PROTECTED AT WORK BUT NOT AT HOME: PARA-OCCUPATIONAL 'TAKE-HOME' HERBICIDE RESIDUE EXPOSURE RISKS AMONGST FORESTRY WORKERS FAMILIES IN SOUTH AFRICA

Mini-Dissertation

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Plagiarism Declaration

I, Bonolo Pududu (PDDBON001), hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and neither the whole work nor any part of it has been, is being or is to be submitted for another degree in this or any other university.

Signature: Signed by candidate

Date: February 2018

Part 0: Preamble

DEDICATION

This thesis is dedicated to my late friend Nombulelo Mkhize. We should be celebrating this victory together, praising God for how far He has brought us, but nothing is without purpose. Thank you for all the prayers that have seen me through.

ABSTRACT

Para-occupational 'take-home' exposure amongst worker's families in Low-and middle-income countries (LMICs) is not well characterised. This is concerning as research shows the association between long-term low-dose herbicide exposure and the development of adverse health effects. This study explored 'take-home' herbicide residue exposure risks amongst the families of Working for Water (WfW) forestry workers in the Western Cape, South Africa using aspects of the community-based participatory research (CBPR) approach *photovoice*. In addition, a documentary review of the existing WfW programme policies and regulations was undertaken to assess whether required practices supported or prevented the risk of 'taking-home' herbicide residues. The results of the documentary review revealed that workplace policies and regulations did not address 'take-home' exposure risks. *Photovoice* findings highlighted low compliance to safety practices (e.g., not adhering to PPE requirements) at worksites, and this was identified as the main risk factor for 'take-home' exposure amongst worker's families. It was noted that the transient nature of forestry work impacted on worker's ability to carry out hygiene practices as decontamination facilities were not available at worksites for worker's to use before going home. As a result, all workers took their personal protective equipment (PPE) home. Worker's after work behaviours (e.g., wearing PPE inside the home) and home hygiene practices (e.g., laundering PPE separately from household laundry) varied. That is, some worker's carried out protective practices whilst others did not. This was largely attributed to the workplace policies and regulations which did not cover 'take-home' exposure risks as informed by the national legislation which has not established standards and regulations related to 'take-home' exposure risks. Evidence from this study demonstrated the existence of workers' 'taking-home' herbicide residue and exposing their families to potential health risks from low-dose exposures.

This thesis is structured into the following four parts:

Part A – This section of the mini-dissertation presents the research protocol. The background and problem statement on para-occupational 'take-home' exposure risks are described. An outline of the research scope, including research questions, objectives and methods are provided.

Part B – This section, the literature review, provides a summary and critique of the reviewed literature on 'take-home' residue exposure risks amongst workers families in both High-income countries, and Low-and middle-income countries. This review assisted in characterising the problem of 'take-home' exposure risks and in exploring strategies to address these risks.

Part C – This section presents the main findings of the study and recommendations in the format of a journal article.

Part D – This section comprises the appendices, such as the ethical approval for the study and the informed consent forms for study participants.

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Blessed be the Lord my Rock, who trains my hands for war and my fingers for battle. The God of Abraham, Isaac, Jacob and my God, indeed even from everlasting to everlasting You are God, thank You for leading me to this path.

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To my family: my dad for supporting me in starting this journey and the fulfilment of a dream to serve; my mom for all her relentless prayers, encouragement and strengthening my faith to know that with God nothing is impossible; my brother and sister-in-law for the 'gentle and silent' reminders to finish what I started; my little sister for giving me the final push to complete this journey and my fiancé Bonke Mncwango for all his unfailing prayers, support and soldiering – as tough and painful as it was at times, I remain indebted.

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Part A: Research Protocol

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1. Introduction

Pesticides are chemical substances that are intended to prevent, destroy, repel or mitigate pests such as microorganisms, weeds or animals (U.S. EPA, 2016). They are often classified according to the species that they target, namely; insecticides, herbicides, fungicides and rodenticides (MacFarlane et al., 2013). Herbicides particularly, are a type of pesticide used to eradicate and manage invasive alien plant species. Although registered for extensive use in the removal of alien plant species, exposure to herbicides has been associated with human health risks. These include; birth defects, cancers, upper and lower respiratory illnesses and neurodegenerative diseases amongst others (Chamier et al., 2012; London et al., 2012; Ntzani et al., 2013). This represents a significant public health problem, particularly in Low-and middle-income countries (LMICs) where the actual incidence of occupational and non-occupational poisoning is unknown (Blair et al., 2015; Thundiyil et al., 2008). In relation to occupational exposure, evidence shows that workers routinely engaged in the preparation and application of pesticide mixtures are amongst those at higher risk of exposure (Damalas and Eleftherohorinos, 2011). The most common routes of occupational exposure identified are absorption through the skin, inhalation and ingestion (Aktar et al., 2009; Andrade-Rivas and Rother, 2015; McCauley et al., 2006). Non-occupational exposure occurs through indirect exposure to pesticide residues, for example, when workers unintentionally carry residues on their skin, hair and clothing from work to home, thus exposing their immediate family members to workplace residues (Thompson et al., 2003). Pesticide exposure risks in LMICs have been linked to weak legislative and policy frameworks that regulate pesticide use, poor surveillance and monitoring systems, inadequate training, limited access to information and education, as well as minimal use of personal protective equipment (PPE) (Andrade-Rivas and Rother, 2015; Ecobichon, 2001; London et al., 2001). Furthermore, the existing chemical legislation does not explicitly address potential para-occupational residue exposure risks. This in turn is not translated into workplace policies and

interventions designed to reduce exposures to contaminants. In this research, South African Working for Water forestry workers' practices related to the care and maintenance of PPE will be assessed as a potential source of herbicide exposure to their families. The Working for Water programme principally uses herbicides for the removal of invasive alien plant species.

2. Background

2.1 Impact of herbicide exposure on human health

Concerns have been raised in relation to health risks that result from exposure to pesticide residues. It has been shown that a significant amount of pesticide residues reach other destinations such as, air, water and food, other than their intended target (Blair et al., 2015). Thus, with the increasing use of herbicides and growing evidence of their association with adverse health outcomes, there is a need to appropriately assess the overall risks (Nweke and Sanders, 2009; United Nations Environment Programme, 2013). Assessing actual herbicide exposure risks is complicated and involves multiple factors. Most pesticides are formulated with active ingredients that have been associated with known or suspected adverse health outcomes (Ntanzi et al., 2013). Five of the major groupings of herbicides – that is: chlorophenoxies, dypyridines (paraquat), glyphosate, pentachlorophenols and hexachlorobenzenes – have been associated with a wide range of cancers, neurodegenerative diseases and neurodevelopmental effects, insulin resistance, reproductive and developmental toxicity, endocrine disruptions and respiratory effects among others (Chamier et al., 2012; Hernández et al., 2013; London et al., 2012; Ntanzi et al., 2013). It has been documented that the type and severity of the health outcome is determined by the herbicide grouping, duration of exposure and route (Blair et al., 2015). Due to the challenge of accurately assessing the time of exposure, however, the evidence is less clear in terms of the chronic effects of exposure as exposure may occur before actual symptoms or disease develop (Blair et al., 2015). Furthermore, accurate measurement of

exposure is further hindered by differences in the levels of exposure, toxicity and formulation of the herbicides used (Defarge et al., 2016). The risks associated with long-term low-dose exposure to residues both for workers and their families are particularly of concern.

Most of the evidence that demonstrates an association between pesticide exposure and adverse health outcomes emanates from studies conducted in High-income countries (HICs). This has resulted in the restricted use of a number of pesticides (e.g., glyphosphate) in these countries (London and Rother, 2001; Ntanzi et al., 2013). In most LMICs, particularly South Africa, however, there continues to be widespread use of these herbicides (London and Rother, 2001). Furthermore, the enforcement of regulations that control the use of herbicides in LMICs tends to be less stringent in comparison to HICs (Ecobichon, 2001; London and Rother, 2001; London et al., 2002). This results in a substantial number of people being exposed to residues including workers families, increasing the risk of adverse chronic health effects (London and Rother, 2001). In addition to weak regulation, Sharma et al. (2012) suggest that the adverse effects of pesticides on the health of individuals in LMICs is also due to low hazard awareness of users, lack of proper caution when applying and spraying herbicides and inadequate use of PPE.

2.2 Determinants of herbicide exposure

Various factors lead to acute and chronic exposures to herbicides through inhalation, contact with the skin, occupational and non-occupational routes (Blair et al., 2015; Curl et al., 2002; Curwin et al., 2006). For example, liquids are more likely to splash and spill which may result in contact with the skin through contaminated PPE, increasing worker risk. Secondly, the type of packaging that herbicide mixtures are contained in may expose workers to residues when opening the packaging. Thirdly, the frequency and duration of handling and applying herbicide mixtures may also increase worker risk (Damalas and Eleftherohorinos, 2011). Specifically, a

study by Blair et al. (2015) found that workers who were responsible for mixing, loading, transporting and applying pesticides were at higher risk of exposure and acute poisoning. Fourthly, the overall hygiene practices of workers when mixing, loading, handling and applying herbicide mixtures may increase worker risk. Workers who follow precautionary measures such as the proper use and maintenance of PPE, washing of hands after handling herbicide mixtures, changing work clothes immediately after work, taking a shower prior to going home or soon after reaching home or separating work clothes from the household laundry reduce their exposure to residues (Damalas and Eleftherohorinos, 2011). Fifthly, the type of application equipment utilized increases worker risk. Portable methods such as handheld sprayers and backpack sprayers are more likely to result in workers being exposed compared to mechanised vehicle sprayers (Andrade-Rivas and Rother, 2015). Lastly, weather conditions; for example, the wind causes a significant amount of herbicide that is sprayed to be lost from the initial intended target area. Furthermore, high and humid temperatures have been shown to contribute to rapid evaporation of residues from the spray nozzle (Damalas and Eleftherohorinos, 2011). Consequently, exposure is likely to increase when workers are unable to follow specified instructions on handling and applying herbicide mixtures, use of required PPE and applying general sanitation practices.

The determinants that result in exposure to residues amongst workers have been well documented, even in LMICs (Andrade-Rivas and Rother, 2015; Naidoo et al., 2010; Salameh et al., 2004). Little evidence exists, however, on the determinants of how worker's exposure to herbicides may also be a source of exposure to their families particularly in LMICs. Furthermore, most evidence alludes to precautionary measures that may be implemented by workers, namely taking a shower at the workplace before going home, to minimise the risk of exposure to their immediate families (Damalas and Eleftherohorinos, 2011; Tondl and Schulze, 2008). Limited

research, however, shows preventative measures that the families of workers may adopt to further reduce the risk of exposure.

2.3 Para-occupational 'take-home' exposure

Non-occupational exposure through what is known as the para-occupational 'take-home' pathway occurs when agricultural workers, farmers, applicators or other workers inadvertently carry residues from the workplace to their places of residence. Residues may be brought into the home on the hair, skin, work clothing including boots, work equipment or work vehicles (Curl et al., 2002; Curwin et al., 2002; Lu et al., 2000; NIOSH, 1995). The Centers for Disease Control National Institute for Occupational Safety and Health (NIOSH) conducted a study in response to the 1992 Workers' Family Protection Act (Public Law 102-522, 29 USC 671) that was commissioned by the Congress of the United States (U.S.). This study assessed the contamination of workers' homes with chemicals, including pesticides transported from the workplace. One critical finding from the study was that cases of contamination resulting from the 'take-home' pathway were identified in 28 countries and 36 states in the U.S. (NIOSH, 1995; NIOSH 2002). The findings of another study amongst a population of farmworker households in Washington State, U.S. showed an association between workers' that remained without changing their work clothes for two hours when they reached home after work and increased levels of residues in house dust (Strong et al., 2009). This resulted in the families of worker's within these households being exposed to residues. Thompson et al. (2003) suggest that the implementation of protective practices in the homes of agricultural workers tends to be dependent on their occupational characteristics. According to their findings, pesticide handlers who worked directly with chemicals were more likely to adopt protective measures such as washing hands after work, washing work clothing immediately after single use and taking work clothing off before holding children compared to other workers. The authors attribute these practices to the training that the pesticide handlers received, which covered the aspects of the

prevention of 'take-home' exposure to residues. For this reason, it was presumed that pesticide handlers were more aware of the risks associated with pesticide exposure than workers who undertook other tasks. Similarly, in the South African Working for Water (WfW) programme, applicators receive additional training as it is assumed that these workers may be at a higher risk of exposure to herbicide residues than other workers. The challenge, however, is that in practice, general workers who have not received this specialised training which is provided to applicators, are also involved in activities related to the application of herbicide mixtures (Andrade-Rivas and Rother, 2015). Nonetheless, this specialised training provided to applicators does not explicitly address the prevention of 'take-home' exposure.

A concerning finding from the study by Thompson et al. (2003) was that children living in the homes of exposed workers had elevated urinary metabolites of workplace residues. The abovementioned evidence suggests that children, in particular, have increased risk of exposure to take home residues due to their less mature physiological system and their behavioural practices; that is, they are more likely to engage in hand-to-mouth behaviours compared to adults. Exposure to residues in children has been associated with increased risk of cancer particularly childhood leukaemia, congenital malformations and neurobehavioral deficits amongst others (Curl et al., 2002; Lu et al., 2000, Strong et al., 2008). Numerous studies have also documented the impact of exposure to residues on the health of women (London et al., 2002; Ntanzi et al., 2013; Rother, 2000).

It is interesting to note that countries such as the U.S. enacted legislation that is specific to the protection of worker's families from exposure to hazardous substances transported from the workplace to the home, as far back as 1992; no such legislation, however, exists in South Africa. The legislation that is in place in the country specifically refers to the prevention of contamination in the workplace (South African Department of Labour, 1993). This raises concern, as the absence of a guiding framework to protect worker's families from exposure may

result in the adoption and implementation of protective practices that are fragmented, uncoordinated and lack comprehensiveness. Although there may be no guarantee of the effectiveness of such a policy, as has been shown in the case of the weak enforcement of occupational safety legislation in LMICs (London and Rother, 2001) a policy specific to protect workers' families may be foundational to the development of robust strategies. More importantly, enacting such a policy would be telling of the country's leaderships' willingness to commit to and support raising awareness in regard to 'take-home' exposure risks. Nevertheless, the absence of this policy in South Africa may be indicative of the lack of evidence that 'take-home' exposure is a problem in the country. Additional research is therefore needed in the country to demonstrate the risk of exposure to residues amongst worker's families through the 'take-home' pathway and to further support the development of a policy that addresses this issue.

The multi-country study by NIOSH concludes that exposure to residues resulting from the 'take-home' pathway is a public health concern worldwide. This is also confirmed by other studies, mostly conducted in HICs which provide compelling evidence of exposure amongst the families of workers (Curl et al., 2002; Curwin et al., 2002; Lu et al., 2000; Strong et al., 2008; Thompson et al., 2003). Some studies have further shown an association between 'take-home' exposures and the impact on the health of family members, especially children (Lu et al., 2000). However, in comparison to the extensive research that has been undertaken to establish the health effects resulting from residue exposure amongst workers, significant gaps in knowledge exist in terms of the extent, types and severity of health effects resulting from residue exposure amongst workers' families.

Numerous studies have assessed occupational exposure to residues through contaminated PPE but limited studies have focussed on 'take-home' residue exposure through contaminated work clothing (MacFarlane, 2013). Likewise, most studies have focussed on exposure to pesticides as a result of the 'take-home' pathway (Curl et al., 2002; Lu et al., 2000, Strong et al.,

2008; Thompson et al., 2003); with few being specific to contamination resulting from herbicide exposure (Curwin et al., 2002). The evidence is further limited for LMICs. Consequently, the extent to which para-occupational herbicide exposure may be a concern for public health in South Africa is not fully known.

Additionally, most studies assessing 'take-home' exposure made use of sampling methodologies such as biological (e.g., urine), environmental (e.g., dust, surface wipe) and personal (e.g., handwipe) (Curl et al., 2002; Curwin et al., 2006; Lu et al., 2000, Strong et al., 2008). However, these sampling methods are not always feasible (e.g., lack of laboratories for analysis). Interestingly, few studies have used visual methodologies (for example; *photovoice* – see Section 4 Methods) to assess 'take-home' exposure when conventional sampling methods cannot be used (Stedman-Smith et al., 2012). Furthermore, no studies, to the knowledge of the researcher, have been conducted in a middle- income country, namely South Africa, to assess 'take-home' exposure risks amongst forestry workers' families using visual sampling methodologies.

2.4 The South African Working for Water (WfW) programme

Compared to farmers and other agricultural workers, forestry workers remain an under-researched population in LMICs. This, therefore, provides an important case study as they primarily work with herbicides but little is known about the effects of herbicide residue exposure amongst this population of workers and their families. The WfW programme commenced in 1995 as an initiative of the South African Department of Water Affairs and Forestry. The programme is primarily aimed at sustainably restoring water supply through the removal of invasive alien plant species (Andrade-Rivas and Rother, 2015; Binns et al., 2001). Evidence shows that invasive alien plant species have been correlated with "reduced surface water runoff and groundwater reserves, increased biomass and fire intensity, and reduced biodiversity

resulting in substantial economic consequences" (van Wilgen et al., 2000). This control of invasive alien plant species is managed through concentrated efforts of initial removal of the invasive alien plant species through mechanical, chemical and biological control methods (depending on the differing alien plant species) and restoration of indigenous low water consuming vegetation in cleared areas (van Wilgen et al., 2012). This is then followed by maintenance and management of invasive alien plants of up to five years to prevent regrowth (van Wilgen et al., 2012; Hosking and Du Preez, 2004).

The WfW initiative also responds to South Africa's developmental needs as it addresses the immediate social needs of marginalised and vulnerable groups through the provision of training and low-levelled skilled employment opportunities (Andrade-Rivas and Rother, 2015; Hope, 2006). Numerous employment opportunities have been created within the programme, with a strong emphasis on gender equality (Turpie, 2008). In 2015, 53% of those employed were women who are mostly single heads of households (South African Department of Environmental Affairs, 2015).

Despite the success of the WfW programme which leans on the combination of its environmental goals and poverty alleviation efforts while protecting the health of its workers, secondary herbicide residue exposure, through the 'take-home' pathway, amongst the families of workers remains an issue.

2.5 Training of workers within the WfW Programme

The entire spectrum of workers – that is; general workers, peer educators, herbicide applicators, first aiders, health and safety representatives and drivers, within the WfW programme receive vocational training that qualifies them as general workers. The training encompasses aspects that are related to the risks of herbicides to the environment, risks of exposure to the workers themselves, measures to reduce the risk of exposure to herbicides such as use of Personal

Protective Equipment (PPE) and the overall health and safety of the workers. The training methodology involves mixed methods which provide workers with the opportunity to practically apply the knowledge they would have obtained. This is critical in order to ensure workers correctly implement work-related tasks and more importantly risk reduction measures to exposure to herbicides (Andrade-Rivas and Rother, 2015).

Although the training that WfW workers undergo appears to adequately cover the aspects related to the occupational safety of workers as well as their health and wellbeing, the aspect of minimising and possibly eliminating the risk of herbicide exposure to workers' immediate family members, especially children, is not covered. It may be argued that the training on the management and care of PPE, specifically cleaning and laundering contaminated equipment, addresses 'take-home' exposure risks, especially if workers adhere to the stipulated requirements. The assumption that this is imbedded in the current training offered may be a challenge in reality, however, as workers may be unaware of the extent to which their practices and behaviours related to PPE maintenance and personal hygiene practices may be a potential risk for their families.

