduce the incidence of respiratory problems among brewery workers, and ensure the protection and promotion of the respiratory health of employees in the workplace.

5.4 Limitations

There are potential limitations of this study (Please refer to 3.11.4 page 43: Bias) that need to be borne in mind when interpreting the results of this study. Selection may bias results of this study due to the opportunistic nature of the sample selected. All individuals would, however, have had an equal chance of presenting to the clinic for their annual medical surveillance. There is a possibility that there may have been some exposure misclassification in grouping the workers as no objective measurements were done. Similarly, there were no objective tests done to confirm the presence of asthma, and no objective tests done, such as Xrays to confirm the presence of Silicosis. There were no tests done to confirm the diagnosis. However, the questionnaire instrument has been well validated in other settings to identify asthmatic individuals. It is acknowledged that the definition for possible allergic alveolitis may be quite crude and therefore lacked specificity. Furthermore, only permanent, full time employees, who were generally of higher socio-economic status, and, therefore, possibly healthier than non-permanent employees, participated in this study. This may have caused the 'healthy worker survivor effect'. This 'effect' results when workers become ill are 'selected out' of employment, through either medical disability or resignation. This will result in reduced risks estimates in a cross-sectional study assessing the relationship between the exposure and the outcome, such as asthma (Joubert & Ehrlich 2007). Since this study was cross-sectional in nature, this study may have reflected the resulting 'survivor effects'. Workers who had recently left the company or changed jobs in order to safeguard their health may also have contributed to the 'healthy worker survivor effect' observed. Attempts were made to account for this latter effect by collecting data and analyzing for those who had changed their jobs on the basis of their symptoms, but due to power issues this was not possible.

5.5 Recommendations

5.5.1 Research Objectives

i. To describe the demographic profile of the workforce in relation to personal and occupational characteristics.

ii. To classify the subjects into 3 exposure groups based on subjective levels of exposure to dusts, gases, vapors and fumes in different departments. This was based on the principle investigators prior knowledge and assessment of departmental level of exposure to chemical and biological dusts, gases, vapours and fumes. Prior knowledge of the principle investigator, to the level of exposure, was built on current risk assessments and level of medical surveillance to which each department was currently subjected to, at the brewery. Exposure levels included:

- High exposure: Brewing (Including Utilities), Logistics.
- Medium exposure: Packaging, Warehouse, Laboratory (Including QAQC).
- Low exposure: Administration (Including Sales and Distribution).

iii. To determine the prevalence of work-related respiratory symptoms associated with allergic respiratory outcomes (rhino-conjunctivitis, asthma, extrinsic allergic alveolitis and chronic bronchitis) among workers in these different exposure groups.

iv. To document the relationship between work-related respiratory symptoms reported and potential risk factors for disease with specific reference to:

- Host factors: Age, gender, smoking status, atopy (allergic tendency), previous family history (of allergy, hay fever or asthma);
- Work-related factors: Exposure group category (to dusts, gases, vapors or fumes)

5.5.2 Presentation of results with reference to tables

A total of two hundred and fifty-one (n=251; 61%) permanently employed brewery workers (n=414) were selected to participate in the survey. The mean age of this study sample was 40 years. The majority of the participants were male (n=195; 78%). The years of service in current jobs of participants averaged 10 years (Table 3) Job categories varied quite substantially (Addendum 8). Of interest, twenty-five percent (n=62; 25%) of participants reported a family history of allergy, hay fever or asthma. A total of five percent (n=13; 5%)

of workers reported a past history of a serious lung problem for which the participant had to be hospitalized. Only two percent (n=5; 2%) of participants reported a history of tuberculosis for which they did not need to be hospitalized (Table 3).

Subjects were classified into 3 exposure groups, based on visual inspection of levels of exposure to dusts, gases, vapors and fumes in different departments. Exposure levels included:

- High exposure: Brewing (Including Utilities), Logistics.
- Medium exposure: Packaging, Warehouse, Laboratory (Including QAQC).
- Low exposure: Administration (Including Sales and Distribution).

The study population was predominantly male (n=95; 78%) with a mean age of 40 years and an average of 10 years employed in the current job. Thirty-five percent (n=88; 35%) of the workforce were smokers, twenty-five percent (n=62; 25%) reported a family history of allergy, hay fever, asthma and sixteen percent (n=39; 16%) reported doctor- diagnosed asthma (Table 3).

The more common hazardous biological agents used in the analysis and to which brewery workers reported to have been exposed to was kieselguhr and silica dust (n=88; 35%), and to malt dust (n=83; 33%) (Table 4).

The most common potentially hazardous chemical agents reported included sodium hydroxide (n=123; 49%), carbon dioxide (n=108; 43%), ammonia (n=100; 40%), kieselguhr/silica dust (n=88; 35%), and malt dust (n=83; 33%) (Table 5).

The common respiratory disease phenotypes included general asthma (n=39; 16%), atopic asthma (n=18; 7%), work-related asthma (n=15; 6%), work aggravated asthma (n=7; 3%), possible allergic alveolitis / grain fever (n=63; 25%) and possible chronic bronchitis (n=7; 3%) (Table 7).

Upper respiratory symptoms (n=161; 64%) were more common than lower respiratory symptoms (3 – 28%). Between 2% and 38% of workers reported possible work-related respiratory symptom experiences depending on the definition used (Table 6).

The common respiratory disease phenotypes included general asthma (n=39; 16%), atopic asthma (n=18; 7%), work-related asthma (n=15; 6%), work aggravated asthma (n=7; 3%), possible allergic alveolitis / grain fever (n=63; 25%) and possible chronic bronchitis (n=7; 3%) (Table 7).

Among the host factors, age, male gender, previous hospitalization for a lung disease and a family history of allergy, hay fever or asthma was strongly associated with the respiratory symptom outcomes (Table 10).

In the adjusted multivariate logistic regression models, hazardous chemical agents such as sodium hydroxide (OR, 2.27: 95%CI, 1.09-4.73) and kiesselguhr/silica (OR, 2.58: 95%CI, 1.22-5.46) were strongly associated with work-related upper airway symptoms. Workers in the high exposure group were 10 times as likely (OR, 10.45: 95%CI 3.08–35.45), compared to the lower exposure group, to have reported a chest problem caused by peak exposures to a large amount of dust, chemical, vapors, gases or fumes. Chemicals strongly associated with lower respiratory symptoms in general and excessive levels of either dust, chemical, gas, vapor or fume causing a chest problem included sodium hydroxide (OR, 2.79: 95%CI,1.48 - 5.28), carbon dioxide (OR, 3.92: 95%CI, 2.04 -7.56), ammonia (OR,3.69: 95%CI, 2.01 – 6.78). In addition, sodium hydroxide (OR, 7.28: 95%CI, 3.41-15.56), carbon dioxide (OR, 2.93: 95%CI, 1.53-5.62) and kiesselguhr/silica (OR, 2.40: 95%CI, 1.27- 4.53) were significantly associated with possible allergic alveolitis. Only sodium hydroxide demonstrated strong associations with possible, probable or confirmed asthma (Table 13).

Among the biological agents, grain dust (OR, 2.16: 95%CI, 1.08-4.33), hops (OR, 2.05: 95%CI, 1.07-3.93) and malt dust (OR, 2.16: 95%CI, 1.17-4.04) were strongly associated with possible allergic alveolitis/grain fever. Grain dust (OR, 13.28: 95%CI, 2.28-77.39), hops (OR, 7.21: 95%CI, 1.33-39.18) and malt dust (OR, 5.83: 95%CI, 1.08-31.55) were also significantly associated with possible chronic bronchitis (Table 14).

5.5.2.1 Conclusion and significance to clinical practice

Brewery workers exposed to high levels of dust, chemical, gas, vapour, fumes are at increased risk of developing work-related respiratory symptoms and developing work-related asthma, chronic bronchitis and possible allergic alveolitis/grain fever. The symptoms are associated with exposure to once off peak exposures of dust, chemical, gas, vapour or fumes. Both hazardous chemical agents (sodium hydroxide, carbon dioxide, ammonia and kiesselguhr/silica) and biological agents (malt dust, hops and other grain dust) are implicated.

