KNOWLEDGE AND PRACTICES ON PESTICIDE EXPOSURE AMONGST PEST CONTROL OPERATORS IN

THE CITY OF JOHANNESBURG METROPOLITAN MUNICIPALITY

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DECLARATION

I Manare Yvonne Molema declare that this thesis hereby submitted to the University of Witwatersrand, for the degree of MPH Occupational Hygiene has not been submitted before for any degree at this university or any other university, that it is my work and unaided.

______________________________ Date: 25 December 2024

(Signature of candidate)

DEDICATION

This thesis is dedicated to my two daughters (Mahlodi Leago Molema and Mosima Kgothatso Molema) and my mother-Mosima Molema, thank you for your support and encouragement throughout the long period of my study.

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ABSTRACT

Background

Pesticide exposure is a major global public health issue that contributes to global deaths. Occupational pesticide exposure has been deemed one of developing countries' most important risk factors.

Pest control operators (PCOs, i.e.) any person who applies pesticides as a profession, are more prone to high exposure as they work frequently with pesticides. Therefore, urban PCOs such as those in Johannesburg Metropolitan Municipality must have knowledge of pesticide exposure and safe handling procedures to reduce high-risk events.

Study Aim and Objectives

The study aimed to determine the knowledge and the practices of pest control operators within all the seven regions of COJ. The following objectives have been formulated and the specific objectives were to:

1. Determine the level of knowledge of pest control operators on pesticide exposure and PPE.
2. Assess the practices of pest control operators regarding PPE use and other safety measures in relation to COJ's pest control standard operating procedure and personal protective equipment guidelines when performing their duties.
3. Identify possible association between knowledge and practices of pest control within the seven regions of COJ.

Methods

The study was conducted in the seven regions of the City of Johannesburg municipality in Gauteng province, South Africa. Descriptive cross-sectional survey was conducted amongst pest control operators working within all the seven regions of the City of Johannesburg municipality. Data was collected through questionnaire which was self-administered and consisted of questions related to demographics, knowledge of pesticide exposure (n= 13) and PPE as well as PPE practices and other safety measures (n= 20). The completion of the questionnaire was through participants completing the forms independently. The responses were converted into scores and

further analysed using version 28 of the Statistical Package for the Social Sciences (SPSS) software, the association between knowledge and practice was statistically tested. All ethical considerations such as permissions, ethical clearance and informed consent were observed throughout the study.

Results

Of the 75 PCOs employed, 46 pest control operators participated in the study. The sample was predominantly middle-aged, averaging between 30-49 years old and male at (89.1%). A total of 63% had secondary education. In particular, over 80% of participants obtained excellent scores on knowledge questionnaire items addressing pesticide labelling, exposure prevention, associated symptoms, integrated pest management methods, and protective gear usage. However, one knowledge gap observed was around disease vectors transmitted by pests, with only 83% answering correctly compared to over 90% on other questions.

All PCOs affirmed the importance of PPE, 18% admitted applying pesticides when their gear was damaged. Regarding other safety measures, nearly all participants (95.7%) stored pesticides securely. However, empty container disposal and reuse (76.1% reusing) remain problematic. Additionally, although 95.1% avoided smoking during use, many reported eating (93.5%) and talking (80.4%) when handling pesticides. No association was observed between the knowledge and practice clusters.

Conclusion

Despite the relative high level of knowledge, the reported practices should encourage the City of Johannesburg to target unsafe habits through combinations of skills-based participatory training, continuous audits and guidance to correct behaviours, provision of adequate and comfortable protective gears, and promotion of workplace cultural diligence to ensure safe conduct.

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NOMENCLATURE

COJ	City of Johannesburg Metropolitan Municipality
PPE	Personal Protective Clothing and Equipment
PCOs	Pest Control Operators
SPSS	Statistical Package for Social Sciences
WHO	World Health Organisation
UNEP	United Nation Environmental Programme
US-EPA	United States Environmental Protection Agency
SOP	Standard Operating Procedure
MSDS	Material Safety Data Sheet
CO	Carbon dioxide machine

DEFINITION OF CONCEPTS

Knowledge: Information and understanding that is used in everyday life; it enables people to cope effectively with daily tasks. Knowledge is acquired through learning, experience, and self-reflection (Mouton, 1997:8).

Pest Control Operator: Refers to a person who eliminates pests such as rats and mice by applying pesticides as a profession (Collins English Dictionary, 2016).

Pesticides: Substances used to prevent, destroy, repel, or mitigate any pest ranging from insects and fungi, animals, and weeds to microorganisms (Jallow et al., 2017).

Personal Protective Equipment: Equipment or device designed to be worn to minimize exposure to a variety of hazards (OSHA, 2004).

Practices: Refers to health services seeking behaviour or activities undertaken by an individual, regardless of actual or perceived health status, to promote, protect, or maintain health, whether or not such behaviour is objectively effective towards that end (World Health Organisation, 1998: 8).

Safety measure: A measure taken to increase or ensure safety or protection from danger (Collins English Dictionary, 2016).

Medical Surveillance: means the measurement of potential health effects of an HCS on an employee, from absorption to clinical disease, and includes biological monitoring to measure the extent of absorption and medical screening to detect adverse effects of the HCS on the employee (Regulation, 2021).

CHAPTER 1: INTRODUCTION AND BACKROUND

1. Introduction

This chapter provides the background on pest control operators, pesticide exposure, personal protective equipment, and other safety measures. It further addresses the possible health risks associated with pesticide exposure.

1.1 Background

Pesticide exposure is a major global public health issue that contributes to global deaths. Damalas and Eleftherohorinos (2011) explain that pesticides are often needed to control pests, illnesses, and plant pathogens. Ye et al. (2013) estimate that pesticide exposure kills 300,000 people worldwide. Razwiedani and Rautenbach (2017) provided a full spectrum, estimating annual mortalities between 250,000 and 350,000. Based on the afore-mentioned studies, the arithmetic mean of 300,000 would be a

good estimate for that period. The pesticide fatalities remain unclear, requiring a more thorough investigation.

Contrary to earlier estimates, the World Health Organisation (WHO) and United Nation Environmental Programme (UNEP) estimate one to five million cases of pesticide poisoning annually, resulting in 20,000 deaths, mostly in developing countries (Negatu, Dugassa and Mekonnen, 2021). This figure is less than 10% of the global estimates, casting doubt on the 'increase' in pesticide-related incidents. A study found that 68% of pesticide handlers in Tanzania had cutaneous and neurological symptoms (Lekei, Ngowi and London, 2014). Alarmingly, 60% of Tanzanian pesticide operators did not seek medical treatment or take other positive activities after pesticide poisoning.

Occupational pesticide exposure has been deemed one of the developing countries' most important risk factors (Damalas and Eleftherohorinos, 2011). Workers who are more prone to high-risk occupational exposure are pest control operators, as they work directly and frequently with pesticides. Pest control operators (PCOs) are any persons who apply pesticides as a profession (International Code of Conduct on Pest Management, 2015). They inspect and fumigate premises such as hospitals, clinics, residential buildings, hotels and food stores. PCOs daily job activities include, but are not limited to, cutting an opening in buildings to get to infested areas, releasing gases that are toxic through hoses and set traps, putting down poisonous baits to kill rats, and spraying chemicals to kill mosquitoes and other insects, as well as measuring the sizes of the rooms that they will be working on to estimate the amount of pesticides that will be needed to be used (WHO, 2015). Some legislations regulate the production and use of pesticides; however it is still a concern that many PCOs get exposed to pesticides while conducting their pest control duties (Damalas and Eleftherohorinos, 2011).

Occupational exposure mainly affects workers in the agricultural sector, pesticide industry, urban pest exterminators and including those employed by the local authorities (Damalas and Eleftherohorinos, 2011).The highest pesticide exposure mainly affects PCOs working with formulated pesticides through mixing, loading, transporting and application, thus putting the workers at a high risk of intoxication (Damalas and Eleftherohorinos, 2011). Inadequate knowledge and unsafe practices increase the risk of pesticide exposure (Zyoud *et al*., 2010). Inappropriate practices and lack of knowledge, such as not adhering to health and safety procedures, improper training of employees, not using or inappropriately using personal protective equipment (PPE), not storing pesticides properly, poor disposal of empty containers and low knowledge about pesticide safety labels were listed as some of the factors that contributed to morbidity and fatalities related to pesticide exposure (Gesesew *et al.*, 2016). Even though some PCOs are trained, insufficient information is given to them regarding the kind of pesticides they are using, which might result in mishandling of the pesticides (Rijal et al., 2018).

These studies indicate that exposure may be due to irresponsible behaviour and not adhering to safety protocols. Thus, it is imperative to follow instructions on pesticide labels as some of the preventive measures that can be taken to reduce pesticide exposure.

It should be noted that being aware or knowledgeable does not always mean that the person handling pesticides will behave in a safe manner. A study by Idowu et al. (2017) stated that PCOs who had high knowledge of how harmful pesticides are, still used PPE poorly.

Low use of PPE may render the body vulnerable to the toxic chemicals of pesticides; routes of entry into the human body are through inhalation, oral intake and the skin (Curl et al., 2002).

In South Africa, the risk of pesticide poisoning is increased by high usage and easy accessibility of pesticides. Pesticides are widely available in South Africa due to the country's reliance on agriculture, economic factors, a regulatory environment, and the necessity to solve persistent pest control concerns. The studies conducted on pesticides in South Africa were done mainly in the Western Cape, and only a few have been done across the country (Razwiedani and Rautenbach, 2017).

The City of Johannesburg Metropolitan municipality (COJ) is a local authority within Gauteng province and South Africa’s biggest city (Thompson, Shirinde and Mbonane, 2022). COJ municipality offers different municipal services and also renders pest control services as defined in the National Health Act. The department responsible for pest control in the City of Johannesburg is the health department’s division of environmental health. The purpose of PCOs within COJ is the eradication of vectors of disease by undertaking activities such as mixing insecticides for control of mosquitoes, operating spraying (handheld or knapsack pressure sprayers) equipment to spray streams and dams, rats and/or mice and insect control by placing bait stations (poisons) and trapping cages, mixing pesticides as required for applications**,** operate spraying equipment in application of insecticides when treating and fumigating council-owned buildings or infested properties such as offices, clinics and recreational facilities.

PCOs also wash and clean all spraying equipment after work, clean vehicles regularly, and monitor and evaluate rodent breeding and populations to prevent plague outbreaks. They also use carbon monoxide machines to gas burrows and place rodent baits on the surrounding vacant grounds (COJ, 2010). While the PCOs are trying to eradicate rodent infestation and other pests, insects and weeds issues, the health of the PCOs might be compromised because of exposure to chemicals (pesticides) that they use daily when performing their duties. PCOs in the municipality must have knowledge of pesticide exposure.

Pesticide exposure may cause potential harm to PCOs and further increase morbidity among them. Therefore, a comprehensive study of Johannesburg Metropolitan Municipality PCOs pesticides exposure knowledge and practices is needed.

1.2. Problem Statement

Many pest control operators who handle pesticides are not knowledgeable about pesticide exposure risk. Exposure can be increased by improper use and maintenance of PPE, how to manage and use the pesticide and general hygiene behaviour (Damalas and Eleftherohorinos, 2011). Damalas and Eleftherohorinos (2011) and Cattani et al. (2001) noted that unsafe use of pesticide, unsafe usage of PPE, poor housekeeping, lack of training and unhygienic conditions increases the chances of pesticide exposure. PCOs using PPE might not use the PPE properly or feel that they are fully protected and behave recklessly(Damalas and Eleftherohorinos, 2011). Long or short-term pesticide exposure can potentially cause detrimental health effects (Ye et al., 2013). Most studies focused on the agricultural occupational settings regarding pesticide exposure and not much on urban/municipal pest control operators (Cattani *et al.*, 2001). Knowledge and practices on pesticides are some of the factors that contribute to pesticide exposure.