2.6 Personal Protective Equipment use

As a minimum measure of protection, all WfW workers are provided with PPE to reduce the risk of exposure whilst handling and applying herbicide mixtures. The equipment includes; chemical resistant gloves and boots, respirators, protective eyewear, aprons and overalls. A study by Tomenson and Matthews (2009) amongst farmers and applicators in 24 different countries, four of which were in Africa, found that the use of PPE was an important measure of control in reducing exposure to pesticides and the resulting adverse health effects. They further found that the frequency of compliance to PPE use amongst the study population was critical in determining the effectiveness of the equipment to reduce exposure. Similar findings were

observed by Quandt et al. (2006) and Recena et al. (2006) where the use of PPE was effective in reducing exposure to pesticide residues. Both studies, however, conclude that the provision of PPE to workers did not necessarily translate to use of the equipment for protection. Though monitoring compliance of PPE use may be employed as a potential strategy to enforce consistent use of the equipment, the widespread setting of the work of applicators and farmers hinders the ability to do so effectively (Andrade-Rivas and Rother, 2015; Hosking and Du Preez, 2004).

Despite the fact that PPE remains an important protective measure in reducing exposure to herbicides amongst workers, the equipment, if contaminated, becomes a potential source of exposure to the families of workers when brought into the home. This source of exposure was documented by Curwin et al. (2006) who stated that the para-occupational pathway is an additional route of exposure to pesticides and occurs when applicators, farmers or other workers unintentionally contaminate their homes by carrying residues on their clothing and shoes.

2.7 Knowledge, attitudes and practices of workers

Knowledge of the risks of pesticide exposure amongst workers is imperative as erroneous beliefs may result in workers failing to implement protective measures against the risk of exposure (Blanco et al., 2005; Mekonnen et al., 2002). Consequently workers' families may be exposed to residues. Quandt et al. (2006) observed that the resulting behaviour of farmworkers, for example, either choosing to adopt or failing to adopt protective measures, was moderated by their individual psychosocial factors which included their knowledge, beliefs, attitudes and values. A study amongst Lebanese agricultural workers confirms this, as the authors conclude that the lack of PPE use was influenced by the workers perceived understanding that exposure to pesticides was not harmful (Salameh et al., 2004). It has also been documented that even in

circumstances where PPE requirements were in place to assist workers to differentiate between the essential equipment that was required for the varying levels of toxicity of the chemicals, these distinctions were not reflected in practice by their behaviour, even when workers had clear perceptions of the risk of the harmful substances being handled (Perry et al., 2002; Richardson, 2011). Seemingly workers have adequate information in order to comprehend the risks of exposure to herbicides but have little knowledge related to residues that cannot be seen or smelt. An important observation by Perry et al. (2002) suggests that the extent of exposure tends to be moderated by the behaviour of workers in both the work and home environment; they observed that in some instances workers brought contaminated work clothing or articles into their homes.

The working conditions of the WfW workers are mostly characterised by steep terrains where workers are exposed to varied environmental conditions, such as heavy rainfall. Due to the vastness of the areas being cleared, workers have to walk long distances carrying work equipment, for example, spraying containers and their PPE. This not only poses physical challenges to the workers but the risk of exposure to herbicide mixtures (Andrade-Rivas and Rother, 2015). These conditions are indicative of the likelihood of exposure lasting for longer periods (e.g., in the case of spillage, as washing facilities are not located at the worksites).

Similarly, numerous studies have documented the behaviours of workers that are related to the risk of exposure in the workplace (Perry et al., 2002; Quandt et al., 2006; Richardson, 2011; Salameh, 2004). Nonetheless, fewer studies exist that are linked to workers' practices in the home that may contribute to the risk of exposure among their families. Further understanding in this regard is needed as this affects the scope of behavioural interventions which in most cases tend to be limited to only reducing exposure risks in the workplace.

Occupational exposure to herbicides amongst workers is well documented (Ntanzi et al., 2013). Little is understood, however, regarding exposure to families that occur as a result of 'take-home' residues, especially in LMICs. Most interventions aimed at reducing the risk of exposure in the WfW Programme have focussed on the prevention of exposure in the workplace with no interventions specifically targeting the prevention or management of exposure in the homes of these workers. Since the WfW programme is a countrywide initiative that employs a substantial number of workers, the impact of 'take-home' residues carried from the workplace to the home may be widespread. Likewise, the resulting health effects from exposure to residues on the workers' families may also be widespread.

3. Research aim and objectives

3.1 Research aim

This research aims to determine whether the families of workers in the Working for Water programme are at risk of exposure to 'take-home' herbicide residues carried from workplace to the home, specifically through contaminated Personal Protective Equipment as the main source of exposure.

3.2 Objectives

The objectives of this research are:

1. To assess the extent of exposure to workplace herbicide residues in the homes of Working for Water workers.
2. To document the different types of workers' practices, related to care of Personal Protective Equipment (PPE) at home that may be risk factors for exposure.
3. To identify the determinants of exposure to residues for workers' families including those members most at risk of exposure as a result of contaminated PPE.
4. To provide recommendations for the prevention and management of para-occupational exposures, specifically related to the care and management of PPE.

3.3 Research questions

The research questions for this study are divided into the primary research question which is followed by the secondary research questions.

Primary research question

1. What is the magnitude of 'take-home' herbicide residue exposure specifically resulting from contaminated PPE amongst the families of WfW workers?

Table 1: Secondary research questions

Area of inquiry	Secondary research questions
Work related exposure	1. Are there worker's practices in the workplace that may result in the contamination of their PPE? Which articles of the PPE are more likely to be contaminated? 2. Are any of these identified practices in the workplace avoidable? 3. Which of the worker's practices in the workplace may be possible risk factors for the transportation of herbicide residues to the homes of the workers?
'Take-home' exposure	1. Do workers carry contaminated PPE including work clothing to the home? Are there any other sources of contamination such as work equipment that are carried into the homes of these workers? 2. What do workers perceive are the herbicide exposure pathways for themselves and their families? What are the main perceptions of workers related to 'take-home' residue exposure resulting from contaminated PPE and work-clothing? How do these perceptions contribute to the measures adopted by workers to reduce exposure to residues in the home? What specific risk reduction methods do workers practice in order to prevent their families from exposure?

Area of inquiry	Secondary research questions
'Take-home' exposure (continued)	3. Do workers change their PPE immediately after work? 4. How do workers wash, clean and store their PPE in the home? Are the contaminated articles stored separately from household laundry if they remain unwashed? 5. Is contaminated PPE washed separately from the household laundry? Is the same washing machine or laundry dish used by other household members to wash their laundry? Who is most likely to wash contaminated articles and therefore likely to be exposed? 6. What are the risk factors related to the practices of the workers families that increase their likelihood of exposure? Who is most at risk of exposure amongst workers' family members?
WfW training	1. To what extent do the current gaps in training, that is the exclusion of an aspect that covers the prevention and management of 'take-home' residue exposure to residues, affect the practices of workers in the home? How can these be improved, if relevant?

4. Methods

4.1 Context of research

This study forms part of a larger research project, titled '*Assessing Working for Water workers washing and storing of herbicide contaminated Personal Protective Equipment and work clothes: Identifying risk prevention measures of cross-contamination for family members and home environment*' which is being piloted in the Western Cape Province led by the principal investigator Professor Hanna-Andrea Rother (HREC REF: 213/2015). The larger research project aims to identify best practice strategies for the care and management of PPE and make recommendations to improve WfW's standard operating procedures that will guide workers in preventing residue exposure to their families. This will be achieved through collection of baseline data, mainly through ethnographic methods, related to how workers wash, clean and

store their PPE at home. Since the focus of the proposed research also relates to residue exposure resulting from contaminated PPE amongst worker's families, the findings of this research will serve as an additional source of evidence for the development strategies aimed at preventing and reducing exposure to residues. The type of evidence namely, visual data in form of photographs, collected in research will be critical to understanding the actual practices of workers and their perceptions related to PPE and exposure to residues. Thus, it may further contribute to the specificity of the recommendations and strategies that will be developed under the larger study.

4.2 Research design

The study will make use of a qualitative research design and specifically an adaptation of the participatory research method, *Photovoice*. The use of this method will enable the researcher to gain an in-depth understanding of the real life experiences of forestry workers, rather than what could be captured with the use of standardised instruments. The study will further undertake a documentary review of the current WfW standard operating procedures and the South African chemical legislation.

4.3 Study population and sampling strategy

The study participants will be selected using purposive sampling methods which Maxwell (2008) defines as a technique whereby participants are consciously selected to take part in a study, on the basis of practical knowledge, in an attempt to provide a study with specific information to answer the research question at hand. He further states that purposive sampling methods enable researchers to accurately obtain the essence of the participant's experience. Thus, the study population will comprise a sample of approximately 40 participants which will be selected from four teams of workers located in the Western Cape Province. The participants will be specifically selected from sites that have been identified by the WfW management where teams

are actively spraying during the time of the study including; Gouda, Citrusdal, Liesbeek River and Westlake.

The study population will be comprised of four teams of WfW workers, approximately 10 workers per team, recruited by individual contractors under the WfW Programme. All workers are community members which reside in those specific localities that need to be cleared of invasive alien plant species.

It is noted that there are limitations to using the proposed purposive sampling method, namely, that the selected participants in the sample may not be representative of the entire study population and that those agreeing to take part in the study may have similar characteristics. The challenge with these abovementioned limitations is that this then creates an opportunity for bias in the study, where participants with certain characteristics may be over-selected or under-selected or still others may be missed altogether (Maxwell, 2008). The former limitation is particularly relevant to this study as it has been mentioned, that the groups of workers will be selected by the WfW management. This limitation, however, will be addressed through the selection of participants from different teams in the Western Cape Province, which should therefore contribute to the sample being representative of the larger population of forestry workers in the Western Cape.

4.4 Data collection

Participatory research methods are characterised by the involvement of communities in the research process. These methods empower community members by enabling them to be co-researchers that contribute to various processes within a given study rather than only being subjects (Carlson et al., 2006; Minkler, 2014). Furthermore, participatory research methods allow researchers to gain an in-depth and accurate understanding of the needs of the study population contrary to those perspectives that may be provided by external individuals. Thus, it

incorporates the perspectives, perceptions and experiences of those involved in the research process (Wang et al., 2000). A critical aspect of participatory research methods is that of social change, as it strongly contributes to interventions being sustained in the long term mainly for the reason that community members are actively involved in the research (Wang et al., 2000; Catalani and Minkler, 2009). This study will specifically make use of the participatory action research method '*photovoice'* as a means to collect data and information related to 'take-home' herbicide residue exposure (Stedman-Smith et al., 2012).

Photovoice is a participatory action research method aimed at stimulating social action. The method is based on the theoretical principles of education for critical consciousness developed by Paulo Freire (1970) which emphasises the importance of individuals conveying their personal circumstances, forming linkages within their personal circumstances, connecting these circumstances to underlying causes and providing recommendations improve their lived realities. Secondly, feminist theory which suggests that power increases for those who articulate their opinions and take an active part in decision making. Thirdly, documentary photography which is a grassroots approach that enables participants to represent their experiences through photographic techniques in order to facilitate social change (Stedman-Smith et al., 2012; Wang and Pies, 2004). Based on these theoretical principles, *photovoice* has been instrumental in empowering marginalised communities through the development of their skills and enabling them to contribute collectively to changes within their communities (Madrigal et al., 2014). As a result, communities are empowered to contribute to social change through critical engagement and discussion.

The technique has since been adapted within the fields of public health, education and youth development research. Within the field of public health research, the method has been described as a participatory action research method and approach intended to address prevailing public health issues (Wang et al., 2000; Catalani and Minkler, 2009). The use of the

method within the field has primarily targeted marginalised and vulnerable populations, including workers, in an attempt to empower these groups through research that extends beyond in-depth discussions of their issues to action that influences change at the policy level (Carlson et al., 2006; Kuratani and Lai, 2011). This was demonstrated in a study by Wang and Burris (1994), where *photovoice* research pioneered changes in policy for women in the rural communities of China. The research method enabled these village women to communicate their needs to decision makers and resulted in policy changes that were favourable to women living in these rural communities.

Thus the use of *photovoice* methods for data collection in this study will be aimed at answering the research question from the viewpoint and real life experiences of the workers in the WfW programme. Data collection for the study will include two phases: 1) capturing of photographs by participants and 2) focus group discussions of the photos taken.

Photo taking

Two fieldworkers conversant in the local languages, namely Afrikaans and isiXhosa, will be trained on providing a background of the research project, the roles of the fieldworkers and research staff and the format of the workshop to be held with study participants by the project coordinator and two research assistants. Working for Water workers participating in the study will be trained by the fieldworkers and research staff on the research methodology, that is, how to use the cameras as a means for data collection. They will also be issued an instruction guide (see Appendix A) that provides specific details on the types of photographs to be captured. This includes photographs that show access to water supply, electricity and waste removal containers in their home environment and the surrounding area in relation to using, cleaning and storing of their PPE as well as the facilities they use for cleaning and storing their PPE. Confidentiality procedures will be explained to all workers taking part in the study and workers

will also be provided with a consent form (see Appendix B) that they will be expected to complete and sign.

Each worker will then be issued a disposable camera comprised of 27 exposures that will be used to capture the specified photographs related to their interpretations of the risks of herbicide exposure as a result of the 'take-home' pathway. This phase of data collection is expected to last for the duration of one week for each team. Following this, the research staff will collect the used cameras (containing captured photographs) from the study participants. Thereafter the research staff will develop the captured photographs. As an incentive to participating in the study, workers will be requested to capture one photograph of their family which will be developed by the research team and issued to participants.

Focus group discussions

The second phase of the data collection process will involve hosting four focus group discussions with workers at their respective worksites. All workers agreeing to take part in the study will participate in these focus group discussions, thus each focus group will consist of approximately 10 WfW workers. These sessions will be facilitated by the research staff and fieldworkers guided by the *Photovoice Focus Group Guide* (see Appendix C) and will last for 1.5 to 2 hours. Focus group participants will be requested to respond to general questions and more specific questions regarding the photographs they have taken (see Appendix C). A selected number of photographs demonstrating the care and maintenance of PPE and risks of 'take-home' exposure will be displayed and participants will be provided with an opportunity to discuss their interpretations of the photographs that have been captured. It is important to note that the participant's faces in the photographs will be blurred out to ensure that workers are protected from being easily identified. All focus group discussions will be audio recorded with the consent of the study participants.

The use of *photovoice* data collection methods for this study has been taken into account as a possible limitation, as varied data sources will not be compared to assess the similarities and discrepancies in responses. However, the justification for the use of this method is that the study aims to assess the risk of para-occupational exposure initially through observational methods that will then serve as basis for assessment using other methods based on the findings of the study.

4.5 Data analysis

The documentary review data and photographs taken by the study participants and will be coded, categorised into themes and analysed using the qualitative data analysis tool, Nvivo 11. This tool has been used extensively in qualitative research to analyse various forms of data including images and audio files (AlYahmady and Alabri, 2013). The use of an electronic qualitative data analysis, rather than manual qualitative analysis methods, ensures rigour in the coding and analysis of data. AlYahmady and Alabri (2013) state that there are five phases in which Nvivo facilitates the analysis of qualitative data:

1. Management of data by organising the various forms of data, that is, images, questionnaires, interview transcripts;
2. Management of ideas by recognising the conceptual and theoretical overarching issues emerging from a study;
3. Querying of data through in-built questions and also utilising the tool to answer these queries;
4. Modelling by generating visualisations (e.g., graphs) to show correlations between the conceptual and theoretical data; and
5. Reporting by formulating transcript reports of the study results.

One of the key principles of *photovoice* methods is that study participants themselves contribute to the process of data analysis. This process occurs during the previously mentioned focus group discussions that will be held with participants where they share their understandings of

the captured photographs through a guided process. The audio recorded focus group discussions (with consent), where participants discuss their personal interpretations of the captured photographs will be reviewed and transcribed. Thereafter, the transcribed data emanating from the focus group discussions will undergo the same process of analysis in Nvivo 11 as the photographs namely; coding, synthesis and organisation.

5. Ethical considerations

The larger research project titled: '*Assessing Working for Water Workers washing and storing of herbicide contaminated Personal Protective Equipment and work clothes: Identifying risk prevention measures of cross-contamination for family members and home environment'* was granted ethics approval (HREC REF: 213/2015) by the University of Cape Town Human Ethics Research Committee (see Appendix D). This proposed research will be submitted for approval to the UCT Human Ethics Research Committee as per the University's guidelines for undertaking research.

The proposed research will involve human subjects in order to investigate the risk of 'take-home' herbicide residue exposure in the homes of WfW forestry workers. In light of this, the research will be conducted according to the principles of the Declaration of Helsinki (2013) and the ethical regulations of research for South Africa.

The ethical considerations outlined in this specific study have been adapted from Wang and Redwood-Jones' (2001) recommendations for *photovoice* research ethics.

5.1 Informed consent

The process of obtaining informed consent provides research participants with all information pertaining to a proposed study. This enables participants to make an informed decision regarding their involvement in the study. Thus the process of informed consent recognises the

autonomy of individuals, that is, they should be given the responsibility of deciding whether to take part in the study. The language and terms enunciated in the written consent form must be easily understood by the participants. For *photovoice* research techniques, Wang and Redwood-Jones (2001) recommend obtaining consent from all those who take part in the study namely, research participants and members of the community including family members who are captured in the images. They further suggest that consent be obtained prior to publishing the images.

A briefing session will be held with WfW workers where they will be informed of the following: 1) the purpose of the study and the research process, 2) the planned activities including time frames, 3) the benefits and potential risks of participating in the study, 4) study participants responsibilities as co-researchers within the study, 5) the process of obtaining informed consent prior to photographing individuals, and 6) the process of tendering withdrawal of participation in the study. Emphasis will also be placed on workers' ethical conduct throughout the research process, particularly since they will assume the role of being researchers. Since workers taking part in the study do not all have an English language background and some speak Afrikaans and others isiXhosa, fieldworkers who speak the local languages of the workers will be tasked with translating the consent forms to workers. This will ensure that the participants are well informed and understand all the terms of the study before agreeing to take part (see Appendix B). The signed informed consent form will cover consent by participants to take part in the two phases of the study namely, the photo taking and focus group discussions.

5.2 Privacy and confidentiality

Four types of invasions to privacy and confidentiality may occur when using the *photovoice* methodology. These include imposing on an individual's private space especially since meaning is attached to the image, disclosing negative and humiliating information about an individual with

the aim of social change, using images out of context in order to support certain views and developing images and selling them in order to generate income (Wang and Redwood-Jones, 2001).

The above mentioned forms of invasion to privacy and confidentiality will be addressed during the initial information session where WfW workers will be informed on the research methodology and trained on the use of cameras and the ethics of capturing photographs of people including their responsibility in protecting the confidentiality of those captured in the photographs. In addition, the *photovoice* instruction guide (see Appendix A) provides further guidance to participants on the types of photographs that should be captured.

5.3 Anonymity

Photographs captured by participants that portray faces of people or specific symbols in the community raise ethical issues and failure to take this into cognisance by protecting the identity of individuals may be a violation of that individual (Wang and Redwood-Jones, 2001).

Workers will be informed that part of the study will involve openly sharing the captured photographs as well as their experiences with other participants during the focus group discussions. These photographs, however, will only be viewed by the research staff and study participants in their respective focus group. Study participants will be determine whether photographs can be published or displayed in a public space. Furthermore, in order to ensure that the anonymity of the workers is maintained, only the researchers conducting the study will have access to the data. For photographs that will be published, pixelisation techniques (e.g., blurring or blacking out parts of the images) will be employed to protect the participant's identity. Workers will also be trained on explaining the principle of anonymity within the context of *photovoice* research to their families or community members when requesting their consent to capture their photographs.

5.4 Risks

There are no anticipated risks to workers that will be participating in the proposed study. It should be noted, however, that workers themselves may anticipate possible risk of participating in the study. This may arise from workers being fearful that if, for any reason, anonymity is not maintained that the study may be a threat to their employment, especially if they are portrayed as being negligent in the captured photographs. The consent form, however, alludes to the worker's employment not being impacted by their involvement in the study. Furthermore, the research team will reassure concerned workers that the use of this method will assist in developing interventions aimed at reducing exposure both at the workplace and home. If workers. Workers will also have the option of not participating in the study nor being photographed. In summary both the employers and the researcher have a combined interest in the worker's wellbeing.