The high prevalence of work-related respiratory symptoms associated with chemical and biological exposures in a brewery were identified. In addition, several host-related factors were also identified. This survey points to the need for appropriate preventative strategies to be undertaken in order to reduce exposures and more targeted respiratory medical surveillance of exposed workers. This, in the long term, will reduce the incidence of respiratory problems among brewery workers and ensure the protection and promotion of the respiratory health of employees in the workplace.

5.5.3 Present recommendations based on results obtained

Work-related factors can be responsible for up to 25% of adult asthma cases. It has been revealed that WRA is under-diagnosed, poorly diagnosed and managed and inadequately compensated in South Africa (Jeebhay 2010). It is recommended that WRA (OA + WRA), be considered in all adult patients with new onset or worsening asthma through the taking an appropriate history. Upon a confirmed positive diagnosis it is advised the patient be investigated to determine the presence of WRA. These tests should be performed prior to advising the patient to change his job (Jeebhay 2010).

5.5.3.1. Adequate history taking to assess the probability of respiratory problems

It is recommended that the probability of WRA and other respiratory problems should by assessed, based on adequate history taking (Jeebhay 2010). According to Nicholson, however, care should be taken that health practitioners avoid use of poorly discriminating factors, such as atopy, cigarette smoking or a family or personal history of asthma which may increase individual susceptibility to occupational asthma for some agents, as a reason to exclude individuals from employment (Nicholson et al.2010).

5.5.3.2. Confirm the diagnosis of asthma/respiratory problem

It is recommended that a diagnosis of occupational asthma be confirmed by objective criteria and not on the basis of a compatible history alone. Tests could include skin prick tests, specific IgE tests, spirometry. It has been recommended that arrangements be made for workers who are suspected to having occupational asthma to perform serial peak flow measures at least four times per day for at least 3 weeks (Tarlo et al. 2008).

5.5.3.3. Establish the work-relatedness of the asthma/respiratory problem

In relation to the above, in individuals who have asthma not caused by work but subsequently worsens while working, the diagnosis of WEA should be considered (Tarlo et al. 2008).

In individuals with suspected sensitizer-induced OA, in addition to carefully documenting the occupational history, additional objective tests could be performed when feasible (e.g. serial peak flow recordings, serial methacholine challenges, immunologic assessments, induced sputum testing, SICs to improve the diagnostic probability).

In individuals with suspected WRA who are currently working at the job in question, the recording of serial measurements of peak flow as part of the diagnostic evaluation is suggested. A minimum of four times daily, for at least two weeks at work and two weeks off work should be optimally recorded.

In individuals with suspected sensitizer-induced OA, working at the job in question, a methacholine challenge test could be performed or comparable measurements of nonspecific airway responsiveness be obtained during a working period. This could be repeated this during a period away from work exposure to identify work-related changes.

In individuals with suspected sensitizer-induced OA, perform immunological tests (skin prick testing or in vitro specific IgE assays) to identify sensitization to specific work allergens when these tests are technically reliable and available.

In individuals with suspected sensitizer-induced OA, conducting an SIC is suggested when the diagnosis or causative agent remains equivocal, performed only in specialized facilities, with medical supervision throughout the testing (Tarlo et al. 2008).

5.5.3.4 Avoid further exposure

The major determinant of risk for the development of occupational asthma is the level of exposure to its causes (Nicholson et al. 2010). In the light of the findings of this study it is recommended that preventive actions be aimed at avoiding exposure (Jeebhay 2010), reducing occupational exposures, especially peak exposures to chemical irritants and long term exposures to biological agents to reduce the incidence of work-related respiratory disease. This may be achieved by means of the substitution of an agent with a less toxic agent, ensuring adequate enclosure, efficiency and upkeep of the exhaust ventilation system, whether local or general, at various points, and maintaining work and housekeeping practicing (Bernstein et al.2006). Reducing airborne exposure by means of substituting the agent with a less harmful agent, engineering and hygiene measures, including the use of respiratory protection and worker education and training, can prevent acute and chronic respiratory symptoms (Henneberger 2007).

Industrial hygiene monitoring programs (for particulate dust, allergens and chemicals), with aim of the maintenance of respiratory health and safety of all employees, needs to ensure that the preventive measures are effective in reducing exposures. This would include an adequate personal and environmental monitoring program that accommodates peak exposures.

For all individuals with WRA, attempt better control of exposures. Remove patients with sensitizer-induced OA from further exposure to the causative agent in addition to providing optimal asthma management.

In individuals with irritant-induced or WEA, it has been advised that asthma treatment be optimized together with reduction in exposure to relevant workplace triggers.

For workers who are potentially exposed to sensitizers or uncontrolled levels of irritants, primary prevention through the control of exposures (eg. elimination, substitution, process modification, respirator use and engineering control) is to be prioritized (Tarlo et al. 2008).

5.5.3.5 Optimising asthma treatment

The treatment of occupational asthma is no different to the treatment of other types of asthma. It is recommended, however, that efforts be made to increase the use of inhaled corticosteroids early after diagnosis (Jeebhay 2010). General measures to be taken include the cessation of smoking, the avoidance of common aeroallergens to which the patients may also be sensitized, and to prevent further exposure to high concentrations of irritants (Jeebhay 2010).

5.5.3.6 Ensure ongoing follow-up and assessment of impairment and/or disability

Furthermore, it is recommended that a targeted respiratory medical surveillance program with the aim of identifying the common adverse respiratory outcomes observed in this study including allergic alveolitis and grain fever, work-related asthma (work-aggravated and occupational asthma) and chronic bronchitis, be provided. This should be done at least annually, and more frequently in the first years of exposure, as the likelihood of improvement or resolution of symptoms or of preventing deterioration is greater in workers who have relatively normal lung function, and shorter duration of exposure, at the time of diagnosis (Nicholson et al. 2010). Use should be made of standardised questionnaires, as well as objective tests such as immunological tests and lung function spirometry.

5.5.3.7 Assist with worker's compensation claim

According to Jeebhay (2010), about one-third of workers with OA are unemployed at 6 years after diagnosis and are known to suffer financially. It is recommended that impairment and disability evaluation is carried out as soon as asthma is stabilized and 2 years later. Importance is placed on the physician to support the affected workers in the application of workman's compensation claims, and the reporting of the occupational disease to the Department of Labour (Jeebhay 2010).

An individual diagnosis of OA represents a potential sentinel health event.

Evaluate the workforce to identify and prevent other cases of OA in the same setting.

In order to ensure protection of respiratory health of the workforce (Tarlo et al. 2008).

5.6. Recommendations for future research

Further studies are required to validate the usefulness of the ‘follow-up’ questionnaire for workers, to detect early affected workers.

Further studies are required in South African breweries using objective tests to confirm results.

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APPENDICES

Addendum 1: Ethical Approval

UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6626 • **Facsimile** [021] 406 6411
e-mail: lamees.emjedi@uct.ac.za

07 September 2010

HREC REF: 417/2010

Mrs G Irwin
C/o Prof D Khalil
Health & rehab
F Floor
OMB

Dear Mrs Irwin

PROJECT TITLE: A RESPIRATORY HEALTH SURVEY WITHIN A BREWERY IN SOUTH AFRICA

Thank you for submitting your new study to the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the FHS HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until 15 September 2011.

Please send us an annual progress report (website form FHS 016) if your research continues beyond the approval period. Alternatively, please send us a brief summary of your findings so that we can close the research file.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC. REF in all your correspondence.

Yours sincerely

pp **PROFESSOR M BLOCKMAN**
CHAIRPERSON, HSF HUMAN ETHICS

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Addendum 2: Memorandum of Understanding

Memorandum Of Understanding Between S.A. Breweries And Gail Irwin

Principal Investigator: Gail R. Irwin Student: University of Cape Town

Course: MSc (Nursing). Student No: HLMGAI001

Introduction and purpose of the study: The purpose of this survey is to determine the prevalence of respiratory problems, including asthma and allergy, as well as patterns and factors associated with these outcomes within the brewery setting, in order to identify groups of workers that may be potentially at risk of developing respiratory problems, with ultimate aim of further refinement of the medical surveillance and health care programme, if indicated, in order to achieve optimal health of employees.