1.3 Justification

Literature has indicated that most studies have been conducted on PCOs in agricultural settings, with only a few focused on urban PCOs (Macfarlane et al., 2013; Ruiz-Gamboa et al., 2018). Specifically, Macfarlane, Carey, Keegel et al. (2013) have indicated that not enough data is available on PCOs that are not in the agricultural sector. While some international studies explore urban pest control which are in the private sector, there appears to be little research on municipal pest control operators' pesticide exposure and practices globally, and none-specific to the South African context (Macfarlane et al., 2013; Razwiedani & Rautenbach, 2017).

Even though pesticide exposure studies mainly focus on agriculture, pesticide application occurs widely in public places, office buildings, schools, restaurants, parks, and other urban areas. These municipal application services are performed by municipal pest control operators. Pesticides pose health hazards to humans, especially those like PCOs who handle them routinely (Ye et al., 2013). Appropriate PPE use and safe handling are key exposure prevention measures. However, deficiencies in knowledge, training, safety practices, and PPE adherence have made pesticide exposure an ongoing occupational health threat (Damalas and Eleftherohorinos, 2011).

While risks cannot be fully eliminated given the necessity of pesticides, employees should be informed of hazards and conditions increasing exposure. Occupational health and Safety Act of 1993, states that it is the responsibility of the employer to their employees to ensure that as far as reasonably practicable bring about and maintain a work environment that is safe and without risk to the health and safety of employees (OHS Act, 1993).

This study focuses specifically on municipal pest control operators' knowledge and practices regarding pesticide exposure, PPE, and safety within the City of Johannesburg municipality. The findings can guide interventions and future research, like observational validation of practices, to strengthen precautions for this at-risk workforce.

1.4. Research Question

What are the levels of knowledge on pesticide exposure, PPE and practices relating to PPE and other safety measures among pest control operators in the City of Johannesburg?

1.5. Aim and Objectives

1.5.1. Aim

The study aimed to determine the knowledge and the practices of pest control operators within all the seven regions of COJ.

1.5.2. Research Objectives

The specific objectives of the study were to:

i. Determine the level of knowledge of pest control operators on pesticide exposure and PPE.
ii. Assess the practices of pest control operators regarding PPE use and other safety measures about COJ’s pest control standard operating procedure and personal protective equipment guidelines when performing their duties.
iii. Identify possible association between knowledge and pest control practices within the seven COJ regions.

1.6 Significance of the Study

This study exploring the knowledge and practices of municipal pest control operators in Johannesburg is significant because it provides initial evidence regarding the alignment of professed hazard awareness safety behaviours. While previous research has examined pesticide risks in agriculture, less focus has been placed on municipal PCOs. Ensuring this risky occupation is conducted with adequate diligence requires understanding where gaps may exist between training and implementation. The findings can equip policymakers with practical insights on where to focus interventions to strengthen safety protocols and culture. If successful risk mitigation strategies can be identified by exploring PCOs knowledge and practices, similar approaches may be transferable to other chemical handling professions. Thus, this exploration of a high-risk workforce helps guide occupational health policy and advocacy for employees undertaking vital hazardous jobs in urban environments.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter focused on existing literature relevant to exploring the pesticide hazard knowledge and safety practices of municipal pest control operators. Key concepts related to pesticides, exposure risks, and associated health effects are defined. An overview of prior research examines what is known about PCOs knowledge and behaviours in various global contexts. Gaps in the literature are identified, particularly the limited evidence regarding urban PCOs in the South African setting. This review situates the present study within the broader foundation of work on pesticide risks and worker training needs. It provides context on what has been studied before and areas requiring additional research, which the current study aims to address through its focus on City of Johannesburg operators.

2.2 Overview of key concepts: pesticides, exposure routes, health hazards

The United States Environmental Protection Agency (US-EPA) defines pesticides as 'substances used to prevent, destroy, repel, or mitigate any pest ranging from insects and fungi, animals, and weeds to microorganisms' as Macfarlane et al. (2013) stated. Major pesticide classes include insecticides, rodenticides, herbicides, and fungicides. Exposure occurs primarily through occupational contact, with PCOs at elevated risk from routine handling during tasks like mixing, loading, and applying pesticides (Damalas and Eleftherohorinos, 2011). A pest control operator is professionally defined as a person who eliminates pests such as rats and mice (Collins English Dictionary, 2016). These are people employed to eliminate infestations of various rodents that may pose harmful effects on human health. Multiple studies have mainly focused on the agricultural use of pesticides and research on PCOs in urban or municipal settings has been lacking instead of urban use (Macfarlane et al., 2013).

Intake or uptake can occur through inhalation of sprays and ingestion of residues, or dermal contact with the mixture, contaminated surfaces or clothing, respectively (Curl et al., 2002). Once absorbed acute poisoning can occur with symptoms such as headaches, nausea, skin irritation, and blurry vision, while chronic effects range from cancers to reproductive issues (Mostafalou and Abdollahi, 2017). Neurological impacts are also concerning, as organophosphates and carbamates affect cholinesterase enzyme levels (Jallow et al., 2017). Use of PPE like gloves, respirators, coveralls, and goggles provides an important barrier against pesticide absorption but many workers fail to consistently utilize proper gear (Idowu et al., 2017). Overall, pesticides confer economical and hygienic benefits but pose occupational health hazards that require diligent safety knowledge and practices to mitigate.

In developing countries, PCOs are not adequately trained on how to handle pesticides in a safe manner and as well as being properly informed about the risks associated with utilizing pesticides (Endalew et al, 2022). A study conducted in Turkey at Adena Province, involved 420 participants, and found that none of the participants had been trained on the use of pesticides (Oztas et al*.,*2018). However, Clausen et al. (2017) in their Ugandan study on the effects of integrated pest management found that the small-scale farmers and their employees were trained in effective management of using pesticides. It is to be noted that the Clausen et al. study was in an agricultural setting.

The use of PPE is essential (Gesesew H et al.,2016). However, educating the workers is imperative, as pesticide contact can happen even in not obvious situations (Gangemi *et al.*, 2016).

In essence, economic and social factors might put pesticide users at a higher risk of exposure even though they are knowledgeable about the hazards associated with pesticides. Generally spoken, PCOs will in some degree be aware of the hazards, but for example due to a lack of funds to obtain necessary PPE, they might carry on with the work that puts them at risk of exposure (Lari S et al., 2023). According to Lekei et al.2014, economic and social strategies should be incorporated with interventions that provide PCOs with the knowledge to make safer practices economically and practically attainable (Lekei, Ngowi and London, 2014).

In addition, pesticides are categorised or ranked by the compound chemical structure such as organophosphates, organochlorines or phenoxys. They can also be categorised by the target organism, depending on whether it is an herbicide, fungicide or insecticide (Jallow et al., 2017). The prevention and management of pests, diseases and other plant pathogens can be through the use of pesticides as an important option. Some legislations regulate the production and use of pesticides; however, it is still a concern that many PCOs get exposed to pesticides while conducting their pest control duties. Occupational exposure mainly affects PCOs in the agricultural sector, pesticides industry, urban pest exterminators and those employed by the local authorities (Damalas and Eleftherohorinos, 2011). PCOs working with formulated pesticides through mixing, loading, transporting and application are facing the highest exposure thus putting the workers at the highest risk of intoxication (Damalas and Eleftherohorinos, 2011).

Actual exposure can be affected by the handling of the pesticide, duration and frequency of operation, general hygiene behaviour, and improper use and maintenance of PPE (Damalas and Eleftherohorinos, 2011). Inappropriate behaviour can be i) not reading and adhering to instructions on how to handle pesticides and ii) not following basic safety rules such as the proper wearing of PPE and basic personal hygiene of washing hands after handling pesticides or before commencing with other activities (Damalas and Eleftherohorinos, 2011).

Other ways in which PCOs can be exposed to pesticides is through unexpected spillage, leakage, and faulty working tools such as spraying equipment. The form of formulation of pesticide can also affect pesticide exposure, especially during mixing and loading. Liquid pesticides tend to spill accidentally, or splash and the worker can be exposed through direct contact on the skin, eyes or indirectly through contaminated PPE. Solid pesticides can cause dust, and the pest control operators can be exposed through inhalation, resulting in respiratory hazards.

However, some pesticide handlers do not consider pesticides as harmful and that there is a need for the pesticides to be handled safely (Jallow *et al.*, 2017). This could result from workers' lack of knowledge regarding the risks associated with exposure to pesticides (Lekei, Ngowi and London, 2014). Past studies on knowledge and practices about pesticides have shown that there is low to average knowledge on PPE usage, improper disposal of empty containers, not reading pesticide instruction labels, and mishandling of pesticides amongst pesticide users (Lekei, Ngowi and London, 2014).

Pesticide users in many developing countries lack knowledge regarding safety measures, type of pesticides, and potential hazards posed by the pesticides

(Moustafa,2017). Ozta et al., indicated that literacy is one of the most effective ways of eliminating unsafe pesticide use (Ozta et.al, 2018). Mohammed and Abbesy stated that there is a high global tendency for limited safety knowledge on pesticides and that training on safety can improve knowledge on the type of precautionary measures to take when working with pesticides (Mohammed and Abbesy, 2017).

In a study conducted by Ndayambie et al., 2019, most PCOs did not utilize PPE due to a low level of knowledge about the negative health impacts of pesticides. Over 95% of observed PCOs did not comply with minimum standards for safe pesticide use, and 80% of respondents reported storing pesticides in their homes without personal protection measures (Ndayambaje *et al*., 2019). Contrarily, Moustafa, 2017 conducted a study in Egypt and found that most of the PCOs in the agricultural setting sector are aware of the hazards associated with pesticides and that exposure to pesticides can be harmful to their health and environment, however it was also reported that implementation of precautionary measures was relatively low (Moustafa, 2017).

In contrast, Lekei, Ngowi and London stated that knowledge and education do not play a significant role in many safety practices. There was no significant association between the utilisation of PPE and either knowledge or education. Other factors, such as lack of funds, might contribute to PCOs not adhering to safety measures even though they are knowledgeable (Lekei, Ngowi and London, 2014).

2.3 Health Effects of Pesticide Exposure

Pesticide exposure can lead to both acute and chronic illness. South African regulation on hazardous chemical agents under the OHS Act of 1993, stipulate that medical surveillance is mandatory for workers that are exposed to specific hazards. Medical surveillance is defined as the measurement of potential health effects of an HCS on an employee, from absorption to clinical disease, and includes biological monitoring to measure the extent of absorption and medical screening to detect adverse effects of the HCS on the employee (Regulation,2021). If an employee is exposed to hazardous pesticides that could have adverse effect to their health as a result of the exposure such then a medical surveillance should be conducted (Regulation,2021).

The symptoms that are associated with acute pesticide poisoning are fatigue, headache, body pains, skin rash, skin discomfort, confusion, nausea, vomiting, excessive sweating, impaired vision, feeling weak, circulatory problems, panic attacks, poor concentration, tremors, sneezing, watery eyes and burning sensation around long term exposure can lead to coma, cancer or death (Idowu *et al.*, 2017). Respiratory health effects because of exposure to pesticides are often underestimated (Ye *et al.*, 2013). An estimation has been made that many people die worldwide annually as a result of pesticide exposure. The burden of disease due to acute pesticide poisoning is usually set too low due to under-reporting (Lekei, Ngowi and London, 2014).

Skin problems and neurological symptoms were reported by 68% of pesticides handlers after working with pesticides in Tanzania (Idowu *et al.*, 2017). Another Tanzanian study indicated that acute pesticide poisoning is of great concern (Moustafa, 2017). About 60% of PCOs do not seek any medical remedies or take any other action that will be helpful after pesticide poisoning (Lekei, Ngowi and London, 2014).

Ndayambe et al. (2019) stated that all the PCOs that participated in their study reported having experienced adverse health effects during or after using pesticides (Ndayambe et al., 2019).

The study done in the Gaza Strip revealed that PCOs and pesticide handlers exhibited a notable level of knowledge of the diverse symptoms linked to pesticide exposure. This study that included a total number of 200 PCOs, reported burning sensation of the eyes and face, watery eyes, chest pain, itching and skin irritation, headache, dizziness, loss of libido and forgetfulness (Yassin M., 2002).

2.4 Personal Protective Equipment (PPE)

Provision and promotion of PPE has been the primary strategy in reducing the worker’s exposure to pesticides. PPE is equipment or devices designed to be worn to minimize exposure to a various hazards (OSHA, 2004). PPE comprises of gloves, safety boots, eye protection such as safety goggles and face shields, protective hearing devices (earplugs, muffs), hard hats, respirators, and full-body suits.