In terms of possible risks that may result from exposure to herbicide residues, WfW workers that will participate in the study have received training by WfW which covers the aspects of preventing exposure to herbicide residues. Should workers need further clarity regarding herbicide exposure and the related risks, however, the research team will be available to respond to workers in this regard.

5.5 Benefits

The immediate benefits for the workers participating in the research will be as follows: workers will be provided information related to health effects resulting from exposure and will be further provided with information that will guide them on preventing and reducing the risk of exposure.

Another benefit, based on the principles of *photovoice*, is that participants will be provided with an opportunity to contribute to improvements in existing standard operating procedures related

to the care and maintenance of PPE at work and home. This collaborative approach carried out in the design phase, as previously mentioned, is more likely to contribute to strategies being correctly implemented and sustained as workers will support the initiative. Furthermore, the photograph of their families captured by participants will be developed and will be issued to the participants for the personal use and enjoyment.

The long term benefits are that the workers will be less exposed to residues since they will be aware of the risks of 'take-home' exposure, and therefore, take precautionary measures to protect themselves. Furthermore, the families of workers will benefit indirectly as a result of the participants being more aware of the risks of exposure to their families.

As a token of appreciation for participating in the study, workers will also be provided with refreshments during the focus group discussions.

In light of these abovementioned benefits, those participating in the study will not receive any monetary incentives.

6. Project plan

Activity	Jan – Jun 2016	Jul 2016	Aug 2016	Sep 2016	Oct 2016	Nov 2016	Dec 2016	Jan 2016	Feb 2017
Course work									
Complete coursework									
Ethics approval process									
Write up of protocol									
Submission of protocol for ethics approval									
Research									
Finalise write up of literature review									
Data analysis									
Transcription of *photovoice* data									
Data analysis using Nvivo									
Final write-up									
Write-up of manuscript									
Submit manuscript to Supervisors for review									
Incorporate review changes and finalise manuscript									
Submit final thesis draft to Supervisors for review									
Incorporate review changes and finalise thesis									
Submit final write-up									

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Part B: Literature Review

Table of Contents

1. Introduction

Pesticides, including herbicides, are increasingly used in agricultural and environmental pest control and management (Issa et al., 2010; Nweke and Sanders, 2009). However, unintentional exposure to residues may be harmful to non-target organisms, such as those who work with or come into contact with residues (e.g., worker's families) (Damalas and Abdollahzadeh, 2016; Kim et al., 2017; Lucas and Allen, 2009; Tondl and Schulze, 2008). Occupational exposure risks, including the associated health effects, have been extensively researched globally (Deziel et al., 2015). Little is known, however, regarding para-occupational 'take-home' exposure (i.e., the indirect effects of exposures in a work environment) and the resulting health risks, despite being cited as a public health concern worldwide (Deziel et al., 2015). The existing evidence on 'take-home' exposure risks is primarily from studies conducted in High-income countries (HICs) (Arcury et al., 2007; Arcury et al., 2009; Curl et al., 2002; Lu et al., 2000; Strong et al., 2009a; Strong et al., 2009b; Thompson et al., 2003; Thompson et al., 2008; Vida and Moretto, 2007). This type of exposure has not been well researched amongst worker's families in Low-and middle-income (LMICs). Therefore, understanding the nature of workers family's exposure risks, the sources of exposure, contextual factors and structural factors in LMICs adding to the risks will be critical for prevention and management of 'take-home' pesticide exposure risks.

1.1 Purpose and objectives

The purpose of this literature review was to examine the existing evidence on para-occupational 'take-home' pesticide residue exposure risks. The information was relevant in characterising the risk of this type of non-occupational exposure amongst Working for Water (WfW) forestry workers (the study population) and their families in South Africa, and in providing recommendations to address 'take-home' exposure risks in similar settings (i.e., LMICs).

The specific objectives were as follows:

- To summarise the evidence globally relating to 'take-home' pesticide exposure risks.
- To evaluate the interventions and strategies aimed at reducing pesticide exposure risks and the associated health effects for worker's families.
- To review the existing chemical legislation which outlines the protection of workers from hazards in the workplace and their families from exposure risks at home.
- To identify the research limitations and gaps in the existing literature as a basis for this research.

1.2 Search strategy

Relevant peer reviewed articles, publications, reports and policy frameworks relating to the 'take-home' pesticide exposure pathways from both HICs and LMICs were identified. Only those written in English, however, were reviewed. In terms of search limits, date ranges were not applied mainly due to few studies existing on the 'take-home' exposure risks compared to occupational exposure risks.

1.2.1 Peer reviewed Journals

To be included in this review, peer reviewed journals had to meet one or more of the following criteria:

1. specifically focus on the 'take-home' herbicide or pesticide exposure pathways globally;
2. describe exposure risks amongst worker's families;
3. specify sources of exposure for worker's families;
4. define acute and chronic health risks associated with exposures;
5. describe interventions (e.g., training, behavioural interventions) aimed at reducing exposure risks amongst worker's families; and/or
6. include environmental, biological, observational or visual measurements of 'take-home' exposure risks.

Published studies were sourced from the following databases and websites:

- General databases: Scopus, JSTOR and Google scholar
- Journal websites: Elsevier's Science Direct, Springerlink, Wiley Online and PubMed.

The specific search terms that were used included:

- *Para-occupational exposure* (Search terms: exposure pathways and herbicides/ pesticides non-occupational exposure pathways and herbicide/pesticides, para-occupational exposure pathway, 'take-home' exposure pathway, herbicide/pesticide residues, bystander exposure, home contamination, 'take-home' exposure and forestry/agricultural workers, 'take-home' exposure and children).
- *Health effects* (Search terms: herbicides/pesticides and human health, health effects of para-occupational exposure, chronic health effects and herbicides/pesticides, children and herbicide/pesticide exposure; health effects of parental exposure to herbicides/pesticides, effects of herbicides on worker's families).
- *Sources of para-occupational exposure* – Personal Protective Equipment (PPE) (Search terms: PPE and forestry/agricultural workers, sources of herbicide/pesticide exposure; contaminated work clothing/PPE, soiled work clothing/PPE, cleaning/washing/laundering PPE, storage of PPE).
- *Training and behavioural interventions* (Search terms: training interventions and forestry/agricultural workers, training to reduce 'take-home' pesticide/herbicide exposure risks, behavioural interventions and 'take-home' exposure).
- *Knowledge, attitudes, practices (KAP)* (Search terms: worker's KAP and 'take-home' herbicides/pesticides exposure, forestry/agricultural workers beliefs and 'take-home' exposure, workers perceptions of 'take-home' exposure risks, forestry/agricultural workers family's perceptions of 'take-home' exposure risks, forestry/agricultural workers family's KAP, behavioural interventions and 'take-home' exposure, workplace hygiene practices and 'take-home' exposure, home hygiene practices and 'take-home' exposure).

Some reviewed studies led to other relevant articles, which were sourced from the bibliography of the reviewed studies.

1.2.2 Additional information sources

Other information relating to the 'take-home' exposure pathway was sourced from the following:

- Grey literature: conference abstracts, training manuals (e.g., *La Familia Sana Promotora* programme, Farm Family Exposure to Pesticides: A discussion with farm families – Pardue University), presentations and reports;
- Dissertations; and
- Chemical legislation from South Africa and the United States including summaries of legislation and reference sheets.

Although the focus of the study was primarily on 'take-home' herbicide residue exposure risks amongst forestry workers and their families, most of the existing studies were conducted in agricultural populations. Inferences, however, were made from these studies as these workers are somewhat similar to forestry workers despite that their exposure risks (i.e., agricultural workers are exposed to a wider range of pesticides compared to forestry workers) and type of work differ. All studies reviewed on 'take-home' exposure risks were conducted in HICs and no studies, to the knowledge of the researcher, relating to this type of exposure were conducted in LMICs. Nonetheless, the literature from HICs was still relevant. The reviewed literature mostly referred to the collective term 'pesticides' rather than herbicides, but the literature on pesticides remained applicable.

2. Exposure pathways

Pesticide exposure may occur through the occupational (i.e., direct) and the non-occupational pathway (i.e., indirect). The occupational exposure pathway has been defined as workers coming into contact with pesticides at work during mixing, loading and application tasks. The non-occupational pathway refers to pesticide exposure occurring through indirect means and often affecting those who live with workers.

Four non-occupational exposure pathways have been identified and are namely:

1. the *drift pathway*, where pesticide residues are transported to non-target organisms during application or transferred from the soil and plants by the wind following application (e.g., drift into the home);
2. the *residential pathway* where pesticides are used or applied in the home or garden and residues are inhaled or settle on surfaces in the home;
3. the *dietary exposure pathway* where food or drinking water contains residues which are then ingested; and
4. the *para-occupational 'take-home' exposure pathway* where workplace residues are transported by workers into their homes (Arcury et al., 2007; DellaValle et al., 2012; Deziel et al., 2015). When residential areas are located close to treated fields, differentiating between the *drift* and the *'take-home' exposure pathway* is difficult. In this study, however, it was possible to make a distinction between the two exposure pathways as the WfW participants cleared alien plant species using herbicides away from their homes.

Although the levels of pesticide exposure within the non-occupational pathway are generally lower compared to the occupational pathway, these levels remain significant as chronic low-dose exposure to pesticide residues has been associated with adverse health effects (e.g., cancers, diabetes, neurological symptoms, asthma, cognitive impairment and physical developmental effects) (Kim et al., 2017; Roberts and Karr, 2012).

2.1 Para-occupational 'take-home' exposure

Para-occupational exposure has been defined as indirect contact with workplace residues which workers transport on their skin, hair, clothing, shoes and vehicles from work into the home (Arcury et al., 2007; Arcury et al., 2009; Curl et al., 2002; Lu et al., 2000; Strong et al., 2009a; Strong et al., 2009b; Thompson et al., 2003; Thompson et al., 2008; Vida and Moretto, 2007). This exposure pathway has been identified as a distinct source of exposure for those living with workers, especially their spouses and children, as they come into contact with residues on contaminated surfaces (e.g., carpet, laundry room) or materials in the home (Arbuckle et al.,

2004; Coronado et al., 2006; Curl et al., 2002; El-Wakeil et al., 2013; Goldman et al., 2004; Lucas and Allen, 2009; Strong et al., 2009b; Ward et al., 2006). Of concern is that residues persist in the indoor environments for longer periods than in the external environment where they would normally undergo degradation by environmental processes (Arcury et al., 2014; Oliveira-Pasiani et al., 2012; Strong et al., 2008; Thompson et al., 2008). This increases the likelihood of worker's families being continually exposed to pesticides in the home environment.

Five studies conducted in HICs reported the presence of pesticide concentrations such as azinphosmethyl, a pesticide strictly restricted for agricultural pest control, in analysed workers' house and vehicle dust samples. For example; Curl and colleagues (2002) identified azinphosmethyl concentrations in 85% of house dust samples and 87% of vehicle dust samples in participating farmworker households in Washington State, United States. This study provides evidence of worker's transporting workplace chemicals into the home as the identified pesticides were limited to agricultural use and it was not likely that they were used for residential purposes. A further, two studies reported the contamination of worker's homes, specifically with herbicides. Curwin et al. (2006) found higher concentrations of the herbicides atrazine, metolachlor, acetochlor, alachlor, glyphosphate and 2,4 D in the house dust of farmworkers homes compared to non-farmworkers homes in Iowa, United States. Secondly, Ward et al. (2006) noted the concentrations of six herbicides in 85% of agricultural worker's homes compared to non-agricultural workers also in Iowa, United States. Both Ward et al. (2006) and Curwin et al. (2006) reported that the identified herbicide concentrations were strictly for agricultural use. The findings from the abovementioned studies provide further supporting evidence of pesticides used at the workplace being tracked into farmworker's homes and unintentionally exposing their families to residues. Additional evidence from a comparative study amongst agricultural and non-agricultural homes in central Washington State, United States documented that all agricultural homes had significantly (i.e., $p < 0.001$) higher concentrations of pesticide residues

compared to reference homes (Lu et al., 2000). A critical finding from the same study that raises a concern for the 'take-home' pathway is that pesticide residues were present in all households where one of the family members was employed as an agricultural worker. These findings suggest that agricultural worker's families or those who live with the workers are inequitably exposed to workplace residues including the associated health effects compared to the families of workers who were not agricultural workers.

2.2 Sources of exposure: Personal Protective Equipment

The sources of exposure for worker's families through the para-occupational pathway include: worker's skin, hair, work clothing, shoes and vehicles. In a study with farmworker households in eastern North Carolina, United States, work vehicles were identified as one of the main sources of pesticide exposure for worker's families (Arcury et al., 2007). Within the WfW programme, however, workers are transported from designated areas to the sites where they clear alien vegetation using a common work vehicle, that is in most cases, owned by the contractor. Therefore, workers are not likely to use a personal vehicle for work. Although the WfW work vehicle may be a source of exposure for the workers, it is not a source of exposure for worker's families. Instead, a potential source of exposure for their families may be workers' Personal Protective Equipment (PPE).

PPE is clothing or equipment specifically designed to protect workers from the risks of exposure to residues and other hazardous activities (Carpenter et al., 2002; Damalas and Abdollahzadeh, 2016; DellaValle et al., 2012; MacFarlane et al., 2008; Tondl and Schulze 2008). PPE provided to WfW forestry workers includes; protective clothing (i.e., trousers and long sleeved coat), safety boots, chemical resistant gloves, respirators, goggles and a hard hat (Andrade-Rivas and Rother, 2015). Those who live with workers may also be indirectly exposed to residues through household surfaces and house dust contaminated by the worker's PPE (Arbuckle et al., 2006;

Liu et al. 2014; Tondl and Schulze, 2008). Arbuckle et al. (2006) found a correlation between the door handle in farmworker's homes in Ontario, Canada and the presence of residues in the urine samples of all household members. The same study further reported the association between children's urinary residue concentrations and both bathroom and kitchen facilities (Arbuckle et al., 2006). These findings demonstrate that household members who used the same facilities and surfaces as workers were exposed to residues in the home. Since residues are mostly not visible, WfW worker's families may not be aware that household surfaces are contaminated.

2.3 Para-occupational exposure and worker's families

Women and children in particular have been identified as being more at risk of para-occupational exposure to pesticide residues (Lebov et al., 2015; Quandt et al., 2013a; Tondl and Schulze, 2008). This is because women are exposed through the tasks they undertake in the home (e.g., laundering PPE and house cleaning) and may be pregnant, breastfeeding or immune compromised. The CHAMACOS study involving pregnant women living in farming communities in Salinas Valley California, United States reported that all women enrolled in the study had detectable levels of urinary organophosphate metabolites during their pregnancy (Castorina et al., 2003). Eighty seven percent of these women reported that they lived in a home where one of the household members worked as an agricultural worker (Castorina et al., 2003). This is of significance as the implication is that their unborn babies undergoing rapid development may have been at risk of exposure to pesticide residues and the associated health effects, such as neurodevelopmental or physical developmental effects (Roberts and Karr, 2012).

Of concern, is that infants and children are at increased risk of exposure from contaminated sources (e.g., carpet) in the home because of higher rates of metabolism, developing immune

systems, unique diets and distinctly different behaviours compared to adults (e.g., hand to mouth behaviours) (Arcury et al., 2007; Arbuckle et al., 2004; Curl et al., 2002; Strong et al., 2008; Thompson et al., 2003; Vida and Moretto, 2007). Research conducted in Yakima Valley Washington, United States found that the urinary metabolites of children approximated the levels of pesticide metabolites in adults that lived in the same household; for example, 88% of the urine samples of children had dimethylthiophosphate (DMTP) compared to 92% of the adult samples (Curl et al., 2002). These findings suggest that the exposure levels for children living in farmworker households were similar to exposure levels farmworkers had in the workplace. This not only substantiates the view that children have higher absorption rates than adults but is indicative of the danger of children being indirectly exposed to residues. Furthermore, given that residues persist in the indoor environment for longer periods, contaminated surfaces in the home may serve as a continuous source of exposure for children through the dermal (i.e., skin), oral (e.g., hand-to-mouth behaviours) and respiratory routes and possibly result in adverse health effects.

3. Health effects

Health risks that are associated with any chemical compound are a function of its toxicity and the extent of exposure (Hubal et al., 2000; Tondl and Schulze, 2008). The risk of and severity of health effects that result from pesticide exposure are dependent on numerous factors which include personal characteristics such as age, health status, type of pesticide, extent of exposure and toxicity of formulations (El-Wakeil et al., 2013; Kim et al., 2017).

Health Risk = Toxicity x Exposure

Exposure to residues may result in acute or chronic health effects. Acute effects are characterised by immediate and visible physical symptoms such as respiratory problems

whereas chronic health effects mostly result from extended periods of exposure that may lead to neurological disorders, reproductive effects or cancers (Arcury et al., 2007; Arcury et al., 2009; Helmus et al., 2009). Limited epidemiological evidence exists on the effects of long term exposure to pesticides and the resulting chronic health effects in humans (Arcury et al., 2009; Helmus, 2009; MacFarlane et al., 2013). This is mainly due to the complexity of measuring exposure using biological methods and that existing evidence relied on self-reported questionnaires to determine causality from past exposures (Arcury et al., 2009; MacFarlane et al., 2013; Oesterlund et al., 2014). Consequently, most studies fail to provide evidence on the levels and frequency of exposure, lacked exposure specificity which resulted in diluted effects and inappropriately classified health outcomes (Arbuckle et al., 2004; Arcury et al., 2009; MacFarlane et al., 2013; Nweke and Sanders, 2009; Oesterlund et al., 2014; Roberts and Karr, 2012). This suggests that even when workers and their families are consistently exposed to residues including the harmful effects, accurately quantifying this exposure and its effects are limited. The impact of inappropriately defined health outcomes may be greater in LMICs where there is poor regulation and surveillance of pesticide use. Hence, it is important that pesticide exposure in LMICs is reduced.

WfW forestry workers primarily use herbicides and exploring the literature of the associated health effects was of relevance to understand the risks to which workers and their families may be exposed. Exposure to herbicide compounds in adults has been associated with:

- *cancers* (e.g., bladder cancer, colon cancer, breast cancer, stomach cancer, leukaemia and non-Hodgkins lymphoma) (Alavanja et al., 2004; Kim et al., 2017);
- *neurological symptoms* (e.g., Parkinson's disease and increased meningioma in women) (Kim et al., 2017), a*sthma (e.g.,* bronchial hyperactivity and ocular nasal symptoms) (Kim et al., 2017);
- *diabetes* (e.g., type 2 diabetes and its co-morbidities, incident diabetes and gestational diabetes mellitus during pregnancy) (Kim et al., 2017); and

- *other effects* (e.g., inhibition of spermatogenesis, reduction in sperm activities and testis weight, damaging sperm DNA, spontaneous miscarriage, infant deaths, risk of anxiety and depression leading to suicide, endocrine disruptions and end-stage renal disease) (Kim et al., 2017; Naidoo et al., 2011; Lebov et al., 2015; London et al., 2012; Nweke and Sanders, 2009).

A critical finding from a study conducted amongst applicators' female spouses in Iowa and North Carolina, United States, found that 0.3% developed end-stage renal disease as a result of their husbands using the herbicides paraquat and butylate (Lebov et al., 2015). The reviewed studies described the associated health effects of acute and chronic low-dose herbicide exposure specifically amongst workers (Alavanja et al., 2004; Kim et al., 2017; London et al., 2012; Naidoo et al., 2011). It was concerning that the majority of the described health outcomes in the reviewed studies were severe chronic health effects. Although the levels of indirect exposure amongst worker's families differ and are less compared to workers' direct exposures, families remain at risk of the associated health effects as highlighted by Lebov et al. (2015). Thus, absence of visible immediate symptoms amongst worker's families may not be an indication of wellbeing as they may still be at risk of developing adverse health effects from 'take-home' exposure at later stages.