Sample frame and size: A sample of at least 200 workers will be drawn from currently employed permanent fulltime brewery workers (n = 358). The study population will be classified into 3 exposure groups based on subjective levels of exposure to dusts, gasses, vapours and fumes in different departments, categorized into high, medium and low exposure groups. All subjects in the high exposure group, and a proportion of workers in the medium and low exposure groups will be included in the study.

Explanation and procedure: Those that meet certain criteria, including that of being employed at the brewery in a full time capacity will be invited to participate in this study. Participation is entirely voluntary, on an informed basis. Full participation will be encouraged to ensure a 100% response rate. This will take the form of an interviewer-administered questionnaire (which should take no longer than 15 minutes of the subjects time) linked to routine annual medicals, at work, during working hours. An appointment or private phone call will be made if necessary.

Ethical Approval: Ethics approval has been obtained from the Faculty of Health Sciences Human Research Ethics Committee, and adheres to the Declaration of Helsinki (Seoul version, 2008).

Rights and confidentiality: All information collected during the course of this study will be kept confidential to the extent permitted by law. Responses will not be linked to the participant personally and individual names will not be included in the analysis of the findings. The participant may refuse to answer any question. The participant may feel free to withdraw from the study at any time. Withdrawal from the study will not result in any negative consequences to the participant.

Risks and discomforts of the research: There are no risks from completing the questionnaire.

Compensation: There is not remuneration or compensation for participation in the study.

Expected benefits to the participant and others: What we hope to learn from this study is how many people suffer from chest problems. It is hoped this study will provide greater insight into the risk factors for respiratory

health problems among brewery workers and assist in the identification of appropriate preventative strategies that may be taken in order to reduce the incidence of these problems among brewery workers, with ultimate aim of the protection and promotion of the respiratory health of employees in the workplace. It is, however, emphasised that although the study will recommend changes, the study will not implement any changes, as the researcher cannot guarantee that management will act on any recommendations.

Costs: Tthe study is offered at no cost to the participant. In the event a problem is discovered and the participant wishes to be seen by a doctor for it, the principle investigator will recommend to the participant who to see should the participant not have a family doctor. However, it will be emphasized that the study cannot pay for these additional medical visits or treatments. Normal protocol of the brewery will apply, however, regarding the diagnosis, management and reporting of occupational disease.

Questions: If there are any further questions in relation to the research methods to be used in this study, Gail Irwin can be contacted at the following email address: gail.r.irwin@gmail.com

Consent to participate in the study: To voluntarily agree to take part in the study, the participant will be requested to sign a consent form. The participant will not be giving up any of his/her legal rights by signing this form. The signature will indicate that the participant has read, or had read to him/her, the entire consent form, including the risks and benefits, and had all questions answered. The participant will be given a copy of thereof.

Commitment of researcher to S.A. Breweries, Newlands: Gail Irwin acknowledges the commitment that all information collected will be held in the strictest of confidence, and only accessible to the research team. A report of findings will be presented to management. The findings will be reported in a thesis for degree examination purposes. S.A. Breweries recognise that, where appropriate, findings may be published in scientific literature in accordance with academic practice, but the company will have the right to see and comment on any manuscripts; and a period of 6 months will be allowed for the company to respond to any of the findings. Good faith will be expected from the researcher to ensure the findings are interpreted objectively and accurately and presented as such.

_____ _____

Signature of Researcher **Date**

_____ _____

Signature of S.A. Breweries **Date**

Addendum 3: Coding of Questionnaire

RESPIRATORY HEALTH SURVEY WITHIN A BREWERY IN SOUTH AFRICA

2010

CODING SYSTEM FOR THE QUESTIONNAIRE

For all questions;

1 Yes

2 No

3 Do not know

Code for interviewer:

1. gi: Gail Irwin

A. DEMOGRAPHICS

1. Code for 'what is your date of birth'? (dob):

1.1. Code for 'date of birth': year (dob_year)

1.2. Code for 'date of birth': month: (dob_month)

1.3. Code for 'date of birth': day: (dob_day)

2. Code for 'what is today's date'? (today):

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2.1. Code for 'today's date': year: (today_year)

2.2. Code for 'today's date: month: (today_month)

2.3. Code for 'today's date: day: (today_day)

3. Code for 'Are you male or females' (gender)

1. Male

0. Female

4. Code for 'Do you have a family history of allergy, hayfever or asthma?' : (fam_hist)

5. Code for smoking status:

5.1. Code for 'Are you a non-smoker (lifelong absence from smoking cigarettes)?' (non_smok)

5.2. Code for 'Are you an ex-smoker (ceasing of smoking more than a month before the survey)?' (ex_smok)

5.3. Code for 'Are you a current smoker? ' (curr_smok)

5.4. 1 Code for number 'cigarettes smoked currently' (no_cig_smok_curr)

1. 0 cigarettes
2. 1-10 cigarettes
3. 11-20 cigarettes
4. More than 20 cigarettes

5.4. 2 Code for number of 'cigarettes smoked in the past': (no_cig_smok_past)

1. 0 cigarettes
2. 1-10 cigarettes
3. 11-20 cigarettes
4. More than 20 cigarettes

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B. CHEST SYMPTOMS:

6.0. Code for 'Have you had wheezing or whistling in your chest at any time in the last 12 months?' (whz_whist_12mnths)

6.1. Code for 'Have you been at all breathless when the wheezing noise was present?' (b'less_whz)

6.2. Code for 'Have you had this wheezing or whistling when you did not have a cold?' (whz_whist_no_cold)

7. Code for ' Have you woken up with a feeling of tightness in chest at any time in last 12 months?' (woke_tightchest)

8. Code for 'Have you ever had an attack of shortness of breath at rest in last 12 months?' (sh'brth_rest)

9. Code for 'Have you ever had an attack of shortness of breath after exercise/exertion in last 12 months?' (sh'brth_exerc)

10. Code for 'Have you ever had an attack of shortness of breath at night or woken at night by an attack of shortness of breath in last 12 months?' (sh'brth_night)

11. Code for 'Did you have these chest symptoms before or after starting job' (chst_symp_bef_aft):

1. Before
2. After

12. Code for 'Were there changes in work processes in period preceding the onset of wheezing or shortness of breath?' (workproc_whz_sh'brth)

13. Code for 'Are these chest symptoms worse, better or no different when working in our current job?' (whz_sh'brth_cur_job):

1. Worse
2. Better
3. No different

14. Code for 'Do you have chest symptoms, such as wheezing, shortness breath that improve during extended times away from work, such as weekends or holidays?' (whz_sh'brth_away_work)

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15. Code for 'Did a Doctor ever tell you you had Asthma' (dr_tell_asthma)

15.1. Code for 'Have you had an attack of asthma in last 12 months?' (asthma_12mnths)

15.2. Code for 'Are you currently taking medicine for asthma?' (med_asthma)

15.2.1. Code for 'Have you had to increase your asthma medication while working in this job? (increase_med_job)

16. Code for 'Have you ever developed fever, chills, cough, difficulty in breathing a few hours after exposure to a product or after a certain work activity?' (fever_chills_aft_exp)

16.1. Code for 'Have you ever developed fever, chills, cough, difficulty in breathing a few hours after exposure to a product or after a certain work activity? Specify (fever_chills_aft_exp_specify)

17. Code for 'Do you cough on most days/nights for as much as three or more months in each of the last two years?' (cough_3mnths_2yrs)

18. Code for 'Have you ever had any nasal allergies including hay fever, runny nose, blocked nose or itchy, red, watery eyes in the last 12 months?' (nas_allergy_12mnths)

18.1. Code for 'Did you have any nasal allergies, including hay fever, runny nose, blocked nose or itchy, red, watery eyes in the last 12 months, that is worse with work? (nas_allergy_worsework)

0. No (Not worse)

1. Yes (Worse with work)

18.2. Code for 'Did you have any nasal allergies including hayfever, runny nose, blocked nose, or itchy watery red eyes, before or after starting at the brewery, or only with a cold? (nas_allergy_bef_after_cold):

0. Before starting at the brewery

1. After starting at the brewery

3. Only with a cold

19. Code for 'Do you have or ever had, TB of the lungs?' (tblungs)

20. Code for 'Do you or did you ever have a serious lung problem for which you needed to be hospitalized?' (lungproblem_hosp)