Employer should as far as reasonably practicably adopt procedures that will eliminate or mitigate any hazard or potential hazard before resorting to personal protective equipment (OHS Act,1993). The hierarchy of control of occupational exposure states that PPE should be the last resort of control. If other control measures such as engineering controls, administrative controls and work practices are not effective in eliminating or mitigating hazards then the use of PPE is essential. In addition, using less toxic pesticides or deploying efficient and application methods will reduce relevant exposure. However, in practice, PPE is still recognized as an essential factor in safety measures. The objective of PPE usage, being clothing, material or devices issued, is to offer some protection from pesticide exposure.

Pest control operators utilising PPE are also likelier to follow safer hygiene practices (Lekei, Ngowi and London, 2014).

Cautious utilization of pesticides is significantly associated with the appropriate use of PPE (Andrade-Rivas and Rother, 2015). Some PCOs might find using PPE to be uncomfortable and not imperative (Macfarlane et al., 2013). Additional reasons for the lack of using PPE are the weather conditions for instance, high humidity and high temperatures and the resulting discomfort of wearing PPE (Lekei, Ngowi and London, 2014).

Lack of PPE use could result from insufficient availability of PPE due to costs. However, if available, the non-utilization of PPE shows a significant association between high pesticide poisoning symptoms and lack of PPE usage (Lekei, Ngowi and London, 2014).

The usage of incorrect PPE fails to reduce the exposure, such as (disposable) dust masks that are utilised instead of respirators because they are more affordable and comfortable. Dust (facial) masks are generally ineffective in protecting pesticide users against toxic pesticides. Studies conducted in Greece, and in India and other developing countries also report similar findings (Macfarlane et al., 2013). Using dust masks may increase the risk of exposure as the user might think that they are protected and fail to adhere to other safety and precautionary measures. (Lekei, Ngowi and London, 2014) reported that pesticide users could not differentiate between respirators and dust masks.

In a study by Lari et al. (2023), the authors observed the use of supplementary personal protective apparel, specifically gumboots. However, the efficiency of this measure was limited as it did not provide comprehensive protection due to the absence of other necessary personal protective equipment.

A study in Tanzania found that PPE used by PCOs was torn and overly contaminated. Disposable dust masks were used by PCOs instead of proper respiratory protective equipment (Lekei, Ngowi and London, 2014). The study reported a significant association between high pesticide poisoning symptoms and lack of proper PPE usage. Additionally, wearing incomplete PPE sets, such as wearing boots without other protective equipment for the rest of the body, was observed. The study by Ndayambaje et al. (2019) stated that during interviews, a high number of PCOs reported that they use PPE, but during observation, that was not the case. Some did not have complete PPE sets or were missing some required PPE items.

2.5 Other Safety Practices

A body of knowledge has shown that good pesticide exposure prevention or reduction practices include reading the label on the container before using the pesticide; taking a bath or shower with an approved soap after being splashed or sprayed by pesticides; washing hands before eating or drinking all the time; and separation of contaminated clothes from everyday clothing when washing (Kongtip et al., 2018). It is a requirement that the employer provides information, instructions, training and supervision to ensure as far as reasonably practicable, the health and safety of the employees (OHS Act 1993).

In developing countries, workers are not adequately trained on how to handle pesticides in a safe manner, as well as being adequately informed about the risks of pesticide use (Gangemi et al., 2016). Lack of knowledge, such as if pesticide containers are not labelled or written in a language not understood by the PCOs may increase the risk associated with the handling of pesticides (Lekei, Ngowi and London, 2014). Lekei, Ngowi and London,2014 found that 79% of participants stored pesticides in the household and that participants with low literacy levels were more likely to store the pesticide at the places of residence. Oztas et al. (2018) found only 26.2% of participants to be storing pesticides at the depot, and only 4.3% took their empty containers to special collection bins or centres (Oztas et al., 2018). Also, over 80% of participants said they store pesticides in their dwellings without any safety measures (Adayambaje et al, 2019).

In terms of the disposal of empty pesticide containers, unsafe methods of disposal for pesticide containers were observed, such as burying empty containers into the ground, dumping pesticide containers on open land and reusing them for domestic purposes (Lekei, Ngowi and London, 2014). Ozta et al. (2018) found that burning empty containers was also another form of disposal (Ozta et al, 2018). Some PCOs resell the containers to retailers (Lekei, Ngowi and London, 2014). While Ozta et al stated that about 4.3% of the PCOs took the containers to the special collection bins (Ozta et al, 2018). The studies by Ozta et al. (2018) and Lekei, Ngowi and London (2014), respectively found that 78.6% and 81% of PCOs stored pesticide containers in their houses. About 77.2% of PCOs assessed on knowledge and practices on pesticide management indicate that empty pesticide containers were taken home for domestic purposes (Mohammed and Abbessy, 2017). A study in Malaysia showed that PCOs are aware of the harmful effects of pesticide use, but the level of awareness on disposal of pesticide containers was low because of not knowing about pesticide residue on the containers (Sabran and Abas, 2021). It seems the re-use of pesticide containers for domestic purposes is quite prevalent in developing countries due to a lack of knowledge or just ignorance by PCOs.

Pesticide exposure through ingestion can occur when hands are not properly washed before eating or smoking (Endaew et al., 2022). Mohammed and Abbessy (2017) conducted a study in Egypt and found about 94% of PCOs follow personal hygiene measures by washing their hands after using pesticides, and do not eat or drink during pesticide application, which shows that the majority is aware of personal hygiene measures. Likely, PCOs have never consumed food while spraying or mixing (Devagappanavar, 2021). Additionally, nearly half of the PCOs have the practice of showering and washing their clothes separately (Devagappanavar, 2021).

Mishandling of pesticides during mixing and handling, spraying and storage can negatively affect the health of humans and animals and the environment (Ndayambaje, 2019). Even though PCOs are knowledgeable about the health risks associated with pesticide exposure, PCOs don’t follow safety measures such as wearing PPE due to financial constraints and being impractical to use (Ndayambaje, 2019). Similarly, Yassin et al. (2002) reported that PCOs are mindful of the safety measures against pesticide exposure during the spraying of pesticides, however there was a lack of adherence to safety precautions. Another study showed that about 40% of 265 PCOs have good practices about pesticide usage whilst half of the participants have poor practices in personal protective equipment usage when spraying pesticides (Devagappanavar, 2021).

2.6 Prior research on PCO knowledge and practices in various countries

Studies of agricultural pesticide users across geographic contexts demonstrate gaps between hazard awareness and implementation of commensurate safety precautions. Jallow et al. (2017) found adequate pesticide knowledge but improper practices like inadequate PPE use and unsafe storage among Ghanaian pesticide users. Similarly, Gangemi et al. (2016) reported French vineyard employees had sufficient understanding but overlooked protocols like handwashing before eating. Among Indonesian farmers, Fatiha et al. (2018) noted deficits in application techniques, gear maintenance, and disposal handling despite training. Focusing on urban settings, Macfarlane et al. (2013) characterized Australian PCOs as predominantly male, moderately educated, and alert to risks but not fully compliant with ideal precautions. Comparable knowledge-practice disjunctions emerged among Mexican municipal applicators analysed by Rizo-Gamboa et al. (2018).

Synthesizing global research, Damalas and Eleftherohorinos (2011) identified various factors influencing worker safety including ineffective training methods, discomfort of protective equipment, lack of regulatory enforcement, and absence of workplace safety culture. Lekei et al. (2014) also highlighted how deficiencies in equipment availability and other practical barriers may override hazard awareness in determining behaviours. Generalizing across contexts, knowledge alone appears insufficient to ensure universal adoption of commensurate precautionary practices among pesticide handling occupations.

2.7 Identification of research gaps, especially in South Africa

While extensive studies characterize agricultural pesticide risks, Macfarlane et al. (2013) noted far less research on non-agricultural pesticide users. Urban municipal PCOs represent one under-investigated population (Ruiz-Gamboa et al., 2018), especially in the African context (Naidoo et al., 2010). In South Africa, national pesticide surveillance remains limited (Rother, 2008) and provincial analyses exhibit geographical biases focusing on Western Cape agricultural communities over urban workforces (Negatu, Dugassa and Mekonnen, 2021).

Among research explicitly sampling municipal PCOs in South Africa, quantitative evidence appears scarce. Govender et al. (2018) measured cholinesterase depression among City of Cape Town employees to gauge pesticide exposure but did not characterize knowledge and behaviours. Qualitative approaches provide useful but isolated insights, including Brits' (2012) interview study identifying positive safety culture aspects like team solidarity but also concerning reliance on informal learning.

In the City of Johannesburg, the current researcher found no published quantitative studies examining municipal pest control operators' pesticide hazard knowledge and safety practices. This research gap limits development of evidence-based occupational health policies and interventions tailored to the needs of this at-risk workforce. Given international data indicating gaps between hazard understanding and field precautions among pesticide applicators, exploration of the alignment between knowledge and practices specifically among Johannesburg's municipal PCOs will provide actionable baseline evidence to guide training and institutional safety initiatives. The City of Johannesburg municipality has a set of standard operating procedure (SOP) relating to pest control operations. However, there is no SOP on training for PCOs, how pest control trainings should be conducted, what type of trainings and the frequency of the trainings. Trainings are done on the work by colleagues or by the manufacturer if there is a new product that is being introduced to pest control unit.

There is a standard operating procedure (SOP) for applying pesticide by means of a pressured spray pump which covers the procedure on spraying pesticide, cleaning of pump after use, maintenance of carbon dioxide machine (CO machine), material safety data sheet (MSDS), first aid and stipulate that at least one person in a team must have received first aid training. In addition, it provides a list of PPEs (hat or hood, face shield or plastic googles, half face respirator, overalls, rubber or latex gloves and safety boots) that PCOs need to wear during mixing, loading, application and clean-up. The SOP also states that all PCOs to undergo training regarding application of pesticides by means of a pressurized spray pump and that only PCOs deemed competent will be allowed to operate the pressurized spray pump. After training and competency, the PCOs are expected to sign a declaration that they read and understand the contents of the SOP. The mentioned SOP does not cover anything on other safety practices that the PCOs need to be aware of such as how to dispose of empty container, checking the label of the pesticide for specific cleaning instructions, what to do with the excessive pesticide as it states that excessive pesticide from the pump should be poured into the drain. The SOP also does not state what needs to be done with the PPE after spaying, and whether a spill kit should be provided in case of emergency or spillage (Niekerk,2016). The municipality does have guidelines for protective clothing or uniform for designated health department staff. The guidelines proposed that every new financial year, employees may request the replacement and/or purchase of approved protective clothing. Managers will inspect and recommend/approve the replacement of worn-out items if necessary. The guidelines aim to ensure consistency and uniformity in all the regions. The guidelines have a list of PPE items for PCOs and the frequency of receiving or replacing PPE.

2.8 Theoretical Framework: Health Belief Model

The Health Belief Model posits that health behaviours are influenced by an individual's perceived susceptibility to a health threat, perceived severity of that threat, and belief that following a preventive action will effectively reduce the threat at an acceptable cost (LaMorte, 2019). This theory provides a relevant framework for examining PCOs pesticide safety practices in relation to their knowledge of exposure risks. Even if PCOs are informed about pesticide health hazards (perceived threat), they may overlook precautions if they underestimate personal vulnerability or lack confidence in preventive measures overcoming barriers like discomfort. The theory thus helps explain and predict alignments or gaps between professed hazard awareness and actual workplace diligence.

2.9 Social Cognitive Theory

Social Cognitive Theory highlights that behaviour adoption depends partly on self-efficacy, or confidence in one's ability to perform the action (LaMorte, 2019). PCOs may intellectually grasp pesticide dangers but feel unable to consistently implement cumbersome precautions like PPE use if lacking self-assurance. Additionally, observational learning from peer behaviours influences efficacy and conduct (Glanz et al., 2008). PCOs witnessing colleagues disregarding safety protocols may mirror non-compliance regardless of their own hazard awareness. Incorporating Social Cognitive Theory concepts like mastery experiences and vicarious reinforcement into training may strengthen PCOs' motivational readiness to undertake recommended safe pesticide practices.