Since children are more vulnerable to exposure, understanding the effects of exposure on their health was important, particularly in the context of LMICs where children may already be predisposed to disease due to factors such as poverty. Exploring the effects of herbicide exposure in children was relevant for this review as WfW workers mainly use herbicides. In general, the effects of exposure in children have been linked to their physiological systems, namely – the nervous, respiratory and metabolic systems which are undergoing development (Kim et al., 2017; McCauley et al., 2006; Roberts and Karr, 2012). Thus, there is a concern regarding chronic low-dose exposure and the resulting health effects amongst children.

Herbicide exposure in children has been associated with the following health outcomes:

- c*hildhood cancers (*e.g., leukaemia, neuroblastoma, increased risk of central nervous system tumours);
- *neurodevelopment/neurobehavioural effects (*e.g., attention deficit/hyperactivity disorder (ADHD));
- c*ognitive impairment* (e.g., verbal comprehension and working memory at later stages);
- *physical development effects* (e.g., spontaneous abortion, orofacial clefts, limb defects and neural tube defects); and
- e*ndocrine effects* (e.g., endocrine mimicking effects) and a*sthma* (Kim et al., 2017; London et al., 2012; Mostafalou and Abdollahi, 2016; Roberts and Karr, 2012).

These findings demonstrate the detrimental effects for children of potential direct and indirect herbicide exposure. Interestingly, these effects of exposure, that somewhat mimic the health effects in adults directly exposed to residues at the workplace, were as a result of indirect exposure. Few studies exist which show the link between parental pesticide exposure and the development of adverse health effects in children (Mostafalou and Abdollahi, 2016; Roberts and Karr, 2012). Still, these studies do not explicitly state that these links were observed as a result of the 'take-home' pathway.

Given the abovementioned evidence that shows the associated health effects of pesticide exposure, various approaches are needed in order to prevent and reduce the risks of 'take-home' exposure amongst workers and their families.

4. Exposure reduction measures

As workers are a conduit for 'take-home' exposures, reducing their exposures and residue contamination remains key. Workers, especially in LMICs, do not adequately protect themselves and their families from pesticide exposure and the resulting health effects. It has been suggested that this is a result of poor knowledge, incorrect understandings and beliefs regarding the associated risks of exposure, recommended practices at work and at home, and weak

legislative support (Damalas and Abdollahzadeh, 2016; Lekei et al., 2014). Existing literature on training and behavioural interventions at work and home and legislation, specific to 'take-home' exposure was reviewed to identify effective approaches and strategies to reduce this type of exposure among workers and their families.

4.1 Training

Training was identified in the literature as a key intervention for increasing and enhancing worker's knowledge of exposure risks and how they could prevent these. This was supported by the findings of Strong et al. (2008), where it was observed that pesticide safety training provided to farmworkers in Yakima Valley, Washington, United States was directly related to their home protective practices (e.g., 83% reported that they always washed their work clothes separately from household laundry). A subsequent study involving farmworker households in the same region reported that female spouses adopted safety practices in the home as a result of the training provided to their husbands at work (Strong et al., 2009b). Another study noted that launders were not aware of the specific preventative measures they could apply in order to reduce exposure to residues when this was not communicated by workers (Tondl and Schulze, 2008). Therefore, incorporating information related to 'take-home' exposure in the standard training provided to workers may be an effective strategy for raising awareness of the risks of exposure amongst worker's families. This could motivate workers to adopt safety practices to reduce the risk of families' exposure. The findings from the reviewed studies also highlight the importance of workers taking responsibility in informing their families of the risks of exposure.

4.2 Workplace hygiene facilities

In addition to occupational safety training provided to workers to influence their safety practices, contextual and structural factors at the workplace were identified as a critical determinant of whether workers consistently applied the recommended practices (Salvatore et al., 2008).

These included the presence or absence of hygiene facilities such as hand wash facilities, changing areas, storage rooms for work clothes including PPE, laundry or washing facilities, showers as well as the employer's commitment to promoting safety behaviours amongst workers (DellaValle et al., 2012; Thompson et al., 2003; Salvatore et al., 2008). This was well demonstrated by Thompson et al. (2003) who reported that applicators were more likely to take precautionary measures than workers who were not involved in pesticide handling activities as applicators were provided hygiene facilities. The limitation, however, of using a selective approach when providing workers with these facilities based on the type of work they undertake is that workers share responsibilities. Thus, workers who are not designated as applicators may undertake handling activities but may not be permitted to use hygiene facilities for applicators. Furthermore, defining exposure levels on the basis of certain occupational tasks and using this as a determining factor in the provision of hygiene facilities is likely to result in the unequal distribution of protective measures exposure for workers and ultimately their families. A study conducted by Carpenter et al. (2002) amongst farmers in six Midwestern States in the United States, identified that the majority of farmers did not have decontamination stations or hygiene facilities and as a result the most common place where PPE was stored was in the homes of these workers. Given that the nature of forestry work tends to be short-term (Quandt et al., 2013b) and mostly conducted in isolated locations, there may be difficulties in providing workers with hygiene facilities at the workplace. Consequently, workers take and store their PPE at home, including contaminated PPE. On the contrary, a recent study amongst migrant and seasonal farmworkers in North Carolina, United States, showed that even when facilities were available for workers to use, workers only used these facilities 35% of the time before eating and 13% of the time before drinking (Walton et al., 2016). Therefore, there may be other individual factors that need to be considered in developing interventions to reduce exposure, as the provision of facilities did not seem to be the only factor that influenced workers to engage in safety behaviours.

4.3 Workers family's behavioural practices

Targeting interventions in worker's homes and amongst their families may be an additional strategy for reducing 'take-home' exposure risks. Of the few studies aimed at reducing exposure risks through home hygiene practices most alluded to the difficulty of changing workers and their family's behavioural practices at home (Arcury et al., 2009; Cabrera and Leckie, 2009; Fenske et al., 2013; Salvatore et al., 2009; Snipes et al., 2009; Strong et al., 2009b). For example, a study amongst agricultural workers in Lower Yakima Valley, Washington State, United States reported that workers delayed showering after work as they believed that the body should be given time to cool down before showering as this could cause pain in the bones and joints (Snipes et al., 2009). These findings suggest that the individual beliefs and views held by workers and their families may hinder the effectiveness of safety practices aimed at reducing exposure risks. As a result 'take-home' exposure risks may be unintentionally propagated in the home. The working conditions of WfW workers are characterised by hot weather and workers may hold similar beliefs that could impact their ability to adopt safety practices. A behavioural intervention study, the *La Familia Promotora* programme, found that the training provided to mothers from farmworker families in five counties in North West Carolina and in three counties in Virginia, United States was not effective in enhancing their pesticide knowledge and the associated health effects especially health effects in children (Arcury et al., 2009). For example, the difference in mother's knowledge of the effects of pesticide exposure in children before and after the intervention was not significant (i.e., $p = 0.057$). Still, a recent study by Coronado et al. (2012) amongst orchard workers in Yakima Valley, Washington, United States reported that high compliance to home hygiene safety practices (e.g., handwashing practices and glove use) was not associated with the urinary dimethylthiophospate (DMTP) concentrations in farmworkers and their children, as well as the levels of azinphosmethyl (AZM) concentration in the house dust. Thompson et al. (2008), similar to the findings of Coronado et al. (2012),

observed no correlation between home hygiene practices and the reduction of pesticide concentrations in house dust and children's urinary concentration levels. The findings of these studies suggest that behavioural interventions, such as training worker's families as a single intervention, may not be effective in reducing exposure risks. The findings further support the support the view that there may be personal factors amongst workers and their families which have the potential to limit the effectiveness of the interventions. Another study involving women farmworkers identified factors such as; health beliefs, perceived lack of control, differing abilities to change the behaviours of their spouses and cultural dynamics that may be a hindrance to the implementation of safety practices in the home (Strong et al., 2009a). An important consideration raised by the abovementioned studies is that interventions need to take into account the social context in which recommended safe hygiene behaviours occur as there may be many external factors that have the potential to limit the effectiveness of these recommendations in reducing exposure risks.

The findings of the reviewed studies assessing both workplace and home hygiene practices raise questions for future research regarding the most appropriate practices that should be implemented in order to interrupt the 'take-home' pathway; whether both workplace and home hygiene practices should be employed as a combined intervention. Furthermore, the literature demonstrated that changes in work and home practices intended to reduce residue exposure were not likely to be sustained in the absence of the enforcement of existing safety regulations and the implementation of new targeted regulations.

5. Chemical legislation

Legislation is a vital legal basis for promoting the control and enforcement of policies and regulations to protect workers, as well as establishing relevant standards and controls. Furthermore, it is key in ensuring that effective interventions are institutionalised (e.g., through

workplace standard operating procedures) and more importantly, that these interventions remain sustained (WHO, 2010). Thus, in addition to workplace and home interventions aimed at reducing 'take-home' residue exposure, legislation which addresses 'take-home' exposure may be instrumental in reducing this type exposure. As an additional mechanism to reduce 'take-home' residue exposure risks; the existing national legislation in South Africa (S.A.) was examined in light of international legislation, specifically the United States (U.S.) legislation as this was the only legislation, to the knowledge of the researcher, which made reference to 'take-home' exposure risks.

The prevention and management of exposure to chemical substances at the workplace in South Africa is guided by three policies: 1) the Occupational Health and Safety Act (OHSA) (Act no.85 of 1993) (see Appendix F), 2) the Hazardous Chemicals Regulations, 1995 (see Appendix G), and 3) the Pesticide Management Policy for South Africa, 2010 (see Appendix H). The United States (U.S.) is guided by the Environmental Protection Agency Agricultural Worker Protection Standard (WPS), 2015 (see Appendix I). The existing literature on 'take-home' exposure is mostly from studies conducted in the U.S. hence the reference and comparison to the U.S legislation. There was limited literature on 'take-home' exposure from other regions. The comparison of the legislation is discussed below.

5.1 Legislative occupational exposure provisions

5.1.1 Personal Protective Equipment provisions

In terms of the maintenance and care of PPE; the S.A. Hazardous Chemicals Regulations (1995) is more specific regarding the responsibility of the employer than workers. Although this responsibility is appropriately allocated, the limitation is that the provisions do not address how workers themselves should care and maintain their PPE to reduce contamination. This is particularly relevant for South Africa and other LMICs where employers mostly do not provide

decontamination facilities at worksites. On the contrary, the U.S. WPS (2015) includes provisions that specify how workers should care for their PPE (e.g., if PPE will be re-used, clean it before each day of re-use). The legislation further states that employers should not allow workers to take used PPE home; however, this is only relevant to pesticide handlers and not all workers.

5.1.2 Hygiene facility provisions

The provision of decontamination facilities at worksites is essential, as this enables workers to wash and change in order to reduce exposure risks prior to going home. The Hazardous Chemical Substances Regulations (1995) states that employers are responsible for providing workers with containers or storage facilities for PPE when the PPE is not in use and that it should be stored in a designated place. Furthermore, it states that as far as is reasonably practical, workers should be provided with washing facilities, separate lockers for work and personal clothing as well as separate change rooms for soiled work clothing. Since the legislation states that the employer '*may provide hygiene facilities as is reasonably practical'*, employers are not necessarily obliged to provide these facilities to workers. The regulations narrow the recommendations for hygiene facilities to employers who provide these facilities, but fail to provide recommendations in instances where these facilities are not available at worksites. The U.S. WPS, on the other hand, requires employers to provide all workers with one gallon of water for decontamination purposes. However, the standard still differentiates provision of all other hygiene facilities on the basis of occupational task. This is a concern as workers share responsibilities and may be exposed to the similar exposure risks as pesticide handlers. Due to not being designated handlers, however, they may not be permitted to use hygiene facilities provided for handlers (see Section 4.2 Workplace hygiene facilities).

5.1.3 Legislative training provisions

As discussed, training is vital for educating workers on the risks of exposure and the precautions they may take to minimise risks. According to the S.A. legislation and the U.S. legislation, all workers are expected to undergo training which informs them of their tasks, the hazards of their work (e.g., the risk of exposure to harmful substances) and the precautions workers may take to reduce these hazards. The U.S. WPS (2015) mandates that expanded training should be provided to workers and include the aspects of reducing 'take-home' specifically from contaminated work clothing. The Hazardous Chemicals Regulations (1995) states that workers should be trained on the health risks that may arise from exposure as well as protective measures they may take to protect themselves. Although the scope of the S.A. training appears to be exhaustive in informing workers of the associated risks of exposure the legislation makes no reference to the training addressing potential 'take-home' residue exposure risks. Thus, if the training workers receive does not cover critical aspects such as the risk of exposure outside of the workplace and amongst their families, workers are likely to know how to employ minimal protective measures to reduce exposure.

5.2 Legislative 'take-home' provisions

In relation to specific legislation on preventing pesticide residues being taken home from work, the legislation is less specific. The S.A. OHSA (1993) places the responsibility of protecting non-employees on the employer. The legislation states that the employer is responsible for protecting non-employees who may be affected by the activities of the employer. These include contractors or delivery or service workers who visit the workplace and also members of the public who live in close proximity or pass by the activities of the employers. Although this legislation by definition allows itself to extend its scope to the protection of worker families, it appears that the 'protection of non-employees' does not include worker's families.

Furthermore, it is not specific to the protection of worker's families from 'take-home' residue exposure.

In terms of the responsibility of workers, the S.A. legislation specifies that they are responsible for taking care of their health and the health of others. However, the legislation is not specific to who this 'other' constitutes and lends itself to different interpretations. On the other hand, the U.S. WPS establishes a number of regulations both for workers and their families that are specific to the prevention and reduction of 'take-home' exposure risks. The recommendations specific to workers include training that covers the use of protective clothing at work, removal of work clothing and shoes immediately after work, washing or showering with both water and soap, washing hair and changing into clean clothes. Those specific to worker's families include washing and storing work clothes separately from household laundry, dry cleaning PPE before storing. Furthermore, the WPS requires employers to specifically inform handler's families of the following: that PPE may possibly be contaminated with residues, the health effects of pesticide exposure and precautionary measures (e.g., correct procedures for decontamination and cleaning of PPE) worker's families should undertake when handling contaminated work clothing. It is of importance to note that the U.S. WPS has undergone numerous revisions since it came into effect in 1992 and recently revised in 2015. Initially, the U.S. legislation was specific to protecting workers from pesticide exposure at the workplace but has since expanded its scope to protecting worker's families from exposure to workplace residues, unintentionally carried into the home by workers.

The comparison of S.A. the national legislation with U.S. legislation demonstrates that significant gaps exist in the S.A. legislation and opportunities to strengthen protection of workers and their families. The S.A. legislation lacks specificity in regard to the outlined regulations and is not comprehensive in terms of the scope they cover. That is, only occupational exposure risks are covered yet workplace exposure remains the main source of exposure for worker's families.

It was further noted that the S.A. chemical legislation that was developed 20 years ago and possibly out of date continues to be the same legislation that is used to inform current practice. Thus, the main distinguishing factor in the S.A. legislation compared to the U.S. legislation is that none of the S.A. chemical legislation specifically addressed the aspect of 'take-home' residue exposure risks amongst workers and their families, whereas the U.S. WPS (2015) covers this within its scope recognizing that this is an important exposure pathway that employers could prevent.

6. Discussion and identified gaps in literature

The reviewed literature confirmed that the 'take-home' exposure pathway is a risk factor for exposure and its associated adverse health effects for workers and their families, especially children (Arbuckle et al., 2004; Coronado et al., 2006; Curl et al., 2002; El-Wakeil et al., 2013; Goldman et al., 2004; Lucas and Allen, 2009; Strong et al., 2009b; Ward et al., 2006). The strength of the evidence regarding this exposure pathway was that studies attempted to assess the problem from varied perspectives, some employed biological sampling methods (Bradman et al., 2007; Bradman et al., 2009; Lu et al., 2000) whilst others used environmental sampling methods (Arbuckle et al., 2006; Curl et al., 2002; Liu et al., 2014; Lu et al., 2004; Thompson et al., 2003). Still others used observational methods (Walton et al., 2016). All studies were in agreement in terms of para-occupational exposure being a risk for workers and their families and no studies were found, to the knowledge of the researcher, which disputed this pathway of exposure.

Although the literature described the various sources of exposure for worker's families (Arcury et al., 2007; Coronado et al., 2006; Curl et al., 2002; Hubal et al., 2000; Quiros-Alcala et al., 2011; Roberts and Karr et al., 2012; Simcox et al., 1995; Strong et al., 2009a; Vida and Moretto, 2007); only two of these studies, examined contaminated work clothing as a source of exposure

for worker's families (Deziel et al., 2015; Tondl and Schulze 2008). The scope of these studies were also limited to launderers of the work clothing and thus did not holistically characterise contaminated work clothing as a potential source of exposure for all those living with workers. Therefore, the extent to which contaminated PPE was a source of exposure for worker's families was not well defined in the literature.

Overall, the reported evidence on herbicide exposure and the development of adverse health effects was not without its limitations. Two studies reviewing evidence related to exposure and the associated health effects both reported that in some cases the findings were contradictory or inconclusive (Mostafalou and Abdollahi, 2016; Roberts and Karr, 2012). This pointed to the need for further research in this regard. Evidence relating to health effects resulting from herbicide exposure amongst forestry workers was limited. No studies assessed the health effects of low-dose herbicide residue exposure as a result of the 'take-home' pathway amongst forestry worker's families. Even evidence regarding the associated health effects of 'take-home' exposure amongst agricultural populations was limited, as only one study was found to demonstrate the associated health effects of 'take-home' exposure (Lebov et al., 2015). Additional studies investigating herbicide health effects specifically as a result of the 'take-home' pathway should be undertaken in order to appropriately define the health effects of 'para-occupational' exposure.

The expectation that training alone would be sufficient to change worker's behaviours failed to take into account that there were external factors (e.g., absence or provision of hygiene facilities at work) which contributed to the change in worker's practices (Thompson et al., 2003; Salvatore et al., 2008). Existing evidence that demonstrated workplace behavioural interventions were studies specifically conducted in agricultural populations with no intervention studies conducted amongst forestry worker populations. There was limited research and evidence to date, however, regarding the effectiveness of the combination of workplace and

home practices; only one behavioural intervention study evaluated the combination of workplace and home practices as outlined in the U.S. WPS (2015) as a means to reduce exposure amongst worker's families (Coronado et al., 2012). Although this study found that these combined practices were not effective in reducing exposure in the homes of workers, conclusions cannot be made on the basis of the findings of one study. Therefore, further investigation on the success of combined interventions is needed.

The standards regulating use of hazardous chemicals differ from country to country; thus countries can only be held accountable to the provisions and recommendations outlined in their country specific policy frameworks (Naidoo et al., 2010). This is a challenge particularly when national legislation is not on par with progressive international legislation (e.g., U.S. WPS) as in the case of South Africa, which does not cover the prevention and reduction of 'take-home' exposure amongst workers and their families. The absence of addressing 'take-home' exposure in the S.A. legislation may also be indicative of the lack of evidence that this type of exposure is a threat to worker's families in S.A.

7. Conclusion

The existing literature from HICs clearly demonstrated the risk of 'take-home' exposure and its associated health effects amongst workers and their families. This was mainly as a result of residues being transported from the workplace into the home. This problem was well characterised in HICs (e.g., United States and Canada) particularly amongst agricultural workers (i.e., farmworkers) and their families who use multiple types of pesticides. The extent to which para-occupational exposure may be a risk amongst workers and their families, particularly forestry workers and their families, in LMICs such as South Africa, however, is not known. The absence of evidence related to 'take-home' exposure in LMICs has resulted in critical omissions in the South African legislation or the lack of revisions thereof. This has also resulted in

interventions to reduce herbicide exposure and its associated effects being limited to the workplace. These limitations in the existing evidence necessitates the need for research that appropriately characterises the issue of ‘take-home’ exposure amongst workers and their families in South Africa and informs legislation or policy.