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20.1 Code for 'Do you or did you ever have a serious lung problem for which you needed to be hospitalized? Specify' (lungproblem_hosp_specify)

C. CURRENT WORK HISTORY:

21. Code for 'As a permanent employee, are you employed by the brewery or by a contracting firm at the brewery? (perm_brew_contr):

1. Permanently employed by the brewery

2 Permanently employed by a contracting firm.

22. Code for 'How long have you been working in this brewery?: (yrs_mnths_brewery):

23. Code for 'How long have you been working in your current job?: (yrs.mnths.currjob):

24. Code for 'In which areas/sections/departments are you currently working?

01. Are you currently working in utilities/Logistics? (util_log_dept_curr)

02. Are you currently working in brewing/brewing Engineering? (brew_dept_curr)

03. Are you currently working in packaging/packaging engineering? (pack_dept_curr)

04. Are you currently working in warehouse? (warehouse_dept_curr)

05. Are you currently working in the laboratory? (lab_dept_curr)

06. Are you currently working in admin/sales/distribution? (admin_sales_dist_dept_curr)

07. Are you currently working in any other department? (dept_other)

If 'yes', specify which department: (dept_other_specify)

25. Code for 'What is your job in this area/section?' (jobtitle1)

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26. Code for 'Give a short description of your job in this section' (jobdescribe1)

D. PAST WORK HISTORY

27. Code for 'Did you previously work in another department in the brewery?' (work_otherdept)

28. Code for 'In which department/s did you previously work?'

01. Did you previously work in utilities/Logistics? (util_log_dept_prev)

02. Did you previously work in brewing/brewing Engineering? (brew_dept_prev)

03. Did you previously work in packaging/packaging engineering? (pack_dept_prev)

04. Did you previously work in warehouse? (warehouse_dept_prev)

05. Did you previously work in the laboratory? (lab_dept_prev)

06. Did you previously work in admin/sales/distribution? (admin_sales_dist_dept_prev)

07. Did you previously work in any other department? (dept_other_prev)

If 'yes', specify which department: (dept_other_prev_specify)

29. Code for 'What was your job in this area/section?' (jobtitle2)

30. Code for 'Give a short description of your job in this section' (jobdescribe2)

E. EXPOSURE HISTORY

31. Code for 'Which dust products do you come in contact with, or work with, whilst working in this brewery?

31.1. Did you come in to contact with malt/malt dust?: (malt_dust)

31.2. Did you come in to contact with grain dust?: (grain_dust)

31.3. Did you come in to contact with hops?: (hops)

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31.4. Did you come into contact with Kieselguhr?: (kieselguhr)

Did you come into contact with silica?: (silica)

31.5. Did you come in to contact with other dust?: (other_dust)

Specify which 'other dust' you came in contact with (other_dust_specify)

32. Code for 'Do you or did you come in contact with, any chemicals such as chemical cleaning/disinfectants/sterilizing agents (e.g. caustic soda, sterilant, make-up fluid, solvents etc.?: (contact_chem)

If yes, specify which chemicals: (contact_chemicals_specify)

33. Code for 'do you/did you come in contact with, any gases, refrigerant/cooling gases, liquids?: (contact_gases)

If yes, specify which gases: (contact_gases_specify)

34. Code for 'Do you come in contact with vapours/fumes? (contact_vap_fumes)

If yes, specify which vapours or fumes: (contact_vap_fumes_specify)

35. Code for 'Has there been an instant when you inhaled a large amount of vapour, dust, gas or fumes in any of these jobs that resulted in you developing a tight chest, wheeze or cough, within the next 24 hours? (large_amnt_symptoms_24hrs)

If yes, specify which vapours, dusts, gases or fumes: (large_amnt_symptoms_24hrs_specify)

36. Code for 'Do you come in contact with other eg. moulds/mildew? (mould_mildew)

If yes, specify which, moulds or mildew? (mould_mildew_specify)

37. Code for 'Do you come in contact with birds, pests, insects (e.g. cockroaches)? (birds_pests_insects)

If yes, specify which birds, pests, insects (birds_pests_insects_specify)

38. Code for "Do you/did you use any personal protective equipment on a regular basis (almost every day) while doing your job? (ppe)

38.1. Code for 'Do you use safety glasses?': (sgl)

38.2. Code for 'Do you use safety goggles?': (sgg)

38.3. Code for 'Do you wear overalls or coveralls?': (cov)

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38.4. Code for 'Do you use mask(s) ?': (msk)

38.5. Code for 'Do you use a face shield?': (fs)

38.6. Code for 'Do you use a respirator?': (resp)

38.7. Code for 'Do you use any other form of personal protective equipment?': (other)

Specify which form of other personal protective equipment: (other_specify)

39. Code for 'Did you ever have to change your job because you had a chest problem? (chnge_chestprob):

INTERVIEW

40. Code for 'Type of interview':

40.1. Code for 'Was it a face to face interview'?' (face_interv)

40.2. Code for 'Was it a telephonic interview?' (tel_interv)

40.3. Who was the interviewer: 'gi: Gail Irwin?'

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Addendum 4a: ECRS Request

School of Health and Rehabilitation Sciences

Faculty of Health Sciences

Divisions of Communications Sciences and Disorders, Nursing and Midwifery, Occupational Therapy, Physiotherapy

F45 Old Main Building, Groote Schuur Hospital,
Observatory 7925
Tel: +27 (0) 21 406 6401 Fax: +27 (0) 21 406 6323
Internet: www.uct.ac.za

12 May, 2010

Dear Professor Peter Burney and Dr. Deborah Jarvis,

Re: **The European Community Respiratory Health Survey 11: Screening Questionnaire**

I am a Masters student at University of Cape Town, and currently wishing to conduct a study, for my thesis, on 'Work-related allergy and asthma and their associated risk factors, among brewery workers in the Western Cape, South Africa".

My Supervisor is Professor Doris Khalil, School of Health and Rehabilitation Sciences, University of Cape Town. My Co-Supervisor is Professor Mohamed Jeebhay, Centre for Occupational and Environmental Health Research, School of Public Health and Family Medicine, University of Cape Town.

I have found this tool very useful and request permission to replicate the tool for this small scale study. It would be my intention for each participant to answer a standard questionnaire, a modified version of the ECRHS 11 questionnaire, modified for local conditions, and specifically designed for the investigation of asthma and allergy, acute and chronic work-related and non work-related respiratory symptoms and conditions, environmental exposure, subjective categorization of exposure including host risk factors, use of personal protective equipment, past medical history, past work history, workers description of job in a specific work area, dietary factors and domestic activities.