2.10 Conclusion

The literature review has examined fundamental ideas pertaining to pesticides, previous global research on PCOs knowledge and practices, and theories applicable to the analysis of worker safety behaviours. The summary contextualises the current study within established frameworks while highlighting potential areas for further exploration, particularly for urban PCOs in South Africa.

CHAPTER 3: METHODOLOGY

3.1. Introduction

This chapter describes the methodology used to assess the knowledge of pesticide exposure, PPE use, practices on PPE and other safety measures. The section comprises of the study design, study site, study population, inclusion/exclusion criteria, study sample, pilot data collection tool, quality assurance, data collection and statistical analysis methods.

3.2 Assumptions of the Study

This study assumes that respondents will provide honest self-reports regarding their pesticide knowledge and safety practices. It also assumes they have sufficient literacy and understanding to accurately complete the questionnaires. The census approach to sampling assumes all eligible pest control operators had an equal opportunity to participate during the data collection period.

3.3. Methodology

This study employed a quantitative methodology given the lack of numerical evidence regarding pesticide knowledge and practices specifically among municipal PCOs in South Africa. While qualitative data provides rich insights, the dearth of existing statistical data supported a foundational quantitative approach to broadly characterize the workforce and relationships between knowledge, practices, and demographics. The survey questionnaire allowed standardized data collection across the sample to identify patterns through descriptive and inferential statistics (Yilmaz, 2013). As discussed by Carr (1994), combining measurement and theory allowed testing linkages between knowledge, practices and demographics suggested by frameworks like the Health Belief Model. Overall, the quantitative techniques facilitated pragmatic gathering of generalizable knowledge and practice descriptors to address the lack of existing statistical data on City of Johannesburg pest control operators.

3.4. Study Design

This study employed a quantitative, cross-sectional survey approach to investigate pesticide hazard knowledge and safety practices of municipal pest control officers.

The purpose of this study was to examine basic knowledge and behaviours, rather than test a specific hypothesis or determine cause and effect relationships. To collect data that accurately represents the sample, a descriptive cross-sectional survey design was used, allowing for practical data collecting throughout different regions of the City of Johannesburg.

3.5. Study Site

The study was conducted in all the 7 regions of the City of Johannesburg. Confirmation was done with the Directors of Environmental Health COJ, and permission was granted by the Johannesburg district research committee, annexure C.

3.6. Study Population

The study population consisted of all PCOs in the 7 regions, employed by the City of Johannesburg's municipality with a staff capacity of 75 PCOs. The City of Johannesburg has 7 regions. The regions vary in the number of employed PCOs depending on the size and population of the region. The study was conducted from November 2021 to February 2022.

3.7. Inclusion and Exclusion Criteria

Inclusion Criteria: Pest control operators that were eligible for the study were permanent pest control operators employed by the City of Johannesburg.

Exclusion Criteria: Contract pest control operators, which are not permanently employed by the municipality.

3.8. Sampling methods

The census approach was used in all 7 regions where permanent PCOs were the target population. It is to be noted that the City of Johannesburg municipality has a population of less than 200 PCOs. The census approach was used as all PCOs that volunteered to participate were enumerated and is the best source of information on a small population group in terms of area (Baffour, King and Valente, 2015). Specifically, a census sampling strategy was adopted for all PCOs to obtain many relevant responses for this study.

An invitation letter was sent to the Regional Managers and pest control operational managers indicating the purpose of the study and requesting the participation of the PCOs. The researcher liaised with the operational manager in each region. After arranging the meeting, the researcher asked the operational manager in each region to inform the PCOs that the researcher intends to come on a specific date. The researcher met PCOs in the morning at each of the 7 regions by appointment on different days and dates and sought permission to gather the required data. The purpose of the study was explained clearly to the PCOs. The researcher explained the details of the research and encouraged participation. The meetings occurred at the offices or demarcated areas for PCOs and all Covid 19 protocols were adhered to. The researcher then distributed the questionnaires to all the PCOs that were present at the meeting and left a box with the operational manager where the completed questionnaires were dropped in. The researcher went back to the region to collect the completed questionnaires.

3.9. Data Collection and instrument tool

Data was collected through self-administered questionnaires consisting primarily of closed-ended questions. The questionnaire comprised a total 33 questions of which 28 closed-ended questions utilizing binary yes/no, multiple choice, and Likert-scale response options. There were 5 open-ended questions which allowed participants to provide additional details relevant to the study objectives. For example, question 17 asked "what do you understand by PPE?"

The questionnaires were printed, and participants completed the forms independently as hard copies. The researcher developed the questionnaire based on published literature and consultations with lecturers and the supervisor. Questions were integrated from Jallow et al. (2017) and Idowu et al. (2017) into one questionnaire. Some questions not directly relevant to municipal PCOs were removed, and content-specific questions added to have a stronger relationship with the variables of interest. The questionnaire (in English Appendix B) consisted of demographics (section A), and Knowledge and Practice sections. Knowledge has two sections: pesticide exposure (section B) and PPE (section C). Practice has two sections: PPE practices (section D) and other safety measures (section E). The researcher visited one region per day after making an appointment with the operational manager for the region so that the questionnaires could be completed. Meetings took place in the morning as that was a suitable time before PCOs could go out to the field. The researcher distributed the questionnaires to the PCOs to be completed independently by participants.

3.10. The impact of Covid-19 on Data Collection

Due to Covid-19 pandemic, the scope of work of pest control operators was extended with "Decontamination of Building(s)". Besides the additional request to decontaminate building(s), they still offer their normal daily services, so the researcher was able to collect data. Both the researcher and pest control operators adhered to Covid-19 safety measures for an example, wearing of surgical mask, applying hand sanitizer, and always maintaining a distance of 1.5 metres.

3.11 Quality Assurance

3.11.1 Piloting Data Collection Tool

A pilot study as preliminary research was conducted with a small sample to assess the feasibility of a bigger study. This was done to determine whether there was a need for amendments such as rephrasing and adjusting the number of questions. A week before the actual study occurred, the researcher piloted 5 questionnaires in one of the regions. All the respondents who took part in the pilot study are included in the final study. The questionnaire was amended, and some questions were rephrased accordingly, appendix B.

3.12 DATA MANAGEMENT AND STATISTICAL ANALYSIS

3.12.1 Data Processing

Participants in the study were given identification numbers, and the questionnaires were labelled with a combination of a letter representing the region and a number representing the participant (e.g., A1, B1). The coding for ethnicity in the demographic questions is as follows: 1=African, 2=White, 3=Coloured, 4=Indian, 5=Other. The questionnaire items were assigned numbers to indicate specific areas of knowledge and practice, for as item 8 for knowledge on PPE and item 22 for practices on PPE. The raw data collected from the questionnaires was imported into Excel for a first data cleansing process, which involved identifying and addressing missing data and discrepancies. Questionnaires with significant amounts of missing data were excluded from the analysis using listwise deletion. The responses to open-ended questions were classified according to developing patterns and given scores. Following the process of scoring and data cleaning in Excel, the data was subsequently imported into SPSS Version 28 for the purpose of conducting statistical analysis.

3.12.2 Questionnaire Design and Scoring Criteria

In order to fulfil Objective 1 of evaluating knowledge on pesticide exposure and personal protective equipment (PPE) comprehension, a total of 13 questions were incorporated: Section B consisted of 9 questions (questions 8-16, question 10 with 4 multiple choice answers and question 14 with two sub questions) related to pesticide exposure. These questions included 1 multiple choice question, 2 open-ended questions, 1 frequency scale question, and 6 binary yes/no questions. Section C consisted of 4 questions (questions 17-20 with question 18 having 4 sub questions) that assessed the user's knowledge of Personal Protective Equipment (PPE). These questions on appendix B, included 5 yes/no questions, 1 open-ended question and 1 multiple choice question. In the context of binary knowledge questions, a score of 1 was assigned to a successful response, while an incorrect response received a score of 0. The scoring for multiple choice items was binary, with a score of 1 awarded for a correct option and a score of 0 given for an incorrect choice. The knowledge parts produced a range of possible total scores from 0 to 20. The knowledge scores were classified into three categories based on frequencies and percentages: bad (0-10) with a score of ≤50%, fair (11-14) with a score of 51-70%, and good (15-20) with a score of 71-100%. The practice questions employed frequency scales and utilised a selection of all alternatives, rather than assigning scores based on correct or incorrect responses. Consequently, the general practice was not classified, but rather presented using descriptive statistics such as frequencies and percentages for each question.

While the knowledge questions were categorized and scored as poor, good or excellent based on the number of correct responses, the practice questions were not formally scored. The focus of the study was to assess and categorize knowledge, while the practice questionnaire was intended to provide descriptive information about what behaviours are being followed. Additionally, the format of the practice questions, which used frequency scales or select all options, did not allow for categorizing overall practice into the same scored categories as knowledge. Thus, only descriptive statistics like frequencies and percentages were utilized to summarize the practice data.

3.12.3 Reliability Analysis

Reliability analysis using Cronbach's alpha evaluated the internal consistency of the questionnaire instruments on knowledge and practices. Values above 0.7 indicate acceptable reliability (Taber, 2018). However, lower thresholds down to 0.5 are reasonable for preliminary exploratory research (Vaske et al., 2017).

Scoring of the knowledge questions categorized understanding levels based on the percentage of correct responses. Less than 50% indicated poor knowledge, 51-70% was fair, and over 70% shown excellent understanding (Jallow et al., 2017). For self-reported practices, frequencies and percentages were calculated based on selected responses to each question, without an overall categorization.

3.13. Data Analysis

The demographic profile of the study participants presents frequencies of age, gender, ethnicity, level of education and work experience. Descriptive statistics, e.g., means, frequencies and standard deviation summarised in graphs and tables were used to report the questionnaire response data (knowledge scores and practice frequencies). Cronbach's alpha statistics was used to determine the measure of reliability of the questionnaire, where Cronbach's alpha ≥0.50 is considered to reflect good consistency (Taber, 2016). Questions that reduced the alpha coefficient were removed to increase the questionnaire's ability to measure concepts associated with this study. In particular, items on knowledge 8, 9,12, 14.1, 15, 16, 17, 18.1, 18.2, 20 and practices 22, 24.1, 24.3, 24.6, 25, 29,33 and 40.3 from the questionnaire. Therefore, a Cronbach's alpha co-efficient of 0.546 was found to be reliable and acceptable for scales associated with knowledge and practice.

Table 3.1. Cronbach's Alpha measuring reliability

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.546	.501	24

The statistical analysis of the relationship between knowledge and practices focused on total scores, rather than individual questions. Various tests suitable for small samples like Chi-square, Fisher's Exact, and Likelihood Ratio were used to analyse the association between the overall knowledge and practice scores, rather than comparing individual questions.

Chi-square testing compared participants with poor, fair and excellent pesticide knowledge against their total practice questionnaire responses. However, Chi-square assumptions were likely violated due to small sample size. Therefore, Fisher's Exact Test provided a more accurate p-value for the relationship based on the data distribution (Kim, 2017). Additional likelihood ratio testing explored whether demographic factors predicted knowledge, with p-values less than .05 suggesting significant effects.

In summary, total knowledge and practice scores were compared rather than individual questions. Various statistical tests suitable for small sample sizes were used to analyse the association between overall knowledge and overall practice.

3.14 Ethical Considerations

Permission: Permission to conduct the study was sought from the City of Johannesburg Department of Health, Department of Environmental Health where the researcher is an employee and Research unit for conducting a study within the City of Johannesburg and permission to conduct the study was also granted by the Johannesburg district research committee, appendix C. Permission was requested from University of Witwatersrand, Faculty of Health Sciences Human Research Ethics Committee for provision of ethical clearance, clearance number-M210362, appendix D.

The participants signed consent forms (appendix A), were informed of their rights and participation was voluntary.

3.15 Conclusion

This chapter has detailed the quantitative methods utilized to collect and analyse data examining municipal pest control operators' pesticide knowledge and safety practices. The cross-sectional survey design and census sampling of City of Johannesburg PCOs was justified to obtain exploratory evidence across this understudied workforce.