8. References

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Part C: Manuscript

Whose Jurisdiction is Home Contamination? Para-Occupational 'Take-Home' Herbicide Residue Exposure Risks amongst Forestry Worker's Families in South Africa[1]

[1] This journal manuscript is written in accordance with requirements as stated in the submission guidelines for authors of the ELSEVIER Health & Place: An International Journal **(Appendix J).** There was one change made from journal submission guidelines in order to keep with instructions for the mini-thesis, namely; images have been inserted in the text of the dissertation instead of as separate files as required by the journal.

Table of Contents

Graphical Abstract

Para-occupational ‘take-home’ herbicide exposure risks

Abstract

Para-occupational 'take-home' exposure risks amongst forestry workers and their families in Low-and middle-income countries (LMICs) are not well characterised. This is a concern as research shows there is an association between chronic low-dose herbicide exposure and adverse health effects. This study explored 'take-home' herbicide residue exposure risks amongst forestry workers in the Western Cape, South Africa using components of the community based participatory research approach, *photovoice*. Low compliance to safety practices at worksites was identified as the main risk factor for 'take-home' exposure. This study demonstrated evidence related to workers' 'taking-home' herbicide residues and exposing their families to potential health risks from low-dose exposures.

Highlights

- Para-occupational 'take-home' herbicide residue exposure risks is occurring amongst South African forestry worker's families.
- Self-taken photographs are useful a method for documenting 'take-home' exposure risks.
- Low compliance to safety practices at work was identified as the main risk factor for 'take-home' herbicide residue exposure risks.
- Workplace policies and standard operating procedures did not cover aspects related to 'take-home' exposure risks.
- National legislation has not established standards and regulations related to preventing 'take-home' exposure risks.

Key words

Para-occupational 'take-home' exposure
Pesticides
Personal Protective Equipment (PPE)
Forestry workers
Chemical legislation

1. Introduction

Herbicides are a pesticide used extensively to eradicate and manage invasive alien plant species. Unintentional exposure to herbicide residues, however, may be harmful to non-target organisms (Damalas and Abdollahzadeh, 2016; Kim et al., 2017; Lucas and Allen, 2009). This includes humans who work with or come into contact with residues. Worker's families in particular may be exposed to herbicide residues at home through the para-occupational 'take-home' exposure pathway. This is despite the home being perceived to be safe from workplace exposures. Furthermore, evidence is increasingly showing an association between herbicide exposure and the development of adverse health effects (Alavanja et al., 2004; Kim et al., 2017; Lebov et al., 2015; London et al., 2012; Mostafalou and Abdollahi, 2016; Naidoo et al., 2011). This represents a significant public health problem, particularly in Low-and middle-income countries (LMICs) where the actual incidence of occupational and non-occupational poisoning is not well documented. Pesticide exposure risks in LMICs have been linked to weak legislative and policy frameworks that regulate use, inadequate training, limited access to information and education, and minimal use of personal protective equipment (PPE) amongst others (Andrade-Rivas and Rother, 2015; Ecobichon, 2001; London and Rother, 2001). Research on 'take-home' exposure risks among agricultural populations in High-income countries (HICs) has been extensive. Given existing evidence of 'take-home'' exposure risks in agricultural related research, the assumption is that forestry workers and their families also experience similar risks. The extent to which 'take-home' herbicide residue exposure is a risk factor amongst forestry workers and their families in LMICs, however, is not known. This research documented a group of forestry workers practices employed under the South African Working for Water (WfW) programme which primarily uses herbicides in the removal of alien plant species. It focuses on practices in relation to workers' care and maintenance of Personal Protective Equipment (PPE)

as a means of identifying potential 'take-home' herbicide residue exposure risks for their families.

1.1 Para-occupational 'take-home' exposure

Para-occupational 'take-home' exposure has been defined as indirect exposure that occurs when workers unintentionally transport pesticide residues on their skin, hair, clothing, shoes and vehicles from the workplace into their homes (Arcury et al., 2007; Arcury et al., 2009; Curl et al., 2002; Lu et al., 2000; Nweke and Sanders, 2009; Roberts and Karr, 2012; Strong et al., 2009a; Strong et al., 2009b; Thompson et al., 2003; Thompson et al., 2008; Vida and Moretto, 2007). Concern for this exposure pathway was initially raised in 1995 by a Centers for Disease Control National Institute for Occupational Safety and Health (NIOSH) study. The study highlighted the contamination of worker's homes with workplace chemicals, including pesticides in 28 countries and 36 states in the United States (NIOSH, 1995; NIOSH, 2002). Subsequent research conducted in High-income countries (HICs) confirms that pesticides, such as herbicides, accumulate in worker's homes (Arbuckle et al., 2004; Curl et al., 2002; Curwin et al., 2005; Lu et al., 2000; Simcox et al., 1995; Strong et al., 2007; Thompson et al., 2003; Thompson et al., 2008; Vida and Moretto, 2007; Ward et al., 2006). Although unintentional, this exposes their families to workplace residues and the resulting health risks. Children, particularly, have been identified as having increased health risks to these exposures. This is mainly due to their high rates of metabolism, developing immune systems and distinctly different behaviours (e.g., hand to mouth practices, playing on the floor) compared to adults (Arcury et al., 2007; Arbuckle et al., 2004; Curl et al., 2002; Strong et al., 2008; Thompson et al., 2003; Vida and Moretto, 2007). Children spend extensive time indoors which is concerning, as a study amongst farmworkers in North Carolina provided evidence of the persistence of pesticides in the indoor environment (Arcury et al., 2014). Concentrations of occupational pesticides no longer registered for use in the United States (U.S.) were identified in the homes of these farmworkers. Thus, workers

families may continually be exposed to residues long after pesticides have been transported into the home. The evidence further shows the difficulty of effectively decontaminating worker's homes once residues have entered. Following the pioneering work of the NIOSH study (1995), the findings of Arcury et al. (2014) confirm that 'take-home' pesticide exposure remains a risk to workers and their families, thus a public health problem.

1.2 Personal Protective Equipment as a source of 'take-home' exposure

Despite Personal Protective Equipment (PPE) being an important workplace exposure risk reduction measure, it may also be a source of 'take-home' residues (Bradman et al., 2009; MacFarlane et al., 2008). A study by Curwin et al. (2005) amongst farmworkers in Iowa U.S provided evidence of herbicide residues (i.e., atrazine, metolachlor, glyphosate, and 2,4-D) being tracked into the homes of farmworkers on their clothing and boots. The study noted that the entrance ways, change areas and laundry rooms in farm homes had higher concentrations of herbicide residues compared to other rooms in the home (Curwin et al., 2005). Another study by Curl et al. (2002) in Yakima Valley, Washington found a strong association between azinphosmethyl concentrations detected in the vehicle dust and in the house dust. These findings demonstrate that workers transport workplace residues on their PPE into the home and contaminate household surfaces used by other household members (Arbuckle et al., 2006; Bradman et al., 2009; Liu et al., 2014; Tondl and Schulze, 2008).

1.3 Herbicide exposure and chronic health effects

Long term, low-dose exposure to pesticides, such as herbicides, has been associated with chronic health effects. These are characterised by mild symptoms which remain unrecognised for long periods, as they are similar to common health illnesses (Helmus, 2009). Thus, the extent and severity of herbicide exposure risks are still not widely known in LMICs (Helmus, 2009; Lekei et al., 2014; Nweke and Sanders, 2009). Exposure, specifically to herbicide

residues, has been associated with the following health effects: non-Hodgkin lymphoma, Parkinson's Disease, asthma, type 2 diabetes, bladder, colon and breast cancers; end stage renal disease, increased risk of anxiety and depression resulting in suicide, spontaneous miscarriage and increased infant deaths (Alavanja et al., 2004; Kim et al., 2017; Lebov et al., 2015; London et al., 2012; Mostafalou and Abdollahi, 2016; Naidoo et al., 2011). Studies have further reported the development of adverse health effects in children as a result of parental herbicide exposure. These effects include: leukemia, increased risk of childhood brain defects, adverse neurodevelopmental and neurobehavioral outcomes including attention deficit/hyperactivity disorder (ADHD), cognitive impairment, birth defects (e.g., orofacial clefts), asthma and endocrine mimicking effects (Kim et al., 2017; London et al., 2012; Roberts and Karr, 2012). Limited evidence, however, exists which ascertains the extent of these health effects attributed to 'take-home' exposure. Only one study conducted in Iowa and North Carolina, U.S. examined the health effects of 'take-home' exposure amongst workers families. The study followed a group of herbicide applicators and their female spouses over a period of five years and found that long term exposure to paraquat and butylate was associated with the development of end-stage renal disease amongst their female spouses who had never had direct contact with these herbicides (Lebov et al., 2015). Although the levels of exposure for worker's families are indirect and therefore considered less compared to direct exposures by workers, they remain at risk of the associated health effects from indirect exposure to residues. Therefore, the absence of visible immediate symptoms by family members may not be an indication of no risk, as they may develop adverse health effects from 'take-home' exposure at a later stage.

2. Methods

This study took place between February and May 2016 as part of a larger research project, which sought to explore WfW forestry workers herbicide exposure risks. Previous studies under

the parent study focused on investigating factors related to worker's occupational herbicide exposure risks (Andrade-Rivas and Rother, 2015). However none of these studies made reference to non-occupational exposure risks.

2.1 Research setting

This study was conducted at four study sites in the Western Cape Province, South Africa: Gouda, Citrusdal, Liesbeek Rivers and Westlake (**Figure 1**). The Western Cape is located in the south-western part of South Africa, and it is the fourth largest province out of nine in terms of land area (129, 449 square kilometres) and also has the fourth largest population (5.82 million people) in the country (Stats SA, 2012; Western Province, 2005). In terms of topography, the province lies between parallel ranges of sandstone folded mountains which vary in height from 1000m to 2300m. The landscape is characterised by semi-desert conditions in the west and north and forests on the periphery of the southern coastline. The province is also rich in biological diversity and has varied vegetation (Western Cape Province, 2005). The increasing presence of invasive alien plant species, however, poses a threat to the biodiversity of the province and the country as a whole as these plants affect both terrestrial and freshwater ecosystems (van Wilgen et al., 2001). To address this issue, the national Working for Water (WfW) programme was introduced to remove, control and manage invasive alien plant species and restore indigenous low water consuming vegetation (van Wilgen et al., 2012). Contracted forestry workers under the WfW programme make of use chemical control methods (e.g., herbicides) to manage alien plant species. The estimated volume of herbicide use per hectare is as follows: medium infestation is 75%, sparse infestation is 50%, scattered infestation 25%, very scattered infestation is 10% and occasional infestation is 1% (WfW, 2015).

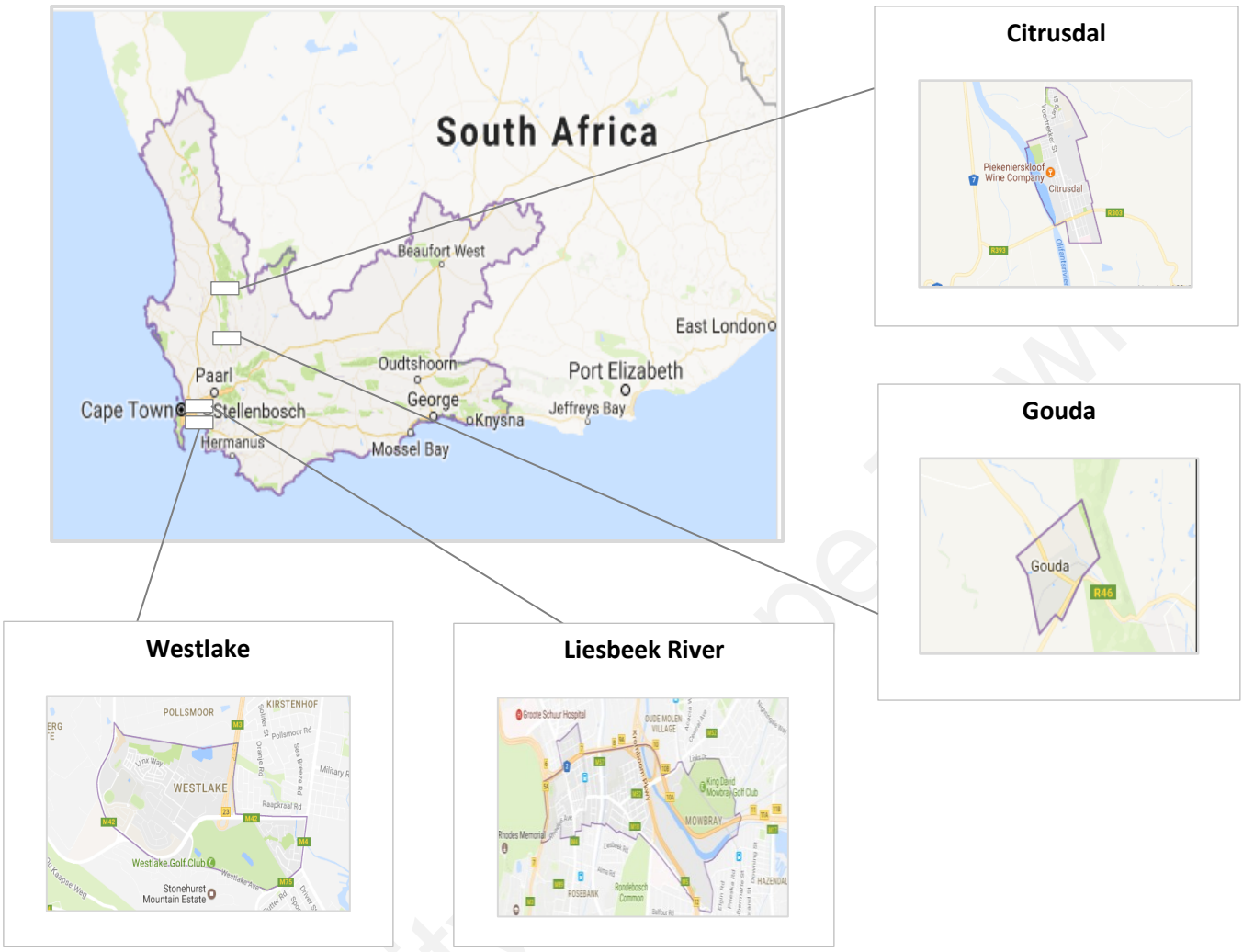

Figure 1: Location of the study sites in the Western Cape Province, South Africa.

2.2 Study population

The study population comprised of 37 WfW forestry workers from four research sites (**Table 1**). To be included in the study participants had to be: 1) community members recruited by contractors under the WfW programme, 2) responsible for either mixing, handling or spraying tasks, and 3) involved in clearing alien vegetation at one of the four study sites. Participants were selected in consultation with the WfW management, using purposive sampling methods. Female workers comprised 65% of study participants. More than half of the study participants spoke in the local languages (i.e., Afrikaans - 32% and isiXhosa - 22%).

Table 1: Study participant demographics by research site

Research Site	Total Participants (N=37)	Sex	Language
Citrusdal	11	Males = 5 Females = 6	Afrikaans
Gouda (de Hock estate)	10	Males = 4 Females = 6	English
Liesbeek River	8	Males = 1 Females = 7	Afrikaans (1) English (7)
Westlake	8	Males = 3 Females = 5	isiXhosa

2.3 Data collection

The data for this research were collected through a *photovoice* approach and a document review.

2.3.1 *Photovoice approach*

This study used aspects of the *photovoice* research method to document WfW forestry workers and their families herbicide 'take-home' exposure risks. *Photovoice* is a community-based participatory research (CBPR) approach that uses visual methods to raise community concerns such health or environmental concerns. It aims to address existing inequities and ultimately drive social change (Catalani and Minkler, 2010; Dennis et al., 2009; Stedman-Smith et al., 2012; Wang and Pies, 2004). Through *photovoice*, community participants are provided with cameras to photograph the reality of their life and work circumstances (Wang and Pies, 2004; Mitchell and Sommer, 2016). By visually representing their concerns, participants are enabled to express their views and influence decisions. *Photovoice* has been instrumental in empowering marginalised communities by enabling them to contribute to change within their communities (Madrigal et al., 2014).

Each participant was issued with a disposable camera which contained 27 exposures. Thereafter, they were provided with basic training on how to use a camera and photo taking etiquette by fieldworkers who were conversant in Afrikaans and isiXhosa. Participants used the cameras to document their practices related to the care and maintenance of PPE for the duration of one week. This was followed by four focus group discussions, one per worksite, where the photographs they captured were presented to them. It is important to note that the participant's faces in the photographs were blurred out to ensure that workers were protected from being easily identified. Each focus group consisted of approximately 10 WfW workers. The sessions were facilitated by the research staff and fieldworkers guided by the *Photovoice Focus Group Guide* (see Appendix C) and lasted approximately 1.5 to 2 hours. Focus group participants were requested to respond to general questions and more specific questions regarding the photographs they had taken (see Appendix C). This enabled participants to interpret the photographs, openly discuss their views and critically engage on what they saw. These focus group discussions were audio-recorded with the permission of the study participants. The worker's employment was not placed at risk as a result of their participation in the study. The WfW management were aware that the scope of the study involved workers taking photographs of their work and home environment as part of strategies to improve their working conditions. This study adapted one of the pillars of *photovoice* research, social action – that is, the participant's did not engage directly with policy makers and officials on the risks of 'take-home' exposure as documented in their photographs during the focus group discussions.

2.3.2 Document review

Eight WfW programme documents[2] were selected and included in the study on the basis of being the key operational and training documents that are relevant to WfW workers. They were

[2] The eight WfW programme documents that were assessed are as follows: 1) *SANS 10118, 2011; 2) Policy on the use of herbicides and mycoherbicides for the control of alien vegetation, 2012; 3) Pesticide safety and application*

assessed for information related to 'take-home' residue exposure risks. These included workplace policies (e.g., WfW programme HIV and AIDS policy), standard guidelines for contractors, guidelines for training and information and educational material. In addition, three national chemical policies and one United States (U.S.) chemical policy were reviewed to assess provisions related to 'take-home' exposure risks. The national legislation was specifically compared to the U.S. legislation as this was the only legislation, to the knowledge of the researchers, which made reference to 'take-home' exposure risks.

2.4 Data analysis

Data analysis was comprised of three phases: 1) analysis of key WfW programme documents and national and international policies, 2) participant-led analysis of self-taken photographs during focus group discussions, and 3) researchers' analysis of all photographs captured by participants. Data from all three phases were imported into the qualitative data analysis software, Nvivo 11 and were sorted, organised and coded. Thematic analysis was used to code findings from the focus group discussions and the photographs taken by participants. This assisted in identifying, analysing and reporting the recurring themes emerging from the data.

Following the document review, the second phase of data analysis was mainly driven by the participants. This involved a) contextualising the photographs, where participants conveyed their opinions of the visual representation of their families being exposed to workplace residues at home with an attempt to link this to underlying causes, and b) coding photographs where common themes that arose were categorised and grouped (Catalani and Minkler, 2010). The transcripts of all four focus group discussions were compared and contrasted. Although, study

equipment: Sprayer operator pocket book, 2003 4) First aiders and occupational health services facilities, 2012; 5) WfW workplace HIV/AIDS policy, 2004; 6) WfW rules and regulations, 2012; 7) WfW induction training manual; 8) WfW invasive plant management - treatment methods, 2007.

would have benefitted from comparisons across the different worksites, this was beyond the scope of the study.