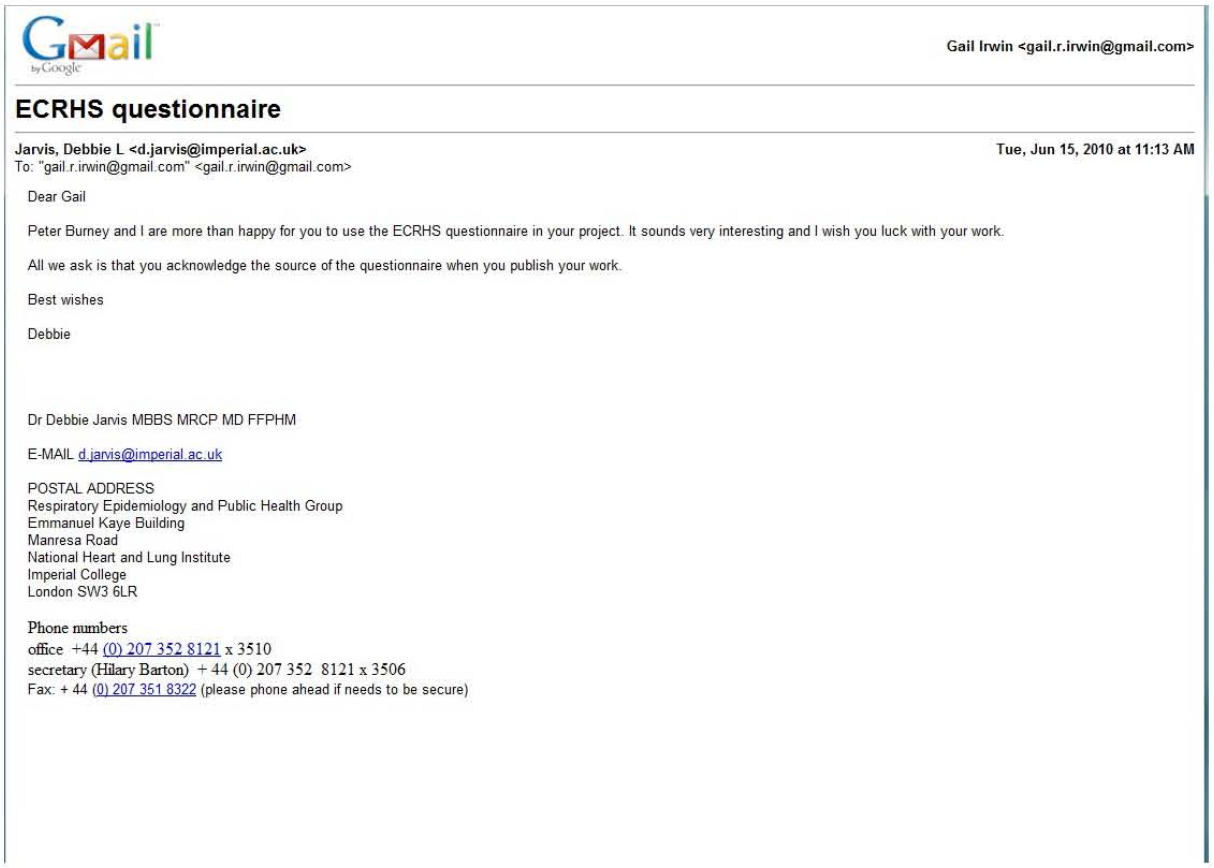
I will be very grateful if you could kindly acknowledge your willingness to permit the use of a modified version of the ECRHS 11 questionnaire, and any terms or conditions that may apply, in this regard.

Thanking you

Yours sincerely,

Gail Irwin
Student Number: HLMgai001
Email: gail.r.irwin@gmail.com

Addendum 4b: ECRS Approval



Gmail by Google

Gail Irwin <gail.r.irwin@gmail.com>

ECRHS questionnaire

Jarvis, Debbie L <d.jarvis@imperial.ac.uk> **Tue, Jun 15, 2010 at 11:13 AM**
To: "gail.r.irwin@gmail.com" <gail.r.irwin@gmail.com>

Dear Gail

Peter Burney and I are more than happy for you to use the ECRHS questionnaire in your project. It sounds very interesting and I wish you luck with your work.

All we ask is that you acknowledge the source of the questionnaire when you publish your work.

Best wishes

Debbie

Dr Debbie Jarvis MBBS MRCP MD FFPHM

E-MAIL d.jarvis@imperial.ac.uk

POSTAL ADDRESS
Respiratory Epidemiology and Public Health Group
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Phone numbers
office +44 (0) 207 352 8121 x 3510
secretary (Hilary Barton) + 44 (0) 207 352 8121 x 3506
Fax: + 44 (0) 207 351 8322 (please phone ahead if needs to be secure)

Addendum 5: English Consent Form

RESPIRATORY HEALTH SURVEY AMONG BREWERY WORKERS

ENGLISH CONSENT FORM

Title of research project

Respiratory health survey of brewery workers in a South African brewery.

Purpose of the research

The University of Cape Town (UCT) is conducting this study in order to determine the prevalence of chest problems among brewery workers. This study is going to be done by Sister Gail Irwin (Course: MSc Nursing) under the supervision of Prof. Doris Khalil, School of Health and Rehabilitation Sciences, UCT, and Prof Mohamed Jeebhay, Centre for Occupational and Environmental Health Research , UCT, who are both independent of the company. Due to the fact that you meet certain criteria, you have been selected to participate in this study. It is hoped that this study will provide greater insight into the risk factors for respiratory health problems among brewery workers and identify appropriate preventative strategies to be implemented in order to reduce the incidence of these problems among brewery workers.

Description of the research project

If you agree to participate you will be asked to complete a questionnaire, which will take approximately 10 minutes, during your working time. A member of our research team, Sister Gail Irwin, will interview you in privacy in order to complete the questionnaire. You will be asked questions about any breathing or chest problems, allergy and work history.

Rights and confidentiality of information collected:

Your name will not appear in any reports in this study. The records of the questionnaires will be kept completely confidential, and will be seen only be members of the study team.

Risks and discomforts of the research:

There are no risks from completing the questionnaire.

Expected benefits to you and to others

What we will learn from this study is how many people suffer from chest problems. We will also be able to identify groups of workers that may be potentially at risk of developing chest problems, which will be useful in further refinement of the medical surveillance and health care programme of this brewery, where appropriate, in order to protect and promote the health of all employees.

Costs to you resulting from participation in the study

The study is offered at no cost to you. In the event a problem is discovered and you wish to be seen by a doctor for it, we can recommend to you who to see should you not have a family doctor. However, the study cannot pay for these additional medical visits or treatments.

Contact persons:

You may contact one of the following persons for answers to further questions about the research, your rights, or any problem you may feel is related to the study.

University of Cape Town Researchers (Study team):

Prof. Doris Khalil, Telephone No: (021) 406-6164

Prof. Mohamed Jeebhay, Telephone No. (021) 406-6309

Sister Gail Irwin, Telephone No. (021) 658 7230 (email: gail.r.irwin@gmail.com)

PLEASE KEEP THIS INFORMATION SHEET WITH YOU FOR FUTURE REFERENCE

UNIVERSITY OF CAPE TOWN

OCCUPATONAL ALLERGY AND ASTHMA AND ASSOCIATED RISK FACTORS AMONG BREWERY WORKERS

ENGLISH CONSENT FORM

STUDY/SURVEY NO. _____

Consent of the participant

I have read the information given above, or it has been read to me. I understand the meaning of this information. Sister Gail Irwin has offered to answer any questions concerning the study.

By signing this form, I hereby consent to participate in the study. I also understand that I am free to withdraw from the study at any time without penalty or any negative consequences.

Documentation of the consent

One copy of this signed document will be kept together with our research records for this study. A copy of the information sheet about the study will be given to you to keep.

_____ _____

Printed name of participant **Signature, Mark, or Thumb Print**

_____ _____

Interviewer's name (Print) **Signature**

_____

Date

Addendum 6: Questionnaire

RESPIRATORY HEALTH SURVEY IN BREWERY WORKERS - 2010

Allocated number ☐☐☐ 1-3

A. DEMOGRAPHICS

1. What is your date of birth? YEAR ☐☐ MONTH ☐☐ DAY ☐☐ 04-09

2. What is today's date? YEAR ☐☐ MONTH ☐☐ DAY ☐☐ 10-15

3. Are you male or female? Male ☐ Female ☐ 16

4. Do you have a family history of allergy, hayfever or asthma? NO ☐ YES ☐ 17

5. What is your smoking status?

   5.1. Are you a non-smoker (lifelong abstinence from smoking cigarettes) NO ☐ YES ☐ 18

   5.2. Are you an ex-smoker (ceasing of smoking more than a month before the survey)? NO ☐ YES ☐ 19

   5.3. Are you a current smoker? NO ☐ YES ☐ 20

   5.4. How many cigarettes/ day do you smoke at present/ did you smoke in past?

   0 cigarettes? ☐ 21
   1-10 cigarettes? ☐ 22
   11-20 cigarettes? ☐ 23
   More than 20 cigarettes? ☐ 24

B. CHEST SYMPTOMS

6. Have you had wheezing or whistling in your chest at any time in the last 12 months? NO ☐ YES ☐ 25

   IF 'NO' GO TO QUESTION 7, IF 'YES':

   6.1. Have you been at all breathless when the wheezing noise was present? NO ☐ YES ☐ 26

   6.2. Have you had this wheezing or whistling when you did not have a cold? NO ☐ YES ☐ 27

7. Have you woken up with a feeling of tightness in your chest at any time in the last 12 months? NO ☐ YES ☐ 28

8. Have you ever had an attack of shortness of breath at rest in the last 12 months? NO ☐ YES ☐ 29

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9. Have you ever had an attack of shortness of breath after exercise/exertion in the last 12 months? NO ☐ YES ☐ 30

10. Have you ever had an attack of shortness of breath at night or woken at night by an attack of shortness of breath in the last 12 months? NO ☐ YES ☐ 31

IF 'NO' TO ABOVE QUESTIONS GO TO QUESTION 15, IF 'YES':

11. Did you have these chest symptoms before or after starting this job?

BEFORE ☐ AFTER ☐ 32

12. Were there changes in work processes in the period preceding the onset of symptoms of wheezing or shortness of breath? NO ☐ YES ☐ 33

13. Are these chest symptoms (wheezing; shortness of breath) worse, better or no different when working in your current job?