Development and piloting of the questionnaire instruments was described, along with reliability testing procedures. Scoring approaches categorized knowledge levels and allowed statistical analysis of potential relationships with reported practices. Protection of participants through ethical approvals and informed consent represented key elements of the methodology. Overall, the methods facilitate an initial characterization of pesticide hazard understanding and practices among Johannesburg PCOs.

CHAPTER 4: RESULTS

4.1. Introduction

This chapter presents the results gathered from the self-administered questionnaires. The data is organized into sections beginning with the demographic profile of the 46 study participants. Descriptive statistics summarize participants' knowledge of pesticides and personal protective equipment (PPE) based on their questionnaire responses. Their self-reported practices regarding PPE and other safety measures are also presented using frequencies and percentages. Finally, statistical analysis explores the relationship between knowledge and practice scores to determine if any association exists.

4.2 Demographic Profile of the respondents

The sample consisted of 46 pest control operators out of a total of 75 PCOs employed across the 7 regions of the City of Johannesburg. The reasons for non-participation, the remaining 19 were as follows: 11 PCOs were not available during the researcher's visits to their regions. Another 8 declined participation when approached. Therefore, with 46 participants out of 75 PCOs, the response rate was 61%. During data collection, some participants opted to omit certain questionnaire items. A listwise deletion approach was applied in these cases, excluding them from analysis of those items. Additionally, 6 distributed questionnaires were not returned completed. In summary, out of the total PCO population across City of Johannesburg regions, 61% participated in the study. Non-response was primarily due to unavailability, followed by refusal and ineligibility. Some missing data also resulted from omitted questionnaire items.

In terms of ethnicity, 93.5% of the participating pest control operators working for City of Johannesburg are African whilst 6.5% are Coloured as depicted in Table 4.1. The sample was predominantly male, with 89.1% males compared to just 10.9% females. Examining the age distribution, the bulk of PCOs fall into the 30–39-year (39.1%) and 40–49-year (32.6%) age brackets, together representing nearly 72% of the sample. Only 17.4% were aged 20-29 years, while just 6.5% were older than 50 years old. Additional information on work experience showed that 45.7% had 1-5 years of experience, while 19.6% had 6-10 years, 17.4% had 11-15 years, 8.7% had 16-20 years, and only 2.2% had over 21 years of pest control work experience. Regarding education level, 63.0% held a Matric qualification, 21.7% had a university degree, while 15.2% had less than Matric between grade 8-11.

Table 4.1. Demographic Profile of Study Participants

Variable	Category	Frequency	Percentage
Age	<20 years	2	4.3%
	20-29 years	8	17.4%
	30-39 years	18	39.1%
	40-49 years	15	32.6%
	50-59 years	2	4.3%
	≥60 years	1	2.2%
Gender	Male	41	89.1%
	Female	5	10.9%
Ethnicity	African	43	93.5%
	Coloured	3	6.5%
Work Experience	<1 year	3	6.5%
	1-5 years	21	45.7%
	6-10 years	9	19.6%
	11-15 years	8	17.4%
	16-20 years	4	8.7%
	≥21 years	1	2.2%
Education Level	Grade 8-11	7	15.2%
	Matric	29	63.0%
	University	10	21.7%

4.3 Knowledge and Practices of Pest Control Operators

A total of 46 PCO's participated and answered with an estimate of 97.8% responding to all the questions. Table 4.2 provides descriptive statistics summarizing the responses to all knowledge and practice questionnaire items. The table facilitates analysis of knowledge levels across pesticide and PPE domains as well as exploration of self-reported safety practices. Respondents demonstrated knowledge on both pesticides and PPE, as seen in the results for questionnaire items 8, 9, 10, 11, 13, 14.2, 18.3, 18.4, and 19 (Table 4.2). Overall, more than 80% of the participants showed an excellent level of knowledge on pesticide exposure. In comparison, the level of knowledge on PPE appears slightly higher, with 89.1% and 84.8% answering items 18.4 and 19 correctly, respectively.

4.3.1: Results on Knowledge level

Table 4.2. Descriptive Statistics for Knowledge Questions

Statement	N	Minimum	Maximum	Mean	Std. Deviation
Training on Pesticides 6: Have you ever attended any training related to the use of pesticides?	46	0	1	.96	.206
If yes, when was it? 6.1	38	1	5	3.55	1.005
Training on PPE 7: Have you ever received aby training on the use of PPE?	46	0	1	.89	.315
If no, why? 7.2	6	1	1	1.00	.000
If yes, when was it? 7.1	40	1	4	3.37	1.005
Knowledge on Pesticides 8: Is there a need for pesticides to be labelled?	46	0	1	.96	.206
Knowledge on Pesticides 9: Is it important for pest control operators to read pesticide labels and follow instructions?	45	1	1	1.00	.000
Knowledge on Pesticides 10: How can pesticides enter the body?	46	0	4	3.65	.875
Knowledge on Pesticides 11: Do you know other ways of pest control rather than chemical pesticides use?	46	0	1	.83	.383
Knowledge on Pesticides 12: Do you know if pesticides can cause ill health or even death?	46	1	1	1.00	.000

Table 4.2. Descriptive Statistics for Knowledge Questions (continuation)

Statement	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Knowledge on Pesticides 13: What are the signs and symptoms of pesticides poisoning?	46	0	1	.80	.401
Knowledge on Pesticides 14.1 What can cause pest control operators to be exposed to pesticides? Not washing hands before eating, after handling pesticides? (Yes/No)	45	0	1	.91	.288
Knowledge on Pesticides 14.2: What can cause pest control operators to be exposed to pesticides? Not following health and safety measures? (Yes/No)	46	0	1	.89	.315
Knowledge on Pesticides 15: Does bathing or taking a shower immediately after using pesticides decrease pesticide exposure? (Yes/No)	46	0	1	.98	.147
Knowledge on Pesticides 16: Can you name one pesticide, you use?	46	0	1	.91	.285
Knowledge on PPE 17: What do you understand by PPE?	46	0	1	.87	.341
Knowledge on PPE 18.1: What are the reasons to use PPE? To prevent injuries (Yes/No)	45	0	1	.96	.208
Knowledge on PPE 18.2: What are the reasons to use PPE? To prevent pesticides exposure (Yes/No)	45	0	1	.98	.149
Knowledge on PPE 18.3: What are the reasons to use PPE? To prevent insects/animal bites (Yes/No)	45	0	1	.87	.344

Table 4.2. Descriptive Statistics for Knowledge Questions (continuation)

Statement	N	Minimum	Maximum	Mean	Std. Deviation
Knowledge on PPE 18.4: What are the reasons to use PPE? To prevent diseases (Yes/No)	46	0	1	.89	.315
Knowledge on PPE 19: Who is supposed to wear PPE?	46	0	1	.89	.315
Knowledge on PPE 20: Does a respiratory mask protect against lung problem? (Yes/No)	46	0	1	.98	.147

According to the data presented in Table 4.3, a significant majority of respondents, particularly 96%, reported having received training on pesticide usage. Furthermore, 89% of the participants reported that they had received specific training on the proper use of personal protective equipment (PPE). Participants' awareness and understanding of the topics are demonstrated by high mean scores approaching 1 throughout the knowledge questions.

Table 4.3: Assessment of Knowledge Questions

Knowledge Items		Poor (50% or less)	Good (51%-70%)	Excellent (71%-100%)	Missing data
Knowledge on Pesticide 8: Is there a need for pesticides to be labelled?		4.3% (n=2)	-	95.7% (n= 44)	-
Knowledge on Pesticide 9: Is it important for PCO's to read pesticide labels?		-	-	97.8% (n= 45)	2.2% (n= 1)
Knowledge on Pesticide 10: How can pesticide enter the body	10.1 Skin	4.3% (n= 2)		-	-
	10.3 Mouth	13.0% (n= 6)		-	-
	10.4 Eye contact	-	-	80.4% (= 37)	
	Did not answer	-	-	-	2.2% (n= 1)
Knowledge on Pesticide 11: D10.9% (n= 5) do you know other ways for pest control either the chemical pesticide use		17.4% (n= 8)	-	82.6% (n= 38)	-

Table 4.3: Assessment of Knowledge Questions (Continuation)

Knowledge Items		Poor (50% or less)	Good (51%-70%)	Excellent (71%-100%)	Missing data
Knowledge on Pesticide 13: What are the signs and symptoms of pesticide poisoning.		19.6% (n= 41)	-	80.4% (n=37)	-
Knowledge on Pesticide 14.2:		10.9% (n= 5)	-	89.1% (n= 41)	-
Knowledge on Pesticide 18.3: What are the reasons for PPE use: to prevent insects and animal bites		13.0% (n= 6)	-	84.8% (n= 39)	-
Knowledge on Pesticide 18.4: What are the reasons for PPE use: to prevent disease.		10.9% (n= 5)	-	89.1% (n= 41)	-
Knowledge on Pesticide 19: Who is supposed to wear PPE.		10.9% (n= 5)	-	89.1% (n= 41)	-

The results of the knowledge assessment suggest that the PCOs possess a satisfactory level of understanding regarding the potential risks associated with pesticides and the appropriate utilisation of protective equipment. Upon analysis of the specific knowledge areas outlined in Table 4.3, it was seen that a significant majority, above 80%, of PCOs had a commendable level of understanding with regards to pesticide exposure routes and associated health hazards. As an illustration, a significant majority of respondents, specifically 95.7%, shown accurate recognition of the importance of appropriately labelling pesticides. Similarly, a substantial proportion, specifically 89.1%, exhibited knowledge regarding probable routes of exposure of pesticides into the human body. A significant proportion of individuals also demonstrated recognition of symptoms associated with pesticide poisoning, as well as familiarity with integrated pest management methods. The respondents also shown a high level of understanding on the purpose and the utilisation of PPE. The percentage of individuals who accurately responded to questions 18.3, 18.4, and 19 regarding protective gear is within the range of 84.8% to 89.1%. Nevertheless, there were lower scores observed for inquiries regarding diseases carried by insects, with a correctness rate of 82.6%, as well as distinguishing between dust masks and respirators, with a correctness rate of 80.4%. In general, the majority of PCOs have effectively attained a significant level of understanding in pesticide safety.

4.3.2 Practice Results

The Tables 4.4 and 4.5 reveal a mix of positive behaviours and concerning shortcomings. While all PCOs affirmed the importance of PPE, 18% admitted applying pesticides when their gear was damaged. Proper usage rates varied for different equipment types. Gloves, masks, boots and overalls saw high use around 90-100%, but lower reporting for face shields (69.1%) and aprons (63%). Regarding other safety measures, nearly all participants (95.7%) stored pesticides securely. However, empty container disposal and reuse (76.1% reusing) remain problematic. Additionally, although 95.1% avoided smoking during use, many reported eating (93.5%) and talking (80.4%) when handling pesticides. Post-exposure showering (67.4%) and separate laundry (52.2%) lacked full compliance. thus, unsafe practices persist despite hazard awareness.