Since this study adapted traditional *photovoice* methods, the third phase involved the analysis of the entire dataset of the photographs taken by participants. This was used as a means to validate the key themes identified by the participants. Additionally, it was used to identify key factors related to 'take-home' herbicide exposure risks for worker's families which participants had not identified. This phase provided a basis of ensuring that the photographs rather than the participant's transcripts answered the research question (Catalani and Minkler, 2010).

This study was granted ethics approval by the University of Cape Town Health Science Faculty Human Research Ethics Committee (HREC Ref: 114/2017). Written informed consent was obtained from all study participants in their preferred language prior to agreeing to take part in the study.

3. Results and discussion

This section presents the findings and discussion of the document review and those emanating from photographs analysed by the participants and researchers.

3.1 Document review findings

3.1.1 Absence of 'take-home' exposure in workplace policies

The absence of information related to the risk of 'take-home' residue exposure was identified as a key gap in the existing WfW programme documents and South African national chemical legislation. The topics covered in the WfW Standard Operating Procedures (SOPs) predominately focused on aspects related to the risks of herbicides to the environment and worker's health in general. The SOPs further recommended exposure reduction measures for workers to decrease exposure risks at work. None of the WfW training documents reviewed

addressed ‘take-home’ exposure risks and provided risk reduction measures. Neither was ‘take-home’ exposure included in the information and education material issued to workers, such as the *Pesticide safety and application equipment: Sprayer operator pocket book, 2003*. The remaining WfW programme documents reviewed (e.g., *SANS 10118, 2011; First aiders and occupational health services facilities, 2012* and *the WfW Invasive Plant Management - Treatment Methods, 2007)* also did not cover the aspect of ‘take-home’ exposure risks. In relation to non-worker exposures, one document (i.e., *Policy on the use of herbicides and mycoherbicides for the control of alien vegetation, 2012)* emphasised the need to inform those living near to treated areas of exposure risks.

3.1.2 Lack of policy support

National legislation relevant for pesticide exposure risks also does not address the issue of para-occupational exposures and potential health risks. In South Africa (S.A.), the prevention and management of occupational pesticide exposure is guided by the following legislation: the *Occupational Health and Safety Act (OHSA) (Act no.85 of 1993),* the *Hazardous Chemicals Regulations (1995)* and the *Pesticide Management Policy for South Africa (2010).* To illustrate the gaps, the S.A. legislation was compared to the relevant legislation in the United States (U.S.) is for pesticides which is guided the *Environmental Protection Agency (EPA) Agricultural Worker Protection Standard (WPS) (2015)* and previously the *Worker’s Families Protection Act, 1992* (**Table 2**). The existing literature on ‘take-home’ exposure is mostly from studies conducted in the U.S. hence the reference and comparison to the U.S. legislation. There was limited literature on ‘take-home’ exposure from other regions. The table below further highlights the variance in the availability of provisions related to occupational exposure in the legislation versus those linked to non-occupational exposure.

Table 2: Comparison of S.A. and U.S. legislative provisions for occupational and non-occupational exposure

Chemical Legislation Provisions	United States	South Africa
Occupational Exposure *(Protection of workers)*	1) Environmental Protection Agency, Agricultural Worker Protection Standard (2015)	1) Occupational Health and Safety Act (Act no.85 of 1993) 2) Hazardous Chemical Substances Regulations (1995) 3) Pesticide management policy for South Africa (2010) formally Fertilizers, farm feeds, agricultural remedies and stock remedies Act (Act no.36 of 1947)
Non-occupational Exposure *(Protection of worker's families)*	1) Worker's Families Protection Act (1992) 2) Environmental Protection Agency, Agricultural Worker Protection Standard (2015)	1) None

Training was identified as the standard approach that is used in both countries to inform workers of risks of exposure. It was noted, however, that the training provisions in the S.A. legislation do not address 'take-home' residue exposure risks. On the contrary, the U.S. WPS (2015) requires employers to train workers on the risks of 'take-home' exposure and the sources of exposure such as contaminated work clothing. This training encompasses practices they and their families may take to prevent and reduce exposure at home (e.g., washing and storing work clothes separately from household laundry and dry cleaning PPE before storing). To aid workers in reducing occupational exposure risks, the U.S. WPS (2015) further requires employers to provide hygiene facilities at worksites for decontamination purposes. These include a gallon of water, soap and single-use towels. According to the S.A. chemical legislation, employers are not obliged to provide hygiene facilities at worksites. Additionally, the legislation does not outline

recommended practices for workers to reduce exposure when these facilities are not available at work.

PPE is a key source of take home residues. The U.S. WPS (2015) specifies the employer's responsibility for the care and maintenance of PPE. It further mandates employers to inform those (e.g., worker's families) who clean PPE at home of the recommended decontamination procedures. Similar to the U.S., the S.A. legislation is clear regarding the responsibility of the employer in maintenance and care of PPE in relation to the workers having adequate and functional equipment. A limitation, however, is that the S.A. legislation does not provide guidance for workers maintaining or cleaning PPE in a non-work context so as to reduce the likelihood of residues being transported home.

Thus, the main distinguishing factor between the S.A. and U.S. legislation is that the S.A. chemical legislation falls short of recognising 'take-home' exposure risks for workers and their families. This may have been the main reason for the exclusion of 'take-home' exposure risks in the WfW programme documentation. Furthermore, this was likely to influence WfW workers practices at work and home, that is, whether they would undertake precautions to reduce 'take-home' exposure. A survey conducted amongst farmers in five Midwestern States in the U.S. observed two factors namely, government regulations and concerns for other family members that motivated workers to adhere to workplace requirements (Carpenter et al., 2002). This raises an important argument for workers in S.A. given that the existing chemical legislation does not cover 'take-home' exposure. Furthermore, workplace programme documents aligned to the country chemical legislation also omit 'take-home' residue exposure risks. Consequently, workers may not be aware of the risks of this type of exposure for their families through the training they receive at work and may not be motivated to employ protective measures to reduce exposure risks. Therefore, incorporating provisions related to 'take-home' exposure in the national legislation and ensuring that workplace policies align to this may be an important

prevention measure for reducing 'take-home' residue exposure. Of importance, is that the absence of provisions related to 'take-home' exposure risks in the S.A. chemical legislation may be indicative of the lack of evidence that 'take-home' exposure is a problem in the country.

3.2 Photograph findings

Three main themes emerged during the focus group discussions related to 'take-home' herbicide residue exposure risks. These are: 1) worker's workplace practices, 2) worker's after work behaviours, and 3) home hygiene practices. Three sub-themes were further identified under the main theme of home-hygiene practices which included: laundering practices, laundry drying practices and storage practices. The identified themes from the focus group discussions correlated with those emerging from the analysis of the entire body of photographs by researchers. However, an additional theme was identified through the analysis by the researchers namely; worker's living conditions.

3.2.1 Workplace practices

All 37 participants visually documented their use of PPE at their respective worksites in order to identify practices that may be a risk for 'take-home' exposure. Several photographs revealed workers not implementing the minimum precautionary measures such as the use of gloves and long sleeved t-shirts whilst engaged in mixing spraying tasks (**Photo 1**). Failure to adhere to the required PPE during these tasks resulted in exposure to herbicide residues through the dermal route. Thus, residues which settled on worker's skin may have been transported into their homes serving as a source of 'take-home' exposure for their families. Female workers were more likely to wear full PPE which included trousers, long sleeved coat, safety boots, chemical resistant gloves, goggles and a hard hat than to their male counterparts. No workers wore the prescribed respirators whilst mixing, pouring or handling herbicide formulations. This illustrates that in addition to the dermal route, workers were exposed to residues through the respiratory

route. Although this was not likely to be a source of exposure for their families, workers themselves were at risk of the harmful effects of exposure. Despite PPE being a protective measure against exposure, worker's workplace behaviours during handling and mixing may result in PPE being a source of 'take-home' exposure for their families, particularly when contaminated. One participant had blue herbicide dye spots[3] on the back of his PPE from carrying a back-sprayer machine, depicting the spillage of the herbicide formulations at work. Since workers take their PPE home, their families may be exposed to residues transported on the workers clothing. These findings were consistent with other studies which have shown a direct link between worker's practices at work and the risk of pesticide exposure amongst their families (Arbuckle et al., 2006; Damalas and Abdollahzadeh, 2016; Naidoo et al., 2010). An evaluation of a community-based participatory worksite-intervention conducted in Lower Yakima Valley, Washington State, U.S described that workers who wore complete PPE had lower levels of dimethyl alkylphosphates (DMAP) and malathion dicarboxylic acid (MDA) concentrations in their urine (Strong et al., 2009b). This was as a result of PPE contributing to the reduction of residues being absorbed through the dermal route. Therefore, worker's compliance to the required PPE remains an important contributing factor in reducing 'take-home' exposure risks amongst worker's families.

Another important exposure contributing factor was the worker's working conditions such as forest terrain (**Photo 1**). Decontamination and hygiene facilities (e.g., washing, changing facilities) were not available at the participants' worksites. This impacted the worker's ability to carry out hygiene practices at work and all workers had to take their PPE home, including contaminated PPE, despite the S.A. chemical legislation not being specific to how workers should care for and maintain their PPE. Salvatore et al. (2008) raised a critical point, that over and above providing training, contextual and structural factors such as the provision of hygiene

[3] Blue dye is mixed with herbicide formulations and assists with measuring the amount of herbicide formulation that is applied on plants.

facilities, influenced whether workers consistently carried out recommended practices. Therefore, the provision of hygiene facilities at worksites may be one of the key interventions to reduce the likelihood of residues being transported into worker's homes. Given the transient nature of forestry work and the difficulty of having fixed hygiene facilities, mobile decontamination and hygiene facilities (e.g., hand washing facilities) are recommended.

Photo 1: Dermal exposure to herbicide formulations and worker's working conditions

3.2.2 Post work behaviours

An additional theme identified by workers emerging from the photos for potential 'take-home' residue exposure risks was post work behaviours. These included worker's practices related to their care and maintenance of PPE when they arrive home after work. Just under half (i.e., 43%) of workers wore their PPE inside the home. Photographs showed workers did not always change or shower immediately after work at home.

> *"Some days it is too hot to wash your body right after work because one is just sweating too much" (WfW worker A, Citrusdal).*

These findings correlated with the results of a study amongst agricultural workers in Lower Yakima Valley, Washington State, U.S. which reported that workers delayed showering at their

homes after work. They believed that the body should be given time to cool down before showering as this could cause pain in the bones and joints (Snipes et al., 2009). A study by Strong et al. (2009a) in farmworker households also in Lower Yakima Valley, Washington State, U.S. found that showering immediately after work was contrary to the majority of women's health beliefs. An important consideration raised by the findings of this study and the abovementioned studies is that worker's perceptions as well as their social context largely determine whether they practice recommended safety behaviours. Thus, interventions to reduce exposure risks would need to take these factors into cognisance as they have potential to limit the effectiveness of these recommendations.

One of the participants photographed their boots being removed before they entered the home. However, it was not clear whether this practice was related to precautionary measures to reduce 'take-home' exposure risks or other reasons such as their general cleanliness culture. Still, this practice was an anomaly as numerous photographs illustrated worker's entering their homes whilst wearing work boots (this included visibly soiled work boots). Other items of PPE (e.g., trousers and long sleeve coats) were often left out in the open on household surfaces such as the bed. Studies have documented similar findings, describing that the majority of workers entered their homes whilst wearing work clothing (Fenske et al., 2013; Quiros-Alcala et al., 2011; Salvatore et al., 2009). Of concern, is **Photo 2** which illustrates a participant sitting on a household surface wearing contaminated PPE, indicated by the blue dye (added to all WfW herbicides) spots on the t-shirt. Blue spots were also noted on the worker's arms and hands indicative of direct exposure at work and potentially high residues. This provided clear evidence of this worker (and potentially others) transporting herbicide residues into their homes. The risk, therefore, is high of contaminating household surfaces and family members directly or indirectly.

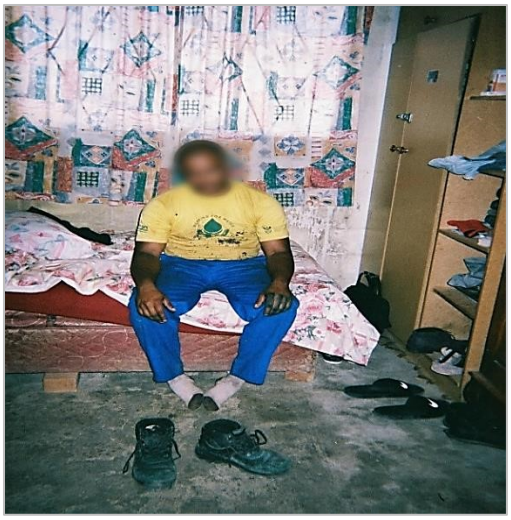

Photo 2: Herbicide residues (blue) on worker's hands, clothing and boots.

The inconsistencies in the participants' post work behaviours were indicative of their lack of knowledge of 'take-home' exposure risks and practices to reduce exposure risks amongst their families. A study amongst farmworkers in Salinas Valley, California, U.S., however, reported that even when workers received training on general safety practices, the majority still wore their work boots inside the home (Cabrera and Leckie, 2009). These findings demonstrate the complexities involved in changing workers behaviours at home, even when workers are well informed of 'take-home' exposure risks. The findings further indicate the difficulty in workers understanding that even though residues are not visible, they may be harmful leading to adverse health effects for their families or continued exposure. Thus, addressing worker's practices (e.g., mandatory changing, washing or storing of PPE) at work may be more effective in reducing 'take-home' herbicide exposure risks as control measures may be more easily enforced at the workplace.

3.2.3 Home hygiene practices

Home hygiene practices in relation to the care and maintenance of PPE was the third theme identified through the focus group discussions with participants. Laundering practices, laundry

drying practices and storage practices of clean and contaminated PPE were the three sub-themes identified within the main theme.

Laundry practices

Due to the absence of decontamination and washing facilities at worksites, all WfW workers washed their PPE at home. In most cases, women washed the PPE. Although all workers had access to water to wash their PPE at home, the distance of the water facilities varied. Some participants had running water in their homes whilst others used communal water taps. The majority (i.e., 35) of participants hand-washed their PPE and only two workers used washing machines. It was noted that those who hand-washed their PPE did not wear chemical resistant gloves to protect themselves from dermal exposure to herbicide residues. It was likely these launderers were exposed to residues that had remained on the PPE. These findings were similar to those observed by Tondl and Schulze (2008) in a study amongst applicators and launderers in Nebraska, U.S., where 80% of workers did not wear waterproof or chemical resistant gloves whilst laundering contaminated work clothing. Of the 37 participants in the study, 18 (49%) laundered PPE separately from household laundry whereas 4 (11%) participants mixed their PPE with household laundry (**Photo 3**). The photographs showing the laundering practices of the remaining participants had to be discarded and could not be included in the study due to the quality of photographs taken. Interestingly, both participants in this study that used washing machines mixed their PPE with household laundry. The above findings suggest that some workers were aware of the risks of mixing household laundry with contaminated PPE and therefore employed protective measures to reduce residue exposure risks. It was a concern that some workers mixed household laundry with their PPE whilst washing. A study amongst farmworkers in Monterey County, California, U.S. observed similar findings and reported that only six percent of workers in their study washed work clothes separately from household laundry (Walton et al., 2016). Although a larger percentage of WfW

workers washed their PPE separately from household laundry, these findings and those of Walton et al. (2016) indicate that a significant number of workers were unaware that residues remaining on their work clothing may be transferred to household laundry. The findings further indicate that there were other factors that contributed to workers not employing protective practices. During group discussions, participants emphasised challenges relating to washing PPE separately from household laundry.

> *"Washing PPE separately means many trips to fetch water and this is difficult as the water point is very far away" (WfW worker G, Gouda).*

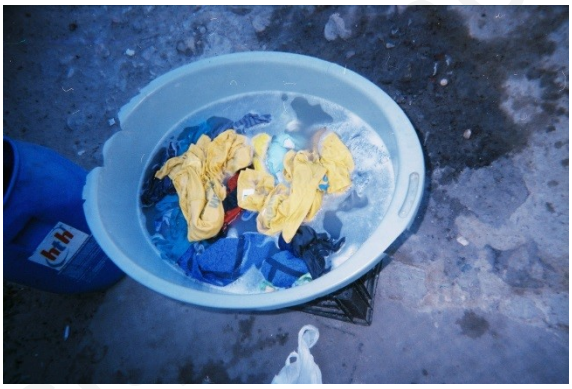

Photo 3: WfW PPE mixed with household laundry during washing

Water used to wash PPE was in some cases a source of exposure for worker's families especially children. One of the participant's children was photographed touching the contaminated water used to launder PPE (**Photo 4**).

Photo 4: Child (right) touching contaminated PPE water.

Laundry drying practices

Practices related to drying washed PPE were inconsistent. Some workers dried PPE together with household laundry (**Photo 5**) whilst others dried it separately. During focus group discussions, participants held the view that drying PPE together with household laundry did not pose a risk, stating that they were unaware that residues may remain on washed PPE and be transferable to household laundry. However, one of the workers specifically dried their children's laundry on a separate washing line from PPE (**Photo 6**).

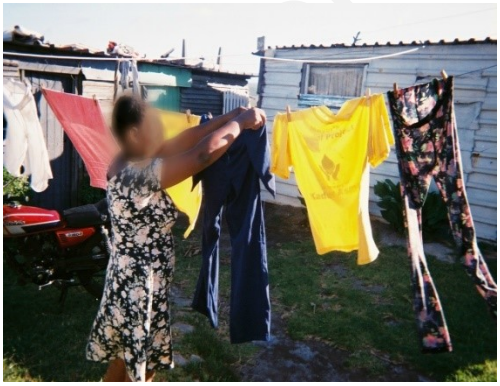

Photo 5: Washed PPE hung to dry with household laundry

Photo 6: Children's laundry hung separate from WfW PPE.

Storage practices

Although some workers washed, cleaned and dried their PPE separately from household laundry, the majority workers did not place their clean PPE in separate storage facilities. As a result, PPE was stored with clean household laundry (**Photo 7**). Similar to the view held regarding drying practices, participants' indicated that the reasons they packed and stored washed PPE with household laundry was because they believed that the washed PPE no longer had residues that could be transferred to household laundry. There was only one instance where a worker stored their PPE in a separate cubicle from household laundry.

> *"PPE is placed in the cupboard after washing because the belief is that it has been cleaned and is free of herbicides" (WfW worker D, Westlake).*

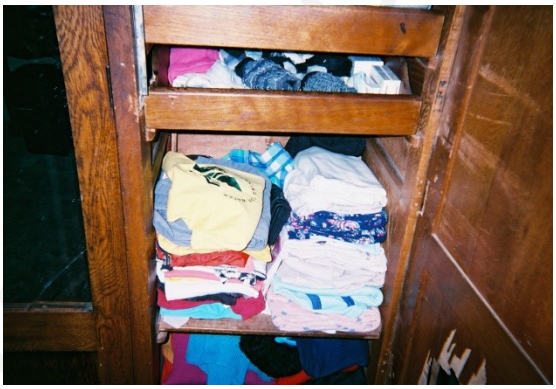

Photo 7: PPE stored with household laundry

There was little evidence in the existing literature of the effectiveness of home hygiene practices in reducing 'take-home' exposure risks. A community based intervention, 'The For Healthy Kids' study in Eastern Washington State, U.S. found that the U.S. chemical legislation recommended practices such as removing work shoes and laundering work clothing separately from household laundry were not associated with the reduction in urinary dimethylthiophospate (DMTP) concentrations in farmworkers and their children and azinphosmethyl (AZM) concentrations in

the house dust (Coronado et al., 2012). This inconclusive evidence further supports the need for interventions to prevent and reduce 'take-home' exposure to be targeted at the workplace where exposures occur. Still, this does not remove the need to inform worker's families of 'take-home' residue exposure risks. Similar to the U.S. WPS (2015), WfW worker's families should be informed that: PPE may be contaminated with toxic herbicide residues, what the associated health effects of herbicide exposure are, what precautions families may take to prevent and reduce exposure risks, and low-risk cleaning practices and decontamination processes for contaminated PPE. Workers may be mandated to inform their families of the recommended safety practices to reduce 'take-home' exposure risks after workers have received training. Furthermore, supplemental educational material related to this type of exposure risk may be issued to workers to share with their families. Further research is needed on effective methods of informing worker's families of 'take-home' exposure risks which may translate to improved practices.