Worse? ☐ 34
Better? ☐ 35
No different? ☐ 36

14. Do you have chest symptoms, such as wheezing, shortness of breath that improve during extended times away from work, such as weekends or holidays? NO ☐ YES ☐ 37

15. Did a Doctor ever tell you that you have asthma? NO ☐ YES ☐ 38

If 'NO' GO TO QUESTION 16, IF 'YES:

15.1. Have you had an attack of asthma, in last 12 months? NO ☐ YES ☐ 39

15.2. Are you currently taking any medicine (including inhalers, aerosols or tablets) for asthma (self- or doctor-diagnosed asthma)? NO ☐ YES ☐ 40

IF 'NO' GO TO QUESTION 16, IF 'YES:

15.2.1. Have you had to increase your asthma medicine while working in this job? NO ☐ YES ☐ 41

16. Have you ever developed fever, chills, cough, difficulty in breathing a few hours after exposure to a product or after a certain work activity? NO ☐ YES ☐ 42

17. Do you cough on most days/nights for as much as three or more months in each of the last two years? NO ☐ YES ☐ 43

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18. Have you ever had any nasal allergies including hay fever, runny nose, blocked nose or itchy, watery, red eyes in the last 12 months? NO ☐ YES ☐ 44

IF 'NO' GO TO QUESTION 19, IF 'YES:

18.1. Did you have any nasal allergies including hay fever, runny nose, blocked nose or itchy, watery, red eyes in the last 12 months that is worse with work? NO ☐ YES ☐ 45

18.2. Did you have any nasal allergies including hayfever, runny nose, blocked nose, or itchy watery red eyes, before or after starting at the brewery, or only with a cold

Before starting at brewery? ☐ 46
After starting at brewery? ☐ 47
Only with a cold? ☐ 48

19. Do you have, or ever had TB of your lungs? NO ☐ YES ☐ 49

20. Do you or did you ever have a serious lung problem for which you needed to be hospitalised? NO ☐ YES ☐ 50

If yes, what was this condition? Specify _____

C. CURRENT WORK HISTORY

21. As a permanent employee, are you employed by the brewery or by a contracting firm at the brewery? Brew ☐ Cont ☐ 51

22. How long have you been working in this brewery? YEARS ☐☐ MONTHS ☐☐ 52-55

23. How long have you been working in your current job? YEARS ☐☐ MONTHS ☐☐ 56-59

24. In which areas/sections/departments are you currently working?

24.1. Utilities/Logistics? NO ☐ YES ☐ 60

24.2. Brewing/Brewing Engineering? NO ☐ YES ☐ 61

24.3. Packaging/Packaging Engineering? NO ☐ YES ☐ 62

24.4. Warehouse? NO ☐ YES ☐ 63

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24.5. Laboratory? NO ☐ YES ☐ 64

24.6. Administration/Sales/Distribution? NO ☐ YES ☐ 65

24.7. Other? NO ☐ YES ☐ 66

Specify _____

25. What is your job in this area/section?

_____

26. Give a short description of your job in this section.

_____

D. PAST WORK HISTORY

27. Did you previously work in another department in this brewery? NO ☐ YES ☐ 67

IF 'NO' GO TO QUESTION 31, IF 'YES':

28. In which department/s did you previously work?

28.1. Utilities/Logistics? NO ☐ YES ☐ 68

28.2. Brewing/Brewing Engineering? NO ☐ YES ☐ 69

28.3. Packaging/Packaging Engineering? NO ☐ YES ☐ 70

28.4. Warehouse? NO ☐ YES ☐ 71

28.5. Laboratory? NO ☐ YES ☐ 72

28.6. Administration/Sales/Distribution? NO ☐ YES ☐ 73

28.7. Other? NO ☐ YES ☐ 74

Specify _____

29. What was your job in this area/section?

_____

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30. Give a short description of your job in this section.

_____

E. EXPOSURE HISTORY

31. Which of the following dust products do you/did you come in contact with, or work with whilst working in this brewery?

	NO	YES	
31.1. Malt/malt dust?	☐	☐	75
31.2. Grain dust?	☐	☐	76
31.3. Hops?	☐	☐	77
31.4. Kieselguhr/Silica?	☐	☐	78
31.5. Other dust(e.g. lucilite, activated carbon, calcium sulphate dust, calcium chloride dust.	☐	☐	79

Specify: _____

32. Do you /Did you come in contact with any chemical cleaning/ disinfectants / sterilising agents (e.g caustic soda, sterilant, make-up fluid, solvents etc.? NO ☐ YES ☐ 80

Specify: _____

33. Do you/Did you come in contact with any gases (e.g N, CO, CO2); Use any refrigerant, or cooling gases, liquids (eg. Ammonia) NO ☐ YES ☐ 81

Specify _____

34. Do you come in contact with vapours/fumes? NO ☐ YES ☐ 82

Specify _____

35. Has there been an instant when you inhaled a large amount of vapour, dust, gas or fumes in any of these jobs that resulted in you developing a tight chest, wheeze or cough, within the next 24 hours? NO ☐ YES ☐ 83

Specify _____

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36. Do you come in contact with other: e.g moulds/mildew, NO ☐ YES ☐ 84

Specify _____

37. Do you come in contact birds, pests, insects (e.g. cockroaches) NO ☐ YES ☐ 85

Specify _____

38. Do you/did you use any personal protective equipment on a regular basis (almost every day) while doing your job? NO ☐ YES ☐ 86

IF 'NO' GO TO QUESTION 39, IF 'YES':

38.1 Which of the following protective equipment do you/did you use on a regular basis, meaning wearing of protective equipment on a daily basis?

38.1.1 Safety glasses? NO ☐ YES ☐ 87

38.1.2 Safety goggles? NO ☐ YES ☐ 88

38.1.3 Coverall/overall? NO ☐ YES ☐ 89

38.1.4 Mask? NO ☐ YES ☐ 90

38.1.5 Face shield? NO ☐ YES ☐ 91

38.1.6 Respirator? NO ☐ YES ☐ 92

38.1.7 Other? NO ☐ YES ☐ 93

Specify _____

39. Did you ever have to change your job because you had a chest problem? NO ☐ YES ☐ 94

Specify _____

40. Type of interview:

40.1. Face to face interview? NO ☐ YES ☐ 95

40.2. Telephone Interview? NO ☐ YES ☐ 96

THANKS FOR YOUR HELP IN THE COMPLETION OF THIS QUESTIONAIRE.