Table 4.4. Descriptive Statistics for Practice Questions

Statement	N	Minimum	Maximum	Mean	Std. Deviation
Practices on PPE 21: Is wearing PPE important to you?	46	1	1	1.00	.000
Practices on PPE 21.1: If yes, why?	46	0	1	.96	.206
Practices on PPE 22: How often do you use PPE	46	0	2	1.76	.639
Practices on PPE 22.1: If never use of PPE, why?	7	1	5	2.57	1.718
Practices on PPE 22.2: If other specify	1	1	1	1.00	.
Practices on PPE 23: How often are you supplied with PPE	45	1	5	2.87	1.290

Table 4.4. Descriptive Statistics for Practice Questions (Continuation)

Statement	N	Minimum	Maximum	Mean	Std. Deviation
Practices on PPE 24.1: Which of the following PPE are used in your pest control unit? 2-piece overalls (Yes/No)	46	1	1	1.00	.000
Practices on PPE 24.2 Which of the following PPE are used in your pest control unit? Chemical Gloves (Yes/No)	46	0	1	.91	.285
Practices on PPE 24.3 Which of the following PPE are used in your pest control unit? Respiratory mask (Yes/No)	46	0	1	.96	.206
Practices on PPE 24.4 Which of the following PPE are used in your pest control unit? Goggles (Yes/No)	46	0	1	.85	.363
Statement	N	Minimum	Maximum	Mean	Std. Deviation
Practices on PPE 24.5 Which of the following PPE are used in your pest control unit? PVC apron (Yes/No)	45	0	1	.64	.484
Practices on PPE 24.6 Which of the following PPE are used in your pest control unit? Safety Boots (Yes/No)	46	0	1	.98	.147
Practices on PPE 24.7 Which of the following PPE are used in your pest control unit? Face Shield (Yes/No)	45	0	1	.71	.458

Table 4.4. Descriptive Statistics for Practice Questions (Continuation)

Statement	N	Minimum	Maximum	Mean	Std. Deviation
Practices on PPE 25: Have you ever had pesticide poisoning/symptoms whilst on duty?	44	0	1	.18	.390
Practices on PPE 25.1: If yes, were you wearing PPE?	8	0	1	.63	.518
Practices on PPE 27: What do you do if your PPE is torn or damaged?	46	1	3	1.83	.709
Practices on PPE 29: Do you use respiratory masks when using of handling pesticides?	46	1	1	1.00	.000
Practices on Safety Measures 30: Where do you store pesticides when not in use?	46	3	5	3.09	.412
Practices on Safety Measures 31: What do you do with empty containers?	46	1	5	2.65	.849
Practices on Safety Measures 32: What do you do with unused left-over pesticides?	45	2	5	3.38	.886
Practices on Safety Measures 33: When working with pesticides in an enclosed room, do you check if there is an exhaust fan or open windows?	46	1	1	1.00	.000
Practices on Safety Measures 34: Do you always have first aid kit on-site when working with pesticides?	45	0	2	.64	.609

Table 4.4. Descriptive Statistics for Practice Questions (Continuation)

Statement	N	Minimum	Maximum	Mean	Std. Deviation
Practices on Safety Measures 35: Do you follow pesticide labels/manufactures instructions?	46	0	1	.98	.147
Practices on Safety Measures 36.1: During pesticide use, do you do the following? Smoke	46	0	1	.04	.206
Practices on Safety Measures 36.2: During pesticide use, do you do the following? Drink	46	0	1	.07	.250
Practices on Safety Measures 36.3: During pesticide use, do you do the following? Eat	46	0	1	.07	.250
Practices on Safety Measures 36.4: During pesticide use, do you do the following? Gum	46	0	1	.07	.250
Practices on Safety Measures 36.5: During pesticide use, do you do the following? Engage in discussions	46	0	1	.20	.401
Practices on Safety Measures 37: Do you take a shower or bath before engaging in any activities after pesticide use?	46	0	5	.78	.786
Practices on Safety Measures 37.1: If no showering or bathing, why?	27	1	5	2.22	1.281
Practices on Safety Measures 38: Where do you wash your work clothes or PPE?	46	1	3	2.26	.648
Practices on Safety Measures 39: Is there any standard operating procedure for use of pesticides in your region?	45	0	3	.80	.548

Table 4.4. Descriptive Statistics for Practice Questions (Continuation)

Statement	N	Minimum	Maximum	Mean	Std. Deviation
Practices on Safety Measures 40.1 Which other non-chemical control measures or alternatives do you use to minimise pesticide use? Non-toxic humane trapping (Yes/No)	46	0	1	.87	.341
Practices on Safety Measures 40.2: Which other non-chemical control measures or alternatives do you use to minimise pesticide use? Snap traps (Yes/No)	46	0	1	.91	.285
Practices on Safety Measures 40.3: Which other non-chemical control measures or alternatives do you use to minimise pesticide use? Rat hunt (Yes/No)	46	0	1	.87	.341

Table 4.5. Assessment of Responses to Practice Questions

Practice Questions	Categories	Frequencies	%
Practices on PPE 21. Is wearing PPE important to you?	Yes	46	100
	No	-	-
Practices on PPE 22. How often do you use PPE	Always	40	87.0
	Sometimes	1	2.2
	Never	5	10.9
Practices on PPE 24.1 2 piece overall	Yes	46	100
	No	-	-
Practices on PPE 24.2 Chemical gloves	Yes	42	91.3
	No	4	8.7
Practices on PPE 24.3 Respiratory masks	Yes	44	95.7
	No	2	4.3
Practices on PPE 24.4 Goggles	Yes	39	84.8
	No	7	15.2
Practices on PPE 24.5 PVC apron	Yes	29	63.0
	No	16	34.8
	Missing data	1	2.2
Practices on PPE 24.6 Safety Boots	Yes	45	97.8
	No	1	2.2
Practices on PPE 24.7 Face shield	Yes	32	69.1
	No	13	28.3
	Missing data	1	2.2

Table 4.5. Assessment of Responses to Practice Questions (Continuation)

Practice Questions	Categories	Frequencies	%
Practices on PPE 25	Yes	8	18
	No	36	82
Practices on PPE 25.1	Yes	8	63
	No	5	38
Practices on PPE 27. What do you do with your torn or damaged PPE?	Throw away or wait till new one is available	16	34.8
	Collect a new one immediately	22	47.8
	Use even if its torn or damaged	8	17.4
Practice other safety measure 30. Where do you store pesticides when not in use?	In the open field	44	95.7
	Locked chemical store	2	4.3
Practice other safety measure 31. What do you do with empty pesticide containers?	Place them in the bin	8	17.4
	Reuse them for other purpose	2	4.3
	Hazardous waste collection site	35	76.1
	Discard them in an open field	-	-
	Other	1	2.2

Table 4.5. Assessment of Responses to Practice Questions (Continuation)

Practice Questions	Categories	Frequencies	%
Practice other safety measure 32. What do you do with used leftover pesticides?	Dispose in the field	-	-
	Dispose in the sewer	7	15.2
	Dispose at hazardous waste collection site	19	41.3
	Apply on other area till it's finished	14	30.4
	Mix only needed pesticide	5	10.9
Practice other safety measure 34. Do you always have first aid kit on-site?	Yes	23	50.0
	No	3	6.5
	Don't Know	19	41.3
	Missing	1	2.2
Practice other safety measure 36.1 Smoke	Yes	44	95.1
	No	2	4.3
Practice other safety measure 36.3 Eat	Yes	43	93.5
	No	3	6.5
Practice other safety measure 36.5 Engage in discussions	Yes	37	80.4
	No	9	19.6

Table 4.5. Assessment of Responses to Practice Questions (Continuation)

Practice Questions	Categories	Frequencies	%
Practice other safety measure 37. Do you take a shower after pesticide use?	Yes	31	67.4
	No	14	30.4
	Missing data	1	2.2
Practice other safety measure 38. Where do you wash your work clothes/PPE	At home with other clothes	5	10.9
	At home separately	24	52.2
	Dedicated laundry area for PPE in the office	17	37.0
	Other...	-	-
Practice other safety measure 39. Is there standard operating procedure in your region	Yes	33	71.7
	No	11	23.9
	Don't know	1	2.2
Practice other safety measure 40.1 Non-toxic humane trapping	Yes	40	87.0
	No	6	13.0
Practice other safety measure 40.2 Snap trap	Yes	42	91.3
	No	4	8.7

In summary, the City of Johannesburg's pest control workforce demonstrated broad understanding of pesticide risks and protective measures but gaps in safe practices. While most acquired substantial knowledge, corresponding utilization of protective gear and avoidance of unsafe habits was incomplete. This aligns with prior evidence that knowledge alone cannot guarantee cautious behaviours.

4.4 Association Between Knowledge and Practice

To understand the relationship between overall knowledge and practices (objective 3), statistical tests were conducted. Specifically, the association between total knowledge score and total practice score was analysed using the Chi-Square test. The knowledge score was calculated as the number of correct responses across questions 8-20 that assessed pesticide and PPE knowledge. The practice score was calculated as the total responses across questions 21-40 capturing self-reported safety practices.

The Chi-Square test yielded a value of 1.155 with a p-value of .283, above the typical .05 alpha level (full results in Table 4.6 below). Since the null hypothesis of the test states that there is no relationship between the two variables, the p value > 0.05 fails to reject the null hypothesis that asserts the two variables are independent of each other, i.e., there is no statistically significant association between the two variables.

Additionally, Fisher's Exact Test returned a p-value of .531 due to the small sample size. Since the p-values are greater than .05, these results demonstrate the test 'failed to reject the null hypothesis' that asserts the two variables are NOT independent of each other, i.e., there is an association between the knowledge and practice scores. Thus, participants' overall knowledge regarding pesticides and PPE appears to be linked to their reported safety practices based on this analysis. However, research with a larger sample may provide more insight into potential relationships between these key factors.

Table 4.6 Chi-Square Test for Association Between Knowledge and Practice

Test	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.155	1	.283
Continuity Correction	0.102	1	.750
Likelihood Ratio	1.808	1	.179
Fisher's Exact Test	-	-	.531
Linear-by-Linear Association	1.129	1	.288

Additional information:

- N of Valid Cases: 45
- 2 cells (50.0%) have expected count less than 5. The minimum expected count is .71.
- Continuity Correction computed only for a 2x2 table.

Table 4.7. Likelihood Ratio Tests to Determine Influence of Predictors on Knowledge in Pest Control

Table 4.7 presents results from likelihood ratio tests examining the influence of various predictors on pesticide safety knowledge levels (output variable). Several demographic and experience factors were analysed:

- Age: Participant's age group
- Education Level: Highest education level attained.
- Work Experience: Number of years working in pest control.
- Training on Pesticides: Whether participant had received pesticide training (yes/no)

Gender and ethnicity were excluded as predictors because the sample lacked variation on these variables, with nearly all participants being male and African.

For each predictor, a likelihood ratio test compared a model with all variables to a reduced model omitting that predictor. Large chi-square values and $p<0.05$ indicate the predictor significantly influences knowledge when included. However, as seen in Table 4.7, all predictors had small chi-square values and $p>0.05$, suggesting omitting each predictor does not worsen model fit. Therefore, there is insufficient evidence that the examined variables meaningfully predict pesticide safety knowledge based on this dataset.

Table 4.7: Likelihood Ratio Tests to Determine Influence of variables on Knowledge in Pest Control

Likelihood Ratio Tests				
Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	Df	Sig.
Intercept	3.348[a]	.000	0	.
Age	6.716	3.368	4	.498
Gender	3.348	.000	1	.996
Ethnicity	3.348	.000	1	.996
Education Level	4.028	.680	2	.712
Work Experience	5.844	2.496	4	.645
Training on Pesticides 6	3.348	.000	1	.996
The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.				
a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.				

Likelihood ratio tests were performed to see whether different predictors have an impact on pesticide safety awareness. Two models were examined for each predictor.

1 **Full model**: Comprised of all predictors, namely Age, Education Level, Work Experience, and Training on Pesticides.

2 **Reduced model**: Excluded the particular predictor.

By comparing the entire and reduced models, we may determine if omitting a particular predictor significantly impairs the model's fit and predictive capability. Gender and ethnicity were excluded as predictors since they did not exhibit sufficient variation within the sample. Thus, the comprehensive model encompassed:

- Age
- Education level
- Work experience.
- Pesticide training

Subsequently, individual reduced models were created by excluding one of the variables at a time.

The discrepancy in -2 log likelihoods between the whole and simplified models signifies the impact of the excluded predictor. A high chi-square value and a p-value less than 0.05 imply that the predictor has a substantial impact on knowledge when it is included. Nevertheless, according to the data presented in Table 3.7, excluding any of the predictors led to minimal chi-square values ranging from 0 to 3.368, and significant p-values exceeding 0.05. This implies that removing each predictor does not significantly deteriorate the fit of the model.

Put simply, the demographic and experience variables do not significantly enhance the model's capacity to predict levels of pesticide safety awareness using this dataset. The analysis lacks adequate data to establish that these factors exert a substantial impact on knowledge.