3.2.4 Risk promoting living conditions

A crucial theme emerged from photographs analysed by the researchers that the workers' living conditions are a contributing factor to increasing health risks from 'take-home' residues. WfW workers predominately live in townships that are characterised by informal (i.e., shacks) and low-cost housing. It was noted that the space within their homes is limited due to size of the dwelling and overcrowding from multiple members living together. This may have contributed to their inability to employ protective practices. These included storing and washing PPE separately from household laundry in order to reduce herbicide exposure risks. Notably, most workers used old paint buckets to hand wash their PPE (**Photo 8**). Consequently, some workers had difficulty in properly removing residues and soil from PPE, for example, one participant's washed PPE remained visibly stained by the dye added to WfW herbicides (**Photo 9**). Research is needed to assess whether herbicide residues remain in stained work clothing and whether

current washing practices (e.g., handwashing) remove residues adequately. Workers also had limited space to dispose of the contaminated water.

"We do not have drains or flush toilets so dirty water from washing PPE is thrown in refuse piles or holes around the home" (WfW worker H, Citrusdal).

A study by Arcury et al. (2009) found that the homes of farmworkers had little space, and were in most cases shared amongst many other individuals. The study concludes that the living conditions of the farmworker families were neither supportive nor conducive for changing workers' family practices. Although the primary recommendation for this study is that interventions to reduce 'take-home' exposure risks be targeted at the workplace, in reality integrated approaches may be needed. Therefore, workers' living conditions are an important factor to consider in the design of interventions that reduce 'take-home' herbicide exposure risks, as these have potential to hinder or accelerate the effectiveness of interventions. Still, effective decontamination is most likely to take place at work.

Photo 8: Old paint bucket used as a washing facility

Photo 9: PPE remains contaminated even after hand-washing.

This study illustrated some key factors promoting herbicide residue exposures occurring outside of the work environment. There were, however, the following limitations that should be addressed in future research. *Photovoice* is characterised by study participant's involvement in different stages of the research process, including proposal development. Participants in this study were unable to contribute to the proposal development phase due to time constraints, which may have been a limitation in terms of incorporating their concerns as forestry workers. Participants, however, were involved in data collection and data analysis, which gave workers the opportunity to voice their concerns. The short duration of the study contributed to the inability of fully incorporating the aspect of social action. Participants did not engage with the WfW management regarding their concerns of 'take-home' exposure risks to their families. This engagement would have further empowered workers to contribute to the joint development of solutions to address 'take-home' residue exposure risks with management. This limitation should be addressed through follow-up studies.

4. Conclusion

This study provided evidence of 'take-home' herbicide residue exposure risks amongst South African WfW forestry workers and their families. Although this study focussed on South African forestry workers and their family's exposure risks, the findings are applicable to LMIC workers in similar non-agricultural settings (e.g., forestry work). The findings highlighted the need for integrated approaches to reduce 'take-home' herbicide residue exposure risks, particularly where the work and living conditions are promoting factors in increasing potential health risks. These include revising the existing national chemical legislation to establish standards and regulations for reducing 'take-home' exposure risks. Secondly, incorporating 'take-home' exposure risks in workplace programme documents (e.g., standard operating procedures) and providing mobile hygiene facilities at worksites. In addition, training workers on 'take-home' exposure and risk reduction measures as part of the standard training they receive. Finally,

ensuring workers inform their families of 'take-home' exposure and strategies to reduce exposure risks following the training they receive. The study findings also suggested that the toxicity of herbicides should be assessed during the registration process taking into account 'take-home' herbicide exposure risks.

To the knowledge of the authors, no other studies have assessed 'take-home' exposure risks amongst forestry workers and their families in LMICs, thus replication studies are needed in order to appropriately characterise this problem in low resourced settings. Furthermore, take-home' herbicide residue exposure risks in LMICs should be explored using other evidenced-based research methods (e.g., biological and environmental sampling methods) in order to determine the extent of exposure amongst workers and their families.

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Part D: Appendices

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Appendix A: Fieldworkers' Photovoice Guide - September 2015

Before giving the participants their cameras, please read the following information to inform yourself about the purpose of this research method. If you have questions, please e-mail A/Prof Rother before handing the cameras out at andrea.rother@uct.ac.za.

1. What is Photovoice?

Photo-voice refers to photographs taken by the research participant (Working for Water workers) at the request of a researcher (A/Prof Rother). Usually the person taking the photograph is given a topic to take photos of. In this case, we are interested in what Working for Water (WfW) workers do with their clothing and any equipment they have worn during the day while foliar spraying. So in order to find this out, we are asking people to take pictures of what they are wearing when they go home, what they do with their clothes and equipment once home and to photograph the cleaning process (who does it, when and where, etc).

We will develop the photos after which we will have focus groups with the WfW workers to ask them to tell us about their photographs. Particularly we are interested in why they took the photo and the meaning of it.

2. What must you the fieldworker tell the participants?

2.1 Guide them on what photos to take but don't tell them exactly what to take.

We do not want participants to just go out and take the pictures you told them to take but rather to take pictures that answer the 3 questions below. So you need to read the 3 questions to them and if they ask for suggestions (only if the ask!) then give some of the ideas listed under the questions below.

Make sure you emphasize that the photos they take should only be linked to the work PPE/clothes/equipment. There are only 27 pictures and so they must be careful not to just take a whole lot of pictures of one thing. Guide them to take about 8 pictures for each of the following questions.

Remember the questions below are not a strict guide. They should not be dictated to participants but rather act as a guide for what to take photos of.

Question 1: What do you wear when you go to work, while you work and when you go home after work? Take photos that show this

- Think about your work environment and what you are wearing.
- How do you dress up for work? Show your feet too!
- What do you wear at different times as you prepare for work, on the way to work, at work?
- Do you change clothes during the day? How many times on a working day?
- Take pictures of all the clothes you wear when you go to work. Try to show if they are clean or have been used before. Show your feet!
- Take pictures of yourself wearing what you normally where after foliar spraying to go home
- Once home, do you change your clothes, when and where? What happens to your work clothes?

Question 2: How do you clean and store your PPE? Please be detailed as to who washes the PPE, where, with what water, how are they dried and when this is done.

- Show where you change your work clothes and when
- Show where do you put your work PPE at home when dirty (before they are washed and if you will wear them again) and when clean
- Show where do you clean and wash your PPE. In house? Out of the house? At the community tap? In the river?
- Who most often does the washing of the PPE?
- What containers are used for washing? Show the containers after washing and where they are kept or what they are used for
- Where are they hung after washing to dry?
- Show where you store your work PPE and where you put your or your family's clothes
- Show anything else to washing, storing and cleaning PPE that you think is interesting.

Question 3: How are your work clothes/PPE part of your home life and when you are out in the community in the evenings/weekends?

- Focus on the area/neighbourhood you live in and what you are wearing. Do you wear your work boots out?

- Show your home and your home in your community.
- Where are the water points? Where do you get your water from
- How many people use that water point?
- Is there electricity?
- Where is rubbish disposed of?

*Remind participants that they can take two family or self-photos. We will print one of them to give as a thank you.

2.2 Give the participants some tips on the process of taking pictures such as:

We would like people to take good and useful pictures but not everyone is familiar with how to use a disposable camera. After teaching them how to use the camera, give them some useful tips on how to make sure the pictures they take are good.

To take good photographs tell participants to:

- Try different angles
- Keep the sun to their back or to the side
- Check if their subject is the centre of their photo or if they should fill the entire photo.

To avoid common mistakes, tell participants to:

- Keep their fingers away from the camera lens
- Do not cover the flash with their fingers or hand
- Stand one to two meters from your subject
- Wind the film forward before taking another picture as the camera does not do this automatically!
- To avoid blurry pictures, hold the camera steady with your elbows to your sides, take a breath and hold it.

2.3 Encourage participants to follow the following guidelines of photovoice ethics.

To promote safety and respect tell the participants to:

- Make sure you are safe when you take the picture. For example, you should be standing on a solid surface, not in the way of traffic/street and be aware of your surroundings
- Ask for people's permission before you take a picture of them
- If a person refuses to have a picture taken respect that decision

- Be prepared to explain to your family and community what you are doing if they ask you
- Respect the privacy and safety of those around you when taking pictures.

3. What is expected of me the fieldworker?

- Make sure the participants have read and understood the consent form
- Make sure all consent forms are signed
- Have two copies of the consent form, give one copy for the participants and one you keep to return to Prof Rother
- Explain to the participants how to use the camera, show them how the camera is operated without taking the camera apart
- Emphasize that it is disposable and can only be used once
- Stress the importance of returning camera as it will provide us with important information to promote health and safety
- Instruct participants to return cameras to contractors once they are full
- Give participants information on what kind of pictures to take
- Tell participants that they can take two (2) pictures of their choice (and that these photos are not for the purposes of this research and that the best one will be printed and presented to them).

4. What do I do if there are questions I cannot answer?

Tell the participants that you will contact the Primary Investigator (PI) and get back to them on their query.

Or you can give the participants the contact details of the PI so they can contact her directly:

A/Prof Andrea Rother
Tel (021) 406 6721
Andrea.rother@uct.ac.za

Appendix B: Photovoice Participant Consent Form – July 2015

Hello, my name is …… I am from the University of Cape Town. I am involved in a project that is studying the health and safety of workers employed by the Working for Water programme. I would like to ask if you are ok with participating in this study. This study will not involve any harm or discomfort to you.

Firstly, you will be given a throw-away camera we would like you to take photograph's at home. I will explain to you what types of pictures to take but there is no right or wrong answer. You must please return the camera after a week or once all the photos are taken so that we can develop the photos. This will help us to understand how you use and clean your PPE so that we can help you to use it as safely as possible. As a 'thank you' for taking these pictures we ask you to take two pictures (NO MORE) of your family and we will print one for you to keep.

Secondly, after you have taken all the photos on your camera, we would like to ask you to participate in a group discussion (called focus group) with other workers who will have taken photos. You will not be paid to participate but you will receive something to eat. **There is no risk to your continued employment with Working for Water if you participate. Your participation is voluntary**, which means that you can refuse to participate at any time. We cannot control what members of the focus group say outside of the group so we cannot guarantee that what you say remains confidential. The focus group will be held during your work time and will take between 45 – 60 minutes.

Your photos and discussion of these will help us to understand what you do with your PPE and work clothes once you are at home. This will help us to give you information on how to better wash and store your PPE at home.

We would like to tape record the discussion if you are happy with this.

May we tape record our discussion? **Yes..... No.....**

We may also like to take photographs or a video of the discussion.

Is it ok if we take photographs or a video? **Yes..... No.....**

Would you like to participate in these two parts of this study? **Yes..... No..... (If yes, please sign below.)**

If you have any questions about any part of the research, please contact:

Study Principal Investigator:

A/Professor Andrea Rother

School of Public Health and Family Medicine, University of Cape Town,

E-mail: Andrea.Rother@uct.ac.za T: (021) 406-6721

OR

Human Research Ethics Committee:

Professor M Blockman, Chairperson, Health Sciences Faculty

University of Cape Town, South Africa

E-mail: shuretta.thomas@uct.ac.za T: (021) 406-6338; F: (021) 406-6411

I, _____ (name of **fieldworker**) have read and discussed this information sheet and consent form with _____ (name of **participant**), and have explained to them that there is no risk to their continued employment with WFW if they participate in this study. Additionally, I explained they can withdraw from the study at any time and that there is no payment for being involved in the research.

I, _____ (name of participant) understand what has been explained to me and agree to take pictures at home for the purposes of this research, **bring the camera back** and discuss the pictures with the researcher on my own and in a group setting.

_____ (signature of **participant**)

_____ (signature of **fieldworker**)

2015/___ /___ (date)

Fieldworker to complete when handing over camera:

Area where participant is working: Westlake / Gouda / Liesbeek River / Citrusdaal

Camera **Number** of this participant: __ __

Team leader's name: _____

Please take our camera home and take pictures of the following:

- One picture outside your house
- Pictures inside your house
- Where you put your work PPE at home before you wash them
- Where you put your work clothes after you wash them
- Where you wash your clothes
- Someone (maybe you?) washing your work clothes
- The containers used for washing after you are finished cleaning your PPE
- Please take one picture of your family (this photo is not for the purposes of this research. We will print this photo for you as a gift and thank you for your participation in this study and for returning the camera).

APPENDIX C: Photovoice Focus Group Guide - 2016

Introduction

Photovoice focus group discussions will be held with the study participants after they have handed over the captured photographs to the research team. The main aim of the focus groups is to present and discuss a selection of the photographs that the Working for Water (WfW) workers captured in a group setting. This will allow participants to reflect and share their insights, understandings and opinions of what they see in the photographs. The focus group discussions will consist of about 10 participants (depending on the number of WfW workers at the specific site) and will be held at worksites in Gouda, Citrusdaal, Liesbeek River and Westlake. Therefore the purpose of this *Photovoice Focus Group Discussion Facilitation Guide* is to assist you regarding the process that should be followed when conducting the discussions.

Please read the following information to inform yourself about the photovoice focus group discussions. If you have questions, please e-mail A/Prof Rother before the focus groups take place at andrea.rother@uct.ac.za.

Focus Group Discussion Format

A compilation of selected photographs, sorted into categories, will be shown to participants in the focus groups in the form of a powerpoint presentation. This will serve as the basis for the discussions that will take place. It is important to note that the faces in the photographs will be blurred out to ensure that workers are protected from being easily identified. Participant discussions will be guided by general questions and more specific questions around the captured photographs. It is expected that each focus group discussion should last for approximately 1.5 to 2 hours and will be audio recorded in order to develop transcipts of what was discussed. Since the allocated time for the focus groups is limited, it is important that you monitor the discussions for each of the images that will be displayed.

The procedure for the focus group discussions is described below and consists of the recommended actions, questions and times for each phase dicussion:

Welcome and introductions (10 minutes) – Beginning the focus group discussion

Display powerpoint presentation title slide on the screen

- Welcome everyone and thank them for attending the discussion
- Introduce yourself as the facilitator of the focus group discussion

- Inform participants that the discussion will take between 1.5 to 2 hours and the session will be audio recorded so that there is an accurate record of everyones contributions
- Briefly expain and remind the participants of the overall study aim namely; to identity the risk of 'take-home' herbicide exposure amongst workers families and worker's practices that may be related to this pathway
- Explain that the focus group process will involve viewing selected captured photographs which they will be expected to react to
- Emphasise that you are interested in their immediate reactions and opinions to what they see. That you would like to hear their thoughts
- Encourage participants to be at ease and inform them that there are no right or wrong answers and that all participant's answers are of value. The aim is not that everyone reach an agreement on what is discussed but to hear the range of opinions since everyone thinks differently
- Explain that their opinions will remain anonymous and will only be used by research team as an additional source of information when analysing the photographs.

'AT WORK' (45 minutes)

1. **Working with herbicides**

Questions will depend on the photographs that were taken, but should highlight issues of wrong/no PPE use in relation to WfW standard operating procedures, sun/heat, mixing, washing hands, eating, and residues on skin.

General questions

- What is happening in this photo (the intention is for workers to indicate whether they aware of safety practices to prevent home contamination)?
- Why do you think this photo was taken?
- What is wrong with this picture?

Specific questions

- What practices at work expose workers to herbicides? Is there anything wrong with these practices? Why or why not?

- What types of PPE should be worn when mixing, handling or spraying herbicides? Are workers aware if there are risks (health) that may arise if they expose themselves directly to herbicides?
- What are workers personal hygiene behaviours? How often do they wash their hands? Do they wash their hands before eating or drinking?
- What could the worker do differently to not come into contact with herbicides?
- Do workers attempt to reduce exposure at work through their practices?
- Allow 7 minutes of discussion for each photograph (repeating the above questions)

'AT HOME' (45 minutes)

The questions should highlight issues of herbicide exposure in the home related to contaminated PPE, safety practices to prevent or reduce exposure such as storing or washing household laundry separately from PPE, exposure risks to children and disposing contaminated water.

General questions

- What is happening in this photo (the intention is for workers to indicate whether they aware of safety practices to prevent home contamination)?
- Why do you think this photo was taken?
- What is wrong with this picture?

Specific questions

- What are worker's storage and laundry practices? Is it fine to store or wash household laundry with contaminated PPE or not? Why or why not?
- Are they aware of the risk of children being exposed to herbicides? Do workers take further measures to specifically protect children from being exposed to contaminated PPE?
- What safety practices do workers carry out to prevent herbicide exposure in the home? Is it important to prevent household surfaces from being contaminated? Why or why not?
- What could the worker do differently both at home and at work to prevent or reduce home herbicide exposure in the home?
- Allow 7 minutes of discussion for each photograph

PPE

Display slides number 25-29

- Which is the correct type of PPE that workers should use? What is the risk of using incorrect PPE

Conclusion

After all photographs have been presented and commented on, thank participants and officially close the discussion.

What do I do if there are questions I cannot answer?

Tell the participants that you will contact the Primary Investigator (PI) and get back to them on their query.

Or you can give the participants the contact details of the PI so they can contact her directly:

A/Prof Andrea Rother
Tel (021) 406 6721
Andrea.rother@uct.ac.za

Tips for Facilitating Focus Group Discussion

Creating a comfortable environment

- Emphasise that you are looking for immediate reactions and that there are no right of wrong answers
- Ease the formality of the session by explaining that the focus group as similar to a 'chat'
- Place yourself as part of the group
- Encourage freedom in reactions to the questions – if there is silence after first showing of a photograph, ask whether there are 'first thoughts? – what came to mind first?'

Encouraging participation

- Briefly repeat the guiding questions as each photograph is discussed. Alternatively displayed questions so participants can refer to them
- Pay attention to the participants, whether they are attentive to you and to each other and if they eager or reluctant to voice themselves. Give attention to even quiet participants so that all participants contribute to the discussion
- Tactfully guide and limit discussions to keep to time. If there is still time left after all have responded, follow-ups and clarifications can be sought

Producing useful opinions

- Encourage participants to share their perceptions, beliefs, opinions and attitudes. Even when a participants says 'I don't know' encourage them to say what has come to mind
- Quickly follow-up general statements like 'its very nice' with a request for more specific qualities – like 'what do you think makes it nice'
- Discourage arguments, by stressing that all opinions are valid and refocus participants on topic
- When participants voice subjective statement such 'I don't like using gloves when washing laundry' attempt to follow up with a 'why' question?. It's more useful for to know for instance that the participants find use of gloves impractical when handwashing rather than just not liking using gloves

Appendix D: Ethical Approval for Larger Study

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6338 • **Facsimile** [021] 406 6411
Email: shuretta.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

17 April 2015

HREC REF: 213/2015

A/Prof A Rother
Environmental Health Division
Room 4.28, level 4
Falmouth Building

Dear A/Prof Rother

PROJECT TITLE: ASSESSING WORKING FOR WATER WORKERS WASHING AND STORING OF HERBICIDE CONTAMINATED PERSONAL PROTECTIVE EQUIPMENT AND WORK CLOTHES: IDENTIFYING RISK PREVENTION MEASURES OF CROSS-CONTAMINATION FOR FAMILY MEMBERS AND HOME ENVIRONMENT

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

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

Approval is granted for one year until the 30th April 2016.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

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

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
This serves to confirm that the University of Cape Town Human 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), South African Good Clinical Practice Guidelines (DoH

Appendix E: Ethical Approval for Current Study

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E52-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: sumayah.arisdien@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

21 February 2017

HREC REF: 114/2017

A/Prof A Rother
School of Public Health & Family Medicine
Environmental Health Division
Office 4.28, 4th Floor
Falmouth Building-FHS

Dear A/Prof Rother

PROJECT TITLE: PROTECTED AT WORK BUT NOT AT HOME: SOUTH AFRICAN FORESTRY WORKERS' PERCEPTIONS OF PARA-OCCUPATIONAL 'TAKE-HOME'HERBICIDE RESIDUE EXPOSURE RISKS TO THEIR FAMILIES (Master's candidate-B Pududu) sub-study linked to 213/2015

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

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

Approval is granted for one year until the 28 February 2018.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

We acknowledge that the student, B Pududu will also be involved in this study.