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Addendum 7: Job Descriptions

MASTER COPY-CODING: JOB DESCRIPTIONS

DEPARTMENT	CODE NO.	JOB TITLE	JOB DESCRIPTION
LOGISTICS			
Logistics	1	Raw Materials Operator/driver	Receives, weighs, packages, issues, raw materials to Operations, ensuring quality control. Operates train on plant
Logistics	2	Raw Materials Controller	Procures raw materials
Logistics	3	Raw Materials Supervisor, Manager	Supervises, schedules and monitors daily processes
BREWING			
Brewing	4	Attendant greaser	Greases gearboxes of machines in the mills
Brewing	5	Operator	Operation, control and monitoring of the brewing process, including tank cleaning, connecting CIP, quality checks, analysing samples, yeast propogation and filtration management.
Brewing	6	Artisan (Brewing/Process/Control Artisan)	Fitter and turner, Instrument technician, maintaining all machinery. Involves instrumentation, operation, sampling, analysis.
Brewing	7	Engineering Controller Maintenance	Supervises Engineering Maintenance teams, maintains machinery and equipment, and assists in breakdowns
Brewing	8	Manager/Team Leader Brewing	Supervises and manages plant and processes of the particular department and/or shift production if supervisor.
Brewing	9	Machine Specialist	Maintains machines and equipment in Brewhouse and silo area
Brewing	10	Manufacturing Development Consultant	Liaises with brewing technicians in the analysis and running of plant processes
Brewing	11	World Class Manufacturing Facilitator Brewing	Conscious of world class manufacturing on-line. Develops training material, trains, assesses, manages policy on-line.
	12	Unit Manager/Team Leader Packaging	Supervises and manages plant and processes of the particular department and/or shift production if supervisor.
PACKAGING			
Packaging	13	World Class Manufacturing Facilitator Packaging	Conscious of world class manufacturing on-line. Develops training material, trains, assesses, manages policy on-line.
Packaging	14	Operator Packaging	Operates and inspects machinery on-line in order to keep lines running smoothly. Cleans the line, connects tanks, performs autonomous maintenance (quick fixes and lubrication of machines), cip and quality checks. May involve overseeing, supervision, training and/or coaching.
Packaging	15	Artisan Packaging	All electrical work: Oversees automations, machine performance and production and attends to breakdowns. Involves planning work, preventative maintenance, fault-finding and small installations. Various levels include those specialized and supervisory.
Packaging	16	Controller Packaging	Plans all maintenance on-line including shutdowns and assett care, maintaining all key Packaging machines. Various levels.
Packaging	17	Attendant Packaging	Relieves workers in all areas of Packaging, operates machines and assists fitters
WAREHOUSE			
Warehouse	18	Shift Controller Warehouse	Supervises,manages and controls shifts and stock in the receipt and despatch of stock
Warehouse	19	Warehouseman	Checks and despatches trucks
Warehouse	20	Stock Administrator Warehouse	Balances and controls stock in the issue and despatch of trucks
Warehouse	21	Forklift Driver	Drives a forklift, offloading, loading and packing of stock. Includes autonomous maintenance of fork lift.
Warehouse	22	Scrubber Driver	Operates the scrubber that cleans the Warehouse and Packaging floors
LABORATORY/QESH			
Laboratory	23	Laboratory Manager	Supervises the analysis and quality assurance of the product throughout the process
Laboratory	24	Trade Quality and Systems Support Manager	Deals with customers, depots and consumers and quality issues, including complaints
Laboratory	25	Quality Control Specialist	Administrates training of laboratory technicians including analysis and calibration of equipment
Laboratory; QESH	26	Laboratory Technician	Takes samples, analyses samples and ensures quality of the product throughout the process, and calibrates equipment
QESH	27	QESH Officer	Ensures safety in the plant
QESH	28	QESH Specialist: Micro	Implements systems for micro-laboratory, managing workloads
QESH	29	QESH Administrator-Specialist	Administers and managers systems to ensure operational safety
All Departments	30	Taste Technician	Tastes be[illegible]

ADMINISTRATION

ADMINISTRATION SAB

Engineering Stores	31	Stores Administrator	Receives, issues and counts stock
Financial Accounting General	32	Financial Planner	Sets, monitors and reports financial budgets
Financial Accounting General	33	Data Capture Clerk	Captures technical information into SAP
Financial Accounting General	34	Procurement Officer (Buyer)	Procures spares for production
Financial Accounting General	35	Management Accountant	Draws up and audits sets of financial accounts
Financial Accounting General	36	Payroll Benefits Clerk	Administers payroll and benefits
Financial Accounting General	37	Finance Administrator	Administers finances
Health and Safety	38	Site Services Supervisor	Supervises maintenance of housekeeping and site services
Human Resources General	39	Human Resources Co-ordinator	Offers support to Human Resources team
Human Resources General	40	Human Resource Specialist	Human Resource management: Consults and advises line managers on human resource practices
Logistics	41	Production Planner	Plans production
Manufacturing Systems General	42	Regional Services Delivery Manager	Offers Information Technology support
Manufacturing Systems General	43	Manufacturing Developer Analyst: Software	Information Technology services analyst
Manufacturing Systems General	44	Process Control Engineer/technician	Controls automation of the brewery
Manufacturing Systems General	45	Technical Trainee	Manages relationships with customers and create sales for company
Operations	46	Operations Manager	Management of Logistics and Supply chain functions
Packaging	47	Learning and Development Specialist	Manages learning and development in Packaging Department
Trade Brewing	48	Telephonist	Attends to visitors, switchboard, courier services
Trade Brewing	49	Tour guide, telephonist	Guides tours and attends to visitors, switchboard and courier service
Trade Brewing	50	Trade Brewer	Promotes beer culture
Various departments	51	Secretary	Administration and secretarial duties

ADMINISTRATION S&D

Finance	52	Financial Secretary	Administrative and secretarial duties
Finance	53	Financial Administrator	Administers finance
Finance	54	Financial Accountant	Manages financial accounts and verifies assetts quarterly at 7 depots
Finance	55	Financial Planner	Administers and manages cost centres, audits, and provides support to line managers
Finance	56	Administration attendant: Driver	Receipt and delivery of goods between depots
Corporate Affairs	57	Corporate Affairs Administrator	Administers corporate social investment programmes
Corporate Affairs	58	Corporate Affairs Specialist: Attorney	Administers all liquor licensing related matters:
Corporate Affairs	59	Corporate Project Manager	Project supervision and engagement
Operation Services	60	Direct Ship Controller	Control of Distribution: Managing trucks in Warehouse
Operation Services	61	Project Manager	Analyzes data
Operation Services	62	Operations Services Manager	Develops strategies for Cape Region
Operation Services	63	Operations Services Administrator	Administration, procurement, extracting reports, personal assistant

Trade Marketing	64	Experiential Events Co-ordinator	Organises brand events at certain venues, with sales personnel
Trade Marketing	65	Sales and Market Analyst	Develops and reports analyses of internal sales and external market measures

Sales Development	66	Project Co-Ordinator	Supports executive and sales force

Human Resources	67	Learning and Development Specialist	Human Resources development
Human Resources	68	Human Resources Specialist	Administers human resource services

Addendum 8: Operational Definitions of Respiratory Symptoms

1. OPERATIONAL DEFINITION OF RESPIRATORY SYMPTOMS

Respiratory Symptom	Definition
Demographics/History:	
2. Male	Answer 'male' to "Are you a male or female?"
3. Female	Answer 'female' to "Are you a male or female?"
4. Family history	Positive answer to: Do you have a family history (Immediate blood relatives) of allergy, hayfever, asthma?
5.1. Non-smoker	Positive answer (lifelong abstinence form smoking cigarettes) to question 5.1: Are you a non-smoker?
5.2. Ex-smoker	Positive answer (Ceasing of smoking for more than a month before survey) to question 5.2: Are you an ex-smoker?
5.3. Current smoker	Positive answer (Smoking cigarette/s within the past month of survey) to question 5.3: Are you a current smoker?
19. TB of lungs	Positive answer to question 19: Do you have, or ever had TB (Tuberculosis) of lungs?
20. Hospitalized for serious lung problem	Positive answer to question 20: Do you, or did you ever have a serious lung problem for which you needed to be hospitalized?
Respiratory symptoms:	
Wheeze: Querie phenotype of asthma: 6. Wheeze or whistling in chest: 6.1 Wheeze or whistling in chest and breathlessness: 6.2. Wheeze or whistling in chest when you did not have a cold?:	 Positive answer to question 6: Have you had wheezing or whistling in your chest at any time in the last 12 months? Positive answers to questions 6 and 6.1 : Have you been at all breathless when the wheezing noise was present? Positive answers to questions 6 and 6.2: Have you had this wheezing or whistling when you did not have a cold?
Possible Asthma: 8. Attack of shortness of breath: 15.0: Doctor tell asthma:	 Positive answer to: Have you had an attack of shortness of breath at rest in the last 12 months? Positive answer to: Did a Doctor ever tell you that you had asthma?