4.5 Conclusion

The results chapter presented findings on the pesticide knowledge and practices of municipal pest control operators in the City of Johannesburg. Descriptive statistics revealed a predominantly male, middle-aged workforce with moderate experience levels and secondary education. Knowledge assessment indicated substantial understanding of toxicity hazards and protective measures, with over 80% of PCOs scoring excellently. However, self-reported safety behaviours showed gaps between hazard awareness and cautious practices. Nearly a fifth admitted applying pesticides when gear was damaged, while many reported unsafe habits like eating during handling. Statistical tests found no significant relationship between overall knowledge and practice scores. The data provides useful characterization of a hazardous occupation's professed risk awareness and field conduct. While proper safety knowledge exists, translating this into resilient safe practices remains a challenge. The results equip policymakers to address weaknesses through supportive interventions beyond standard training. Ultimately, protecting workers requires synchronizing professed hazard diligence with resilient precautions resilient to situational influences.

CHAPTER 5: DISCUSSION

5.1 Introduction

This chapter discusses the key findings from the study exploring municipal pest control operators' knowledge and practices regarding pesticide hazards in the City of Johannesburg. The results are examined in relation to prior literature and theories on pesticide risks, training needs, and safety practices. Implications of the research are presented, along with study limitations and areas for future investigation. The discussion aims to contextualize the results within existing evidence and frameworks to derive practical conclusions.

5.2 Demographic Analysis

The sampled pest control officers averaged between 30-49 years old. This aligns with Damalas and Eleftherohorinos's (2011) finding that pest control tends to be entered later in working life after acquiring relevant skills and experience. The profession likely appeals to mature individuals ready for hands-on vocational work. However, Macfarlane et al. (2013) caution that an aging workforce nearing retirement may require recruitment and training of younger replacements.

Regarding gender, 89.1% of participants were male, reflecting the male domination seen in Macfarlane et al.'s (2013) Australian pest controller sample. Sociocultural biases steering women away from physically demanding occupations may explain this skew (Damalas and Eleftherohorinos, 2011). In terms of ethnicity, 93.5% were African and 6.5% Coloured, broadly mirroring the City of Johannesburg's demographics. However, tailored interventions should consider cultural and educational differences across ethnic communities which may influence pesticide comprehension and practices (Khan, 2021).

For experience, 45.7% had 1-5 years in pest control and 36% had 6-15 years. This moderate experience level balances competency with avoiding complacency among veterans (Jallow et al., 2017). However, ongoing training is still essential to reinforce good practices. Regarding education, 63% had secondary qualifications, 21.7% tertiary, and 15.2% less than secondary schooling. Higher literacy aids pesticide safety knowledge as Negatu et al. (2016) identified. Thus, supplementary education could benefit less schooled employees.

5.3 Knowledge Level of Pesticide Exposure and PPE

The study results demonstrated that most municipal pest control operators in the sampled regions of Johannesburg exhibited extensive knowledge regarding the health hazards associated with pesticide exposure and the purpose and proper use of personal protective equipment. In particular, over 80% of participants obtained excellent scores on knowledge questionnaire items addressing pesticide labelling, exposure prevention, associated symptoms, integrated pest management methods, and protective gear usage. For example, around 96% of individuals accurately recognized the necessity and legal requirement for appropriate labelling of pesticides containing warnings, instructions, and safety information. Proper classification and labelling enable handlers to understand necessary precautions and first aid steps if exposure occurs. As Jallow et al. (2017) discussed, labelling comprehension represents a vital starting point in hazard awareness that should be reinforced through training.

In addition to appreciating labelling, a significant majority of respondents, specifically 91%, exhibited familiarity with probable occupational exposure routes such as ingestion, inhalation, and dermal contact. Lekei et al. (2014) similarly found pesticide users in Tanzania knowledgeable about transmission pathways. This route knowledge provides the basis for targeted precautions like proper mask types, glove usage, protective clothing, and avoidance of eating while handling. Participants also demonstrated substantive understanding of immediate, acute, and chronic health implications linked to pesticide absorption. In particular, around 85% successfully identified symptoms ranging from skin and eye irritation to neurological impairment, reflecting awareness that pesticides confer both short and long-term effects. Multiple studies have advised training programs to thoroughly cover the diverse health consequences, from nausea and headaches to chronic conditions like cancer, to emphasize the importance of precautionary measures (Jallow et al., 2017; Moustafa, 2017).

One knowledge gap observed was around disease vectors transmitted by pests, with only 83% answering correctly compared to over 90% on other questions. Moving beyond pesticide-specific knowledge, respondents also exhibited broad understanding on selecting, utilizing, and maintaining protective gear to create crucial barriers against exposure. In particular, around 85% to 90% demonstrated accurate comprehension on reasons for equipment usage, what constitutes complete protection, and who bears responsibility for proper practices. However, as revealed by the practical response analysis, gaps remained between this protective equipment knowledge and reported usage behaviours.

While the overall knowledge results imply existing educational initiatives provide a useful foundation of toxicity awareness, several areas require ongoing reinforcement. For example, participants had slightly more difficulty distinguishing the necessity of proper respirators over basic dust masks, with around 80% answering correctly. Proper respiratory protection remains essential given inhalation risks, so additional focus on mask types and characteristics could aid retention. The scores also suggest supplemental training on contamination vectors may be beneficial alongside reviewing integrated pest management strategies. Ultimately, as Negatu et al. (2016) observed, combinations of initial and refresher education are ideal for engraining hazard diligence. Periodic knowledge assessments enable trainers to target areas of weakness and evolving scientific understandings.

According to Brits (2012), municipal pest control also inculcates an institutional safety culture including record-keeping and team responsibility. Additionally, the public health orientation of controlling disease vectors reinforces understanding toxicity and precaution. However, as the practice results reveal, gaps between professed hazard diligence and actual field precautions still arise.

5.4 Practices Regarding PPE and Safety Measures

While the majority affirmed awareness of pesticide risks and proper handling, the results on self-reported safety behaviours reveal multiple gaps between knowledge and practices. Concerning percentages admitted to unsafe habits like eating, talking, smoking, and inadequate protective equipment use during pesticide handling. For example, around 18% indicated proceeding with pesticide application even when their personal gear was damaged, and just 67% reported always showering after exposure. Such admissions track with studies by Gangemi et al. (2016) and Abbassy et al. (2017) where pesticide users in the farming sector conceptually grasped dangers but regularly overlooked recommended precautions.

Examining specific gear utilization provides further insights on compliance shortcomings. Although usage rates were relatively high for essential items like gloves, boots, and masks at 90-100%, lower percentages adhered to recommended practices for other equipment. For instance, only 69.1% reported employing face shields and just 63% aprons. Studies in multiple countries including Greece and Tanzania have identified a tendency to utilize incomplete protection sets lacking items deemed less crucial (Lekei et al. 2014; Macfarlane et al., 2013). However, comprehensive gear is necessary to block diverse pesticide exposure pathways. Users must understand the purpose of each item in the ensemble rather than perceiving any as optional or interchangeable.

The results similarly demonstrated unsafe practices regarding disposal of leftover pesticides and empty containers. Around 4% admitted reusing empty containers. These improper behaviours align with observations by Oztas et al. (2018) and Lekei et al. (2014) of haphazard disposal through dumping, burning, or residential reuse. Proper treatment prevents environmental contamination and health risks to operators handling containers with residual traces.

Concerning hygiene habits were also reported during handling such as talking (80.4% admitting) and eating (93.5% admitting) which can increase accidental ingestion. Studies by Sabran & Abas (2021) and Devagappanavar (2021) found users aware of poisoning risks but ignoring food prohibitions, highlighting the need for continuous cultural reinforcement of diligent practices, not just one-off training. Instructions must emphasize that distraction and food contamination can quickly negate protection from proper gear.

Overall, the prevalence of admitted unsafe behaviours despite general knowledge on hazards and precautions echoes the conclusions of past research. According to Damalas and Eleftherohorinos (2011), ineffective training practices that do not adequately translate book knowledge into practical skills application enables this disconnect. Lekei et al. (2014) also point to workplace culture and lack of regulatory enforcement as factors undermining knowledge application. Interventions solely focused on informing handlers thus often falter. For example, Ndayambaje et al. (2019) found Rwandan pesticide users had basic awareness but universally poor practices with 95% not utilizing protective equipment properly.

The City of Johannesburg should utilize the practice results to target unsafe habits through combinations of skills-based participatory training, continuous audits and guidance to correct behaviours, provision of adequate and comfortable protective resources, and promotion of workplace cultural diligence to make safe conduct instinctual. For example, frequent inspection of equipment condition and replacement of damaged gear could reduce usage of compromised protection. Proper disposal facilities and demonstrations must prevent container reuse. Building team responsibility, positive mentoring of new handlers by experienced ones, and celebrating safety achievements rather than penalizing, can gradually embed good practices (Damalas & Eleftherohorinos, 2011). Ultimately pesticide cautions must become habitual norms to achieve resilience against situational factors eroding diligence.

5.5 Relationship Between Knowledge and Practices

Statistical analysis found no significant association between participants' overall knowledge and practice scores. This lack of linkage echoes conclusions by Lekei et al. (2014) that proficient understanding alone fails to dictate safe pesticide handling when intervening factors like resource barriers or social norms persist. The data suggests City of Johannesburg operators can clearly articulate toxicity hazards and protective principles without necessarily applying that knowledge to guide comprehensive safe behaviours. According to Jallow et al. (2017), experienced handlers may gradually ignore risks they feel capable of managing. Additionally, discomfort from gear in hot conditions or peer pressure to work quickly could sway users to overlook precautions despite awareness (Damalas & Eleftherohorinos, 2011).

The health belief model provides theoretical context on the knowledge-practice disconnect by explaining how perceived susceptibility and efficacy shape precaution adoption. Pesticide users may intellectually recognize general health risks but feel invulnerable personally or lack faith in equipment efficacy to provide sufficient motivation. Social cognitive theory further clarifies how negative role modelling and lacking self-confidence in performing safety protocols undermine knowledge application (Glanz et al., 2008).

City administrators must implement multifaceted initiatives to engrain safety conduct by improving skills, providing protective resources, monitoring compliance, encouraging workplace cultural responsibility, and building handler confidence. According to Thompson et al. (2019), supportive organizational environments are essential to translate intellectual caution into resilient field precautions among chemical handling occupations. Achieving this goal requires understanding knowledge limitations and holistically addressing barriers through ongoing engagement rather than one-time training.

Additional data collection through qualitative approaches could provide richer insights on reasons for safety gaps. Interviews examining specific obstacles to compliance would equip the City of Johannesburg to tailor remedial initiatives based on operational experiences and challenges (Lekei et al., 2014).

5.6 Study Limitations

The major limitation of the study was the small sample size, as the study was limited to municipal pest control operators within the geographic boundaries of the City of Johannesburg municipalities, therefore limiting the extrapolation to municipal PCOs in general. The small sample from one city suggests caution in broad generalization of results. Additionally, the reliance on self-reported safety practices rather than direct observation provides insights into professed behaviours which may not fully reflect actual workplace conduct. The modest response rate and uneven demographic distribution limited representativeness. The quantitative knowledge and practice data lacks contextual qualitative information about reasons for unsafe habits or barriers to compliance. However, the study offers useful initial quantification of pesticide knowledge and practices to guide future research.

5.7 Implications of the Study

5.7.1 Implications for Theory

The results provide additional evidence for the limitations of the knowledge-attitude-practice model which assumes that hazard awareness reliably spurs corresponding safety actions. By demonstrating gaps between pesticide knowledge and practices, the findings support models like the health belief framework which consider perceived susceptibility, efficacy beliefs, and barriers as mediators (LaMorte, 2019). The lack of association despite training also aligns with Bandura's social cognitive theory emphasizing that behavioural adoption depends on social learning, reinforcement, and self-efficacy alongside factual comprehension (Glanz et al., 2008).

Ultimately, the data indicates knowledge functions as just one preliminary factor that interacts with others to shape pesticide precautions. While education provides an essential foundation, interventions must address the array of social, emotional, practical and motivational influences on safety conduct to turn intellectual awareness into resilient behavioural diligence.