Please quote the HREC REF in all your correspondence.

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

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval before the research may occur.

Yours sincerely

TBurgess

pp **PROFESSOR M BLOCKMAN**
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE

HREC :114/2017

Appendix F: Occupational Health and Act (1993) Extract Sections 8, 13, 14

8. General duties of employers to their employees

(1) Every employer shall provide and maintain, as far as is reasonably practicable, a working environment that is safe and without risk to the health of his employees.

(2) Without derogating from the generality of an employer's duties under subsection (1), the matters to which those duties refer include in particular-

(a) the provision and maintenance of systems of work, plant and machinery that, as far as is reasonably practicable, are safe and without risks to health;

(b) taking such steps as may be reasonably practicable to eliminate or mitigate any hazard or potential hazard to the safety or health of employees, before resorting to personal protective equipment;

(c) making arrangements for ensuring, as far as is reasonably practicable, the safety and absence of risks to health in connection with the production, processing, use, handling, storage or transport of articles or substances;

(d) establishing, as far as is reasonably practicable, what hazards to the health or safety of persons are attached to any work which is performed, any article or substance which is produced, processed, used, handled, stored or transported and any plant or machinery which is used in his business, and he shall, as far as is reasonably practicable, further establish what precautionary measures should be taken with respect to such work, article, substance, plant or machinery in order to protect the health and safety of persons, and he shall provide the necessary means to apply such precautionary measures;

(e) providing such information, instructions, training and supervision as may be necessary to ensure, as far as is reasonably practicable, the health and safety at work of his employees;

(f) as far as is reasonably practicable, not permitting any employee to do any work or to produce, process, use, handle, store or transport any article or substance or to operate any plant or machinery, unless the precautionary measures contemplated in paragraphs (b) and (d), or any other precautionary measures which may be prescribed, have been taken;

(g) taking all necessary measures to ensure that tire requirements of this Act are complied with by every person in his employment or on premises under his control where plant or machinery is used;

(h) enforcing such measures as may be necessary in the interest of health and safety;

(i) ensuring that work is performed and that plant or machinery is used under the general supervision of a person trained to understand the hazards associated with it and who have the authority to ensure that precautionary measures taken by the employer are implemented; and

(j) causing all employees to be informed regarding the scope of their authority as contemplated in section 37 (1) (b).

13. Duty to inform

Without derogating from any specific duty imposed on an employer by this Act, every employer shall-

(a) as far as is reasonably practicable, cause every employee to be made conversant with the hazards to his health and safety attached to any work which he has to perform, any article or substance which he has to produce, process, use, handle, store or transport and any plant or machinery which he is required or permitted to use, as well as with the precautionary measures which should be taken and observed with respect to those hazards;

(b) inform the health and safety representatives concerned beforehand of inspections, investigations or formal inquiries of which he has been notified by an inspector, and of any application for exemption made by him in terms of section 40; and

(c) inform a health and safety representative as soon as reasonably practicable of the occurrence of an incident in the workplace or section of the workplace for which such representative has been designated.

14. General duties of employees at work

Every employee shall at work-

(a) take reasonable care for the health and safety of himself and of other persons who may be affected by his acts or omissions;

(b) as regards any duty or requirement imposed on his employer or any other person by this Act, co-operate with such employer or person to enable that duty or requirement to be performed or complied with;

(c) carry out any lawful order given to him, and obey the health and safety rules and procedures laid down by his employer or by anyone authorized thereto by his employer, in the interest of health or safety;

(d) if any situation which is unsafe or unhealthy comes to his attention, as soon as practicable report such situation to his employer or to the health and safety representative for his workplace or section thereof, as the case may be, who shall report it to the employer; and

(e) if he is involved in any incident which may affect his health or which has caused an injury to himself, report such incident to his employer or to anyone authorized thereto by the employer, or to his health and safety representative, as soon as practicable but not later than the end of the particular shift during which the incident occurred, unless the circumstances were such that the reporting of the incident was not possible, in which case he shall report the incident as soon as practicable thereafter.

Appendix G: Hazardous Chemicals Regulations (1995) Extract, Sections 3, 4, 11

3. Information and training

1. An employer shall, before any employee is exposed or may be exposed, after consultation with the health and safety committee established for that section of the workplace, ensure that the employee is adequately and comprehensively informed and trained, as well as thereafter informed and trained at intervals as may be recommended by that health and safety committee, with regard to:
    a. the contents and scope of these regulations;
    b. the potential source exposure;
    c. the potential risks to health caused by exposure;
    d. the potential detrimental effect of exposure on his or her reproductive ability;
    e. the measures to be taken by the employers to protect an employee against any risk from exposure;
    f. the precautions to be taken by an employee to protect himself against the health risks associated with such exposure, including the wearing and use of protective clothing and respiratory protective equipment.
    g. the necessity, correct use, maintenance and potential of safety equipment, facilities and engineering control measures provided;
    h. the necessity of personal air sampling and medical surveillance;
    i. the importance of good housekeeping at the workplace and personal hygiene;
    j. the safe working procedures regarding the use, handling, storage and labelling of the HCS at the workplace; and
    k. procedures to be followed in the event of spillages, leakages or any similar emergency situation which could take place by accident.
2. An employer or self-employed person shall give written instructions of the procedures contemplated in paragraph (k) of subregulation (1) to the drivers of vehicles carrying the HCS.
3. An employer or a self employed person shall ensure that he himself or she herself or any other person who in any manner assists him or her in the carrying out or the conducting of his or her business, have the necessary information and has undergone sufficient training in order for him or her to identify the potential risks and precautions which should be taken.

4. Duties of persons who may be exposed to hazardous chemical substances

Every person who is or may be exposed, shall obey a lawful instruction given by or on behalf of the employer or a self employed person, regarding:

a. the prevention of an HCS from being released;

b. the wearing of personal protective equipment;

c. the wearing of monitoring equipment to measure personal exposure;

d. the reporting for health evaluations and biological tests as required by these regulations;

e. the cleaning up and disposal of materials containing HCS;

f. housekeeping at the workplace, personal hygiene and environmental and health practices; and

g. information and training as contemplated in regulation 3.

11. Personal protective equipment and facilities

1. If it is not reasonably practicable to ensure that the exposure of an employee is adequately controlled as contemplated in regulation 10, the employer shall:
    a. in the case of an airborne HCS, provide the employee with suitable respiratory protective equipment and protective clothing; and
    b. in the case of an HCS which can be absorbed through the skin, provide the employee with suitable non-HCS impermeable protective equipment.
2. Where respiratory protective equipment is provided, the employer shall ensure:
    a. that the relevant equipment is capable of controlling the exposure to below the OEL for the relevant HCS;
    b. that the relevant equipment is correctly selected and properly used;
    c. that information, instructions, training and supervision which is necessary with regard to the use of the equipment is known to the employees; and
    d. that the equipment is kept in good condition and efficient working order.
3. An employer shall, as far as is reasonably practicable:
    a. issue no used personal protective equipment to an employee, unless the relevant protection equipment is decontaminated and sterilised;
    b. provide separate containers or storage facilities for personal protective equipment when not in use; and
    c. ensure that all personal protective equipment not in use is stored only in the place provided therefor.
4. An employer shall as far as is reasonably practicable, ensure that all contaminated personal protective equipment is cleaned and handled in accordance with the following procedures:
    a. where the equipment is cleaned on the premises of an employer, care shall be taken to prevent contamination during handling, transport and cleaning;
    b. where the equipment is sent off the premises to a contractor for cleaning purposes:
    c. the equipment shall be packed in impermeable containers;
    d. the containers shall be tightly sealed and have clear indication thereon that the contents thereof are contaminated; and
    e. the relevant contractor shall be fully informed of the requirements of these regulations and the precautions to be taken for the handling of the contaminated equipment.
5. Subject to the provisions of subregulation (4)(b) an employer shall ensure that no person removes dirty or contaminated personal protective equipment from the premises: Provided that where contaminated personal protective equipment has

to be disposed of, it shall be treated as HCS waste as contemplated in regulation 15.

6. Subject to the provisions of the Facilities Regulations, an employer shall, where reasonably practicable, provide employees using personal protective equipment as contemplated in subregulation (1), with:

   a. adequate washing facilities which are readily accessible and located in an area where the facilities will not become contaminated, in order to enable the employees to meet a standard of personal hygiene consistent with the adequate control of exposure, and to avoid the spread of an HCS;

   b. two separate lockers separately labelled 'protective clothing' and 'personal clothing', and ensure that the clothing is kept separately in the locker concerned;

   c. separate 'clean' and 'dirty' changerooms if the employer uses or processes an HCS to the extent that the HCS could endanger the health of persons outside of the workplace.

Appendix H: Pesticide Management Act (2010) Extract Section 2.

2. PROBLEM STATEMENT

The Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act No. 36 of 1947) is almost 60 years old. Changes to the context within which pesticides are managed have taken place and have led to a need to consider reviewing the current Act to improve efficiency and effectiveness of pesticides management in South Africa. The review yielded a number of concerns, including, *inter alia*:

- The Act does not adequately address Constitutional requirements in relation to Bill of Rights (i.e. right of environment which is not harmful to health), Access to Information, openness, transparency and participate in decision- making and also just administration action;
- The Act does not adequately incorporate international obligations and agreements to which South Africa is a Party;
- Under the current Act, anyone contravening a provision of the Act or the regulations is guilty of an offence and will be summarily convicted and liable to a fine not exceeding R1000, and such penalties have limited deterrent effect;

- There is no requirement for review of registered pesticides or re-evaluation of old chemicals;
- Lack of establishment of pesticide use surveillance and monitoring systems to gather information on common conditions of use and their impact on health and environment;
- The act does not adequately protect non-target areas (e.g. residential areas, schools, hospitals, etc) from exposure to activities spraying activities;
- The act does not require prior training and certification to use/apply the most toxic pesticides (e.g. WHO hazard class 1 and II);
- Lack of capacity for research on alternative pest control and crop production measures
- Lack of awareness raising, education and training appropriate to the public and the user
- Does not adequately encourage registration that favours lower risk products and reduced reliance on pesticides overall;
- The Act does not adequately address the problem of obsolete stockpile pesticides and their disposal;
- The Act does not adequately address the issue of pesticide container management; and
- Inadequate integration across government departments and complementing other legislations.

Appendix I: U.S. EPA Worker Protection Standard (2015) Reference Guide

QUICK REFERENCE GUIDE TO THE WORKER PROTECTION STANDARD (WPS) AS REVISED IN 2015

The WPS is a federal regulation designed to protect agricultural workers (people employed in the production of agricultural plants) and pesticide handlers (people mixing, loading, or applying pesticides or doing certain tasks involving direct contact with pesticides). Each section links to the Code of Federal Regulations (40 CFR Part 170) for more information on the revised WPS. (www.ecfr.gov)

The guide summarizes the maximum requirements under the revised WPS. It does not include exemptions and exceptions that may allow you to do less. See the referenced sections below.

Exemptions (general) 170.303 (b) and 170.601

Exceptions for **workers** 170.401 (b) and 170.409 (a)(2)

Exceptions for early-entry **workers** during a restricted-entry interval 170.603

Exceptions for **handlers** 170.501 (b)

Exceptions to PPE required on pesticide labels 170.607

Employer Responsibilities for Supervisors and Labor Contractors

Employers must provide sufficient information to supervisors and/or labor contractors to ensure compliance with the revised WPS. Specify:

- The tasks supervisors/labor contractors must do, and
- The information they must provide to workers/handlers.

Employers are liable for a penalty under FIFRA if a supervisor or labor contractor acting for them fails to comply with the revised WPS requirements. 170.309 (d), 170.313 (d), 170.317 (c)

Duties for ALL Employers

These requirements apply to agricultural employers and commercial pesticide handler employers except the pesticide safety, application and hazard information requirements apply only to agricultural employers.

Anti-Retaliation

Employers must not retaliate against a worker or handler who attempts to comply with the WPS, files a complaint, or provides information in an investigation of alleged WPS noncompliance. 170.315

Minimum Age Requirements

1. Ensure that early-entry workers and all handlers are at least 18 years old. 170.309 (c) and 170.313 (c)

Pesticide Safety, Application and Hazard Information

An agricultural employer must display or make certain information available on the establishment. Commercial pesticide handler employers do not have to comply with information display requirements.

1. Display or make available all of the information listed in #2 together in an easily accessible ("central") location on the agricultural establishment. 170.311 (a)(5) and 170.311 (b)(2)
2. The information includes:
   - EPA WPS safety poster or equivalent information, which must include some additional information by January 2, 2018, and must be kept current. 170.311 (a)
   - Application information that includes:
     - Product name, EPA registration number, and active ingredient
     - Crop or site treated, location and description of the treated area
     - Date, start and end times of the application, and duration of restricted-entry interval (REI). 170.311 (b)(1)
   - A copy of the safety data sheet (SDS) for the formulated product for each WPS-labeled pesticide applied. 170.309 and 170.311
3. In addition, display the EPA WPS safety poster (or equivalent) where decontamination supplies are located at permanent sites and where decontamination supplies are provided for 11 or more workers. 170.311 (a)(5)
4. Allow workers and handlers unrestricted access to all of the information and keep all of the displayed information current and legible. 170.311 (a)(6)-(7) and 170.311 (b)(3)-(4)
5. Display the EPA WPS safety poster or equivalent information before an application takes place and for 30 days after the REI expires. 170.309 (h)
6. Display the SDS and application information within 24 hours of the application and before workers enter treated areas. This information must be displayed for 30 days after the REI expires and kept in records on the agricultural establishment until 2 years after the REI expires. 170.309 (h)&(l) and 170.311 (b)(5)-(6)
7. Provide the SDS and application information upon request of a worker, handler, designated representative or medical personnel, within 15 days. 170.311 (b)(7)-(9)

Pesticide Safety Training

Ensure that **workers** are trained before performing tasks in a pesticide treated area (REI in effect within the last 30 days). 170.401 (a) Ensure that **handlers** are trained before performing any handler activity. 170.501 (a) There is no grace period for worker or handler training.

1. Train workers and handlers annually. 170.401 (a) and 170.501 (a)
2. Present training using EPA-approved materials either orally from written materials or audio-visually. After January 2, 2018, the training must cover additional topics. 170.401 (c) and 170.501 (c)
3. Trainers must be certified applicators or have completed an EPA-approved train-the-trainer program or be designated by the State or Tribal pesticide enforcement agency. 170.401 (c)(4) and 170.501 (c)(4)
4. Training must be delivered in a manner the employees can understand, and the trainer must be present and respond to questions. 170.401 (c)(1) and 170.501 (c)(1)
5. Maintain training records on the establishment for two years from the training date for each worker and handler required to be trained on the agricultural establishment. 170.401 (d) and 170.501 (d)

Continued on next column

Separate from the pesticide safety training, employers must tell workers and handlers where to find the following on the worksite: EPA WPS safety poster (or equivalent), application information, SDSs and decontamination supplies. 170.403 and 170.503 (b)

Decontamination Supplies

1. Establish accessible decontamination supplies located together within 1/4 mile of all **workers** (when required 170.411 (c)) and **handlers**. 170.411 and 170.509
   - 1 gallon of water per worker and 3 gallons of water per handler at the beginning of each work period for routine and emergency decontamination,
   - Plenty of soap and single-use towels, Note: hand sanitizers and wet towelettes are insufficient. 170.411 (b)(2) and 170.509 (b)(2)
   - A clean coverall (or other clean change of clothes) for handlers
2. Provide **water** that is safe and cool enough for washing, eye-flushing, and drinking. Do not use water that is also used for mixing pesticides unless steps are taken to ensure safety. 170.411 (b)(1)
3. Provide **handlers** with decontamination supplies where personal protective equipment (PPE) is removed at the end of a task. 170.509 (a)
4. Provide **handlers** with decontamination supplies at each mixing and loading site. 170.509 (c)(1)
5. When a product requires protective eyewear for **handlers**, and/or when using a closed system under pressure, provide the following in mixing and loading areas: a system that can deliver gently running water at 0.4 gallons per minute for at least 15 minutes or 6 gallons of water in containers suitable for providing a gentle eye-flush for about 15 minutes. 170.509 (d)(1)
6. When applying a product that requires protective eyewear, provide 1 pint of water per **handler** in portable containers that are immediately available to each handler. 170.509 (d)(2)
7. Do not put **worker** decontamination supplies in areas being treated or under an REI. 170.411 (d)
8. For **handlers**, decontamination supplies must be kept outside the treated area, or any area under an REI, unless they are protected from contamination in closed containers. 170.509 (c)(1)&(3)

Employer Information Exchange

1. Before any application, commercial pesticide handler employers must make sure the owner/operator of an agricultural establishment where a pesticide will be applied, is aware of:
   - Location and description of area to be treated,
   - Date of application, estimated start time and estimated end time of the application,
   - Product name, EPA registration number, active ingredient(s), and REI,
   - Whether the product label requires both oral warnings and treated area posting,
   - All other safety requirements on labeling for workers or other people. 170.313 (i)
2. Owners/operators of agricultural establishments must make sure any commercial pesticide handler employer they hire is aware of:
   - Specific location and description of any treated areas where an REI is in effect that the commercial handler may be in or walk within 1/4 mile of, and,
   - Restrictions on entering those areas. 170.309 (k)

The commercial pesticide employer must pass this information along to the handler doing the work. 170.313 (h)

Emergency Assistance

If there is reason to believe a worker or handler has been exposed to pesticides, during or within 72 hours of employment, and needs emergency medical treatment, employers must do the following:

1. Promptly make transportation available to an appropriate emergency medical facility.
2. Promptly provide to the treating medical personnel, information related to each pesticide product to which the person may have been exposed:
   - Safety Data Sheet
   - Product name, EPA registration number, and active ingredient(s).
   - Description of how the pesticide was used on the agricultural establishment.
   - Circumstances that could have resulted in exposure to the pesticide. 170.309 (f)

Appendix J: Elsevier Health and Place Journal Author Guidelines

HEALTH & PLACE

An International Journal

AUTHOR INFORMATION PACK

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ISSN: 1353-8292

DESCRIPTION

The journal is an interdisciplinary journal dedicated to the study of all aspects of **health** and **healthcare** in which **place** or **location** matters. Recent years have seen closer links evolving between medical geography, medical sociology, health policy, public health and epidemiology. The journal reflects these convergences, which emphasise differences in health and health care between places, the experience of health and care in specific places, the development of health care for places, and the methodologies and theories underpinning the study of these issues. The journal brings together international contributors from geography, sociology, social policy and public health. It offers readers comparative perspectives on the difference that place makes to the incidence of ill-health, the structuring of health-related behaviour, the provision and use of health services, and the development of health policy. At a time when health matters are the subject of ever-increasing attention, *Health & Place* provides accessible and readable papers summarizing developments and reporting the latest research findings.

AUDIENCE

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Academics, researchers and students interested in the geography and sociology of health and healthcare, health policy, public health and epidemiology. Policy makers, health care managers and health professionals concerned with locality planning, health care targeting and the geographical impact of health policy.

IMPACT FACTOR

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