15.1. Attack of asthma: 15.2. Use of asthma medication:	Have you had an attack of asthma in the last 12 months (This leads on from Dr-diagnosed asthma) Are you currently taking any medication for asthma? (This leads on from Dr-diagnosed asthma)
Continuous asthma score: 1. Wheeze and breathlessness 2. Feeling of tight chest 3. Attack of shortness of breath at rest 4. Attack of shortness of breath after exercise 5. Woken by attack of shortness of breath 6. Ever asthma? (Only can be yes to question 15: 7. Attack of asthma 8. Medication for asthma	 (Yes to question 6.0 and 6.1) (Yes to question 7) (Yes to question 8) (Yes to question 9) (Yes to question 10) (Yes to question 15: 'Did a Doctor ever tell you had Asthma ?') (Yes to question 15.1: Have you had an attack of Asthma in the last 12 months?) (Yes to question 15.2: Are you currently taking any medicine for asthma?)
Possible Occupational asthma 11. Chest symptoms after starting this job: 12. Changes in work processes preceding onset of symptoms 13. Chest symptoms worse when working in current job	 Positive answer to question 11: "after" Did you have chest symptoms before or after you started this job; Positive answer to question 12: Were there changes in work processes preceding onset of symptoms of wheezing, shortness of breath, tight chest? Answer "worse" to question 13: Are these chest symptoms worse, better or no different when working in current job? Symptoms better? Symptoms no different?

14. Chest symptoms that improve during extended times away from work? 15.2.1 Increase in medicine while working in the job	Answer yes to question 14: Do your chest symptoms improve during extended times away from work, such as weekends or holidays? Positive answer to question 15.2.1: Have you had to increase your asthma medicine while working in this job?
Possible work-exacerbated chest symptoms 11. Chest symptoms before starting this job: 12. Changes in work processes preceding onset of symptoms 13. Chest symptoms worse when working in current job 15.2.1 Increase in medicine while working in the job	 Positive answer to question 11: "before" Did you have chest symptoms before or after you started this job; Positive answer to question 12: Were there changes in work processes preceding onset of symptoms of wheezing, shortness of breath, tight chest? Answer "worse" to question 13: Are these chest symptoms worse, better or no different when working in current job? Positive answer to question 15.2.1: Have you had to increase your asthma medicine while working in this job?
Possible Extrinsic Allergic Alveolitus 16. Development of fever, chills, difficulty in breathing	 Positive answer to question 16: Have you ever developed fever, chills, cough, difficulty in breathing a few hours after exposure to a product or after a certain work activity?
Possible Chronic Bronchitis 17. Coughing on most days nights for three, more months in each of last 2 years	 Positive answer to question 17: Do you cough most days/nights for as much as three or more months in each of the last two years?

Possible rhino-conjunctivitis 18. Nasal allergies including hay fever, runny nose, blocked nose or itchy, red eyes in the last 12 months?	Positive answer to question18: Have you ever had any nasal allergies including hayfever, runny nose, blocked nose or itchy, watery, red eyes in the last 12 months?
Possible work-related Rhino-conjunctivitis 18.1. Development of Nasal allergies last 12 months that is worse with work 18.2. Nasal symptoms after starting this job (starting at brewery)	Positive answer to question 18.1: Did you have any nasal allergies including hay fever, runny nose, blocked nose, itchy, red, watery eyes in the last 12 months that is worse with work? Answer "after" starting at the brewery to question 18.2: Did you have nasal allergies including hayfever, runny nose or blocked nose or itchy, watery, red eyes, before or after starting this job (starting at the brewery)?
21. Permanent employee	Positive answer to question 23: The fact that the employee works on a full time, permanent basis for the brewery, and not for a contracting firm.

Addendum 9: Self-Reported Exposure to Particulate Dust

Dust source specification	dust_code	n
Air hoses/blowers: Dust generated by blowers, air hoses	1	6
Boiler/soot dust: Chimney soot; Smoke when boiler starts up	2	2
Dust from crates, cases, trays, machines, and/or generated by processes	3	36
Diesel dust: Back end, from hysters, trucks, scrubber, from ground, from smoke, from tyres; Black dust	5	38
Dried yeast dust	6	2
Energy-saving dust: Dust created due to energy-saving: Ventilation/blowers switched off	7	1
Glass dust: Bottle washer, EBI (empty bottle inspection), glass crusher; depallitiser, glass under machines, re-cycle	8	5
Label dust: Fibres/paper dust from labels	9	2
Laboratory analysis dust: Media that is made up to do analysis	10	1
Lucilite	11	20
Metal dust: Drilling, grinding of various materials	13	2
Plastic dust: Plastic dust when cutting plastic; plastic dust from intake bottles that go into filler	17	2
PVPP; Polychlor (Additives in beer processing)	18	2
Rail dust: Black soot	19	1
Recycling depot dust: Where contractors sit: Where all dirt, food, filtering close to where work: Dusty and odour	21	1
Sawdust	22	1
Activated Carbon	24	28
Calcium Sulphate and Calcium Chloride Dust	25	33
Sulphur/Sulphur Dioxide	26	3
Malt/malt dust	27	12
Grain dust	28	9
Hops	29	11
Kieselguhr	30	10
Silica	31	8

Addendum 10: Self-Reported Exposure to Hazardous Chemical Agents

Number	CHEMICALS SPECIFIED	chem_code
123	Caustic	3
108	Carbon Dioxide	1
100	Ammonia	2
55	Sterilant (Hydrogen Peroxide Acqueous Solution)	4
48	Carbon Monoxide	5
30	Welding, soldering and cutting	6
25	Make-up fluid	7
23	Chlorine Dioxide	8
20	Lactic Acid	9
17	Sulphurs (Sulphur; Sulphuric Acid; Sulphur Dioxide)	10
15	Solvents	11
15	Various chemicals: General	12
13	Various chemicals: Laboratory/QESH	13
10	Nitrogen	14
9	Diesel	15
6	Glue chemicals: Casin-based, milk-based or Gemkem	16
5	Soap, soap powder, liquid soap for cleaning the machines;	17
5	Hydrox (Hydrogen Peroxide based)	18
5	Methanol	19
5	Nitric Acid	20
5	Various chemicals used by cleaners	21
4	Chemical cleaner used for cleaning floors and used by scrubber	22
4	Hydrogen peroxide	23
4	Synthetic Air	24
3	HCL	25
3	Methylated spirits	26
3	Tapoxi-reactive;	27
3	Hydrogen	28
3	Hydrogen	29
3	Liqueous Petroleum Gas	30
2	Acid AC 30	31
2	Battery gas and acid	32
2	Detergent (EP3)	33
2	Ethanol	34
2	Sodium chloride	35
2	Xonia	36
2	Printing machine fumes	37
1	Acid AC 10	38
1	AC101 (Caustic-based)	39
1	Acetone	40
1	Aceto-Nitrile	41

1	Acetic Acid	42
1	Alcohol	43
1	Beroxole	44
1	Biosperse	45
1	Brewbite	46
1	Brew Plus	47
1	Calcium sulphate	48
1	Carbol	49
1	Degreaser liquid	50
1	Enviro-serve	51
1	Fedta	52
1	HD2 lubricating grease and oil and soap for washing belts	53
1	Hydrolic oil	54
1	Iodine	55
1	Iso-octane	56
1	Media	58
1	Phostoxin: Bag of Phostoxin in malt container	59
1	PWC:	60
1	Sodium sulphide	61
1	Various chemicals: Packaging	62
1	Various chemicals: Brewing	63
1	Topactive DES etc;	64
1	Battery Acid	65
1	Paint fumes	66
1	Running Reds	67
0	Isa solution	68

Addendum 11: Self-Reported Exposure to Gases, Vapours and Fumes

Coding:	**Self-Reported Exposure to Gases, Vapours, fumes**

Ammonia plus Hydrox (no. 12)
Battery Acid fumes
Carbon dioxide
Carbon monoxide
Caustic
Chemical cleaning agents
Chlorine dioxide
Diesel/fuel
Glue
Hydrochloric acid
Hydrogen
Hydrox
Lactic Acid
Liquid petroleum gas
Make-up fluid
Methane gas
Methanol
Nitric Acid
Nitrogen
Paint fumes
Phostoxin
Printing machine fumes
Running reds
Sulphur (Sulphur/Sulphuric Acid/Sulphur dioxide)
Synthetic air
Welding, soldering, cutting
Various and including/excluding lab chemicals