Moving forward, additional exploration grounded in behavioural science theories would enrich understanding of safety decision-making processes. For example, perceived risk susceptibility has been pinpointed as a key mediator between hazard knowledge and precaution taking (Atreya et al., 2020). Structural equation modelling could shed light on how much variation in precautions is explained by knowledge levels versus perceptual variables. Qualitative approaches like focus groups and ethnographic observations could also capture contextual insights on barriers to compliance unavailable from questionnaire data. Ultimately further research integrating models like the health belief framework with qualitative inquiry can unpack why gaps arise between awareness and action.

5.7.2 Implications for Practice

The findings demonstrate that substantial pesticide knowledge does not reliably translate into safe handling practices. This indicates that solely providing preparatory training on risks and precautions leaves users vulnerable in the field without ongoing reinforcement of safety conduct. City administrators should adopt practical initiatives to convert intellectual caution into resilient behavioural habits.

Hands-on demonstrations and return sessions to refresh techniques and update understanding are ideal. Secondly, consistent auditing with supportive guidance rather than just penalties can correct unsafe habits through positive modelling and relationship building with supervisors (Thompson et al., 2019). Thirdly, adequate comfortable protective gear supplies facilitate compliance, so budgets should prioritize quality equipment access. Fourthly, celebrating safety achievements, peer encouragement, and accountability can gradually normalize diligence as a workplace culture habit.

Finally, qualitative inquiry through interviews or focus groups would provide context to guide interventions by uncovering behavioural rationale and barriers. Overall, multifaceted engagement must continue beyond preparatory knowledge transfer to successfully synchronize comprehension with tenacious safe conduct. With ongoing reinforcement of skills and norms, intellectual awareness can be translated into resilient behavioural caution.

5.8 Conclusion

In conclusion, municipal pest control operators showed broad pesticide knowledge with gaps in corresponding safe practices. The study provides initial evidence to guide supportive interventions beyond traditional training for this hazardous occupation. Further research can build on these findings through expanded samples, observational validation, and qualitative inquiry. But characterizing professed understanding alongside reported precaution weaknesses offers actionable insights for strengthening occupational health protections. Proper usage of PPE and adhering to safety practices support Goal 3 (ensures health lives and promotes well-being for all ages) of sustainable development goals which aims to reduce the number of fatalities and ill health from hazardous chemicals by 2023.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This concluding chapter reviews the key findings of the research study exploring municipal pest control operators’ knowledge and practices related to pesticide exposure within the City of Johannesburg municipalities. The results are summarised, and core conclusions derived based on the evidence. Concrete recommendations are proposed in areas including training initiatives, workplace culture, regulatory policy, personal protective equipment provision, and monitoring mechanisms. Suggestions for supplementary qualitative research and expanded quantitative studies are also presented to guide future investigation. The chapter aims to translate the study's empirical contributions into actionable measures for strengthening occupational health protections in this essential yet hazardous public health profession.

6.2 Summary of Findings

The sample of 46 City of Johannesburg pest control operators provided useful quantitative insights into the workforce's pesticide exposure knowledge, PPE and safety practices, experience levels, and demographic characteristics. Key results are reviewed below in relation to the three research objectives focused on awareness, behaviours, and potential connections between the two domains.

6.2.1 The Level of Knowledge on Pesticide Exposure and Protective Equipment

The administered questionnaires revealed relatively high levels of professed understanding regarding pesticide exposure and appropriate usage of PPE to mitigate risks. In particular, over 80% of participants obtained "excellent" scores on knowledge sections addressing health implications, exposure pathways, labelling comprehension, integrated pest management, and protective gear selection and maintenance. Areas of comparatively lower familiarity included distinguishing proper respirators versus basic dust masks. This grasp of key principles likely stems from the prevalence of preparatory and refresher training, with 96% of the sample reporting pesticide instruction and 89% training focused on protective equipment. Overall, the City of Johannesburg PCOs have acquired fundamental pesticide hazard awareness, although knowledge levels exhibit some variation across specific topics.

6.2.2 The Practices of Pest Control Operators Regarding Protective Equipment and Safety Measures

In contrast to the proficient knowledge results, analysis of self-reported safety practices revealed areas of concern regarding actual occupational precaution habits. While all operators affirmed the importance of personal protective equipment, 18% admitted proceeding with pesticide application even when their gear was damaged. Proper usage frequencies were relatively high for crucial equipment like gloves, boots, and masks (90-100%) but dropped for other recommended items like goggles (85%), aprons (63%) and face shields (69%). Additional shortcomings included reusing empty containers, unsafe leftover disposal, and unhygienic practices like eating, drinking and smoking during handling. Immediate precautions like washing after exposure and separate laundry also showed incomplete adherence.

In summary, persistently high-risk behaviours coexist with general understanding of pesticide dangers. This disjunction echoes prior evidence that knowledge alone fails to determine safe conduct when factors like availability, social norms, discomfort and perceived efficacy intervene.

6.2.3 The Association Between Knowledge and Pest Control Practices

Statistical analysis using chi-square tests found no significant relationship between participants' overall knowledge scores and self-reported precaution practices. This lack of linkage substantiates the qualitative narrative that factual understanding does not reliably translate into behavioural caution. Participants could verbalize toxicity hazards and proper control measures without necessarily applying that awareness when undertaking fieldwork. According to theories like the health belief model, perceived susceptibility and barriers also shape safety decisions alongside comprehension. Within the City of Johannesburg, the data indicates operators require continued training, workplace culture reinforcement, and compliance oversight to enact intellectual pesticide diligence. While current educational initiatives cultivate a useful foundation of hazard awareness, resilient safe behaviours require comprehensive engagement and implement relevant SOP’s.

6.3 Conclusion

Several key conclusions emerge from the study results regarding municipal pest control operators' relationship with occupational pesticide risks. The workforce demonstrates fundamentally sound understanding of pesticide exposure, precautions, and protective principles but with some gaps in technical details. Self-reported safety practices exhibit shortcomings and unsafe habits conflicting with general hazard diligence comprehension. No statistically significant association links higher knowledge to safer practices, emphasizing that awareness alone does not determine behaviour.

Demographic variables like experience and education did not exert a major influence on knowledge levels based on this limited sample. Current training establishes a substantive pesticide hazard knowledge foundation but requires ongoing reinforcement.

6.4 Recommendations

6.4.1 Training Initiatives

Currently there is no SOP for training on how training should be conducted, what type of training and frequency so regular supplementary training should be provided to strengthen technical understanding, refresh material, and incorporate updated scientific findings. Annual refresher workshops would be ideal. Interactive teaching methods focused on building skills mastery and self-efficacy, not just conveying facts, should be utilized. This should include simulations, demos, participatory exercises, and opportunities to demonstrate techniques. Areas of lesser knowledge like vectors and mask types should be reviewed in greater depth to improve retention. Anecdotes of real pesticide incidents and affected workers should be shared to increase perceived susceptibility. Group workshops should be supplemented with one-on-one mentoring of novice PCOs by experienced peers to encourage positive modelling.

6.4.2 Workplace Culture

Team responsibility for safety should be cultivated through group discussions of goals, challenges, and solutions. Rewards like recognition for divisions achieving full compliance records over set periods should be instituted. Non-punitive guidance should be provided when transgressions like improper gear usage arise to correct habits while building trust. Reporting of concerns without judgement should be encouraged to uncover and collaboratively resolve obstacles. Respected veteran

PCOs should be selected as volunteer safety representatives in each region to give advice and set an example.

6.4.3 Regulatory Policy

Clear standardized operating procedures and equipment guidelines for all regions should be developed to eliminate ambiguity and ensure that there is uniformity throughout all the regions. Existing rules should be reviewed and updated according to the latest scientific evidence and industry best practices. Record-keeping directives for purchasing inspection, training, incidents, and corrective actions should be strengthened. Third-party external audits of administrative and field operations should be instituted to motivate rigorous adherence.

6.4.4 Protective Equipment Provision

Feedback should be solicited annually from users on preferences, comfort and desired upgrades to equipment. Budgeting should allow for regular replacement of damaged gear before efficacy is compromised. Cleaning and storage facilities should be provided to encourage proper maintenance practices. Supplementing hot weather gear with cooling techniques like cold packs should be considered to improve comfort. Ergonomic enhancements that relieve physical burdens discouraging compliance should be trialled.

6.4.5 Monitoring Mechanisms

Unannounced site inspections should be performed to validate reported practices and usage of intact gear. Records like training logs, purchases, and inspection findings should be reviewed to verify proper documentation. Medical surveillance such as biomonitoring through techniques like urine samples should be conducted to gauge actual vs reported exposure. Anonymous surveys should be administered to uncover unsafe norms that personnel may be reluctant to admit otherwise. Suggestions boxes should be implemented to collect ongoing feedback on potential process improvements.

6.5 Recommendations for Future Research

To expand upon the insights from this initial study, the following recommendations propose directions for supplementary research:

- Conduct focus groups and interviews examining reasons for unsafe practices despite hazard knowledge to uncover behavioural drivers.

- Use ethnographic observations or job shadowing to directly validate actual practices against self-reported behaviours.
- Implement a participatory workshop eliciting PCOs' suggestions on improving training relevance, workplace culture, and overcoming barriers.
- Expand the survey across more municipalities and regions to improve sample size and generalizability.
- Evaluate demographic or psychological variables as predictors of safe behaviours using correlational analysis on larger samples.
- Apply multivariate regression modelling to identify leading determinants of safety knowledge versus practices.
- Examine impact of interventions like culture change or revised training through pre/post testing of knowledge and practices.
- Explore the feasibility to conduct exposure assessment studies, including biomonitoring.

6.6 Overall Conclusion

In conclusion, this research determined the level of knowledge on pesticide exposure, effective PPE usage and safe practices among municipal pest control operators within the City of Johannesburg. The study found that while substantial pesticide safety awareness exists among the workforce, engraining comprehensive safe practices requires an expanded engagement strategy beyond traditional training. The conclusions indicate that knowledge alone does not guarantee safe behaviours. Despite high levels of professed hazard comprehension, concerning percentages of operators admitted to unsafe habits like improper protective gear usage and unhygienic practices during handling. This indicated that knowledge does not always translate into safe practices.

The recommendations provide administrators an actionable roadmap for strengthening occupational health protections. Initiatives spanning training methods, workplace culture, resource provision, and compliance monitoring can synchronize knowledge with tenacious safe conduct. Skills-focused interactive workshops, peer mentoring, rewarding diligence, adequate comfortable protective supplies, and consistent supportive audits represent potential high-impact interventions. With coordinated efforts engaging both workers and institutions, pesticide knowledge can become the foundation rather than the ceiling for safety. As frontline public health defenders against disease vectors, pest control personnel deserve environments empowering them to enact their hazard awareness.

Ultimately this research aimed to strengthen understanding of factors shaping pesticide precaution-taking among municipal operators. While limitations exist, the study provides useful baseline data and insights to guide further research and evidence-based interventions. Ensuring this vital occupation is conducted with adequate safety requires policymakers to bridge gaps between awareness and action through holistic organizational initiatives. With supportive systems enabling skills application and conduct consistency, diligent pest control teams can continue their essential protection of communities while safeguarding themselves.

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Appendix A: Informed Consent

Informed consent for Research Information Study

Title of project: KNOWLEDGE AND PRACTICES ON PESTICIDE EXPOSURE AMONGST PEST CONTROL OPERATORS IN THE CITY OF JOHANNESBURG METROPOLITAN MUNICIPALITY

Researcher: Manare Yvonne Molema

Good day Sir/Madam

My name is Manare Yvonne Molema, and I am a Masters student in Public Health at the University of the Witwatersrand, Johannesburg. As part of my studies, I must undertake a research project. Research is a process used in seeking new knowledge.

The project details are as the below. I am asking or inviting you to take part in a research study.

1. The project/study

I am investigating knowledge and practices on pesticide exposure amongst the City of Johannesburg metropolitan municipality's pest control operators under the supervision of Prof. Derk Brouwer. The aim of this research project is to determine the knowledge and explore the practices of pest control operators on pesticide exposure, PPE and other safety measure within the 7 regions of COJ.

2. What is expected of you?

As part of this project, I would like to invite you to take part in an interview answering a questionnaire. This activity will take around 30-40 minutes. The questionnaire will be captured on Redcap. The questionnaire consists of demographics, knowledge and practices. Knowledge has two sections: pesticide exposure and PPE. Practice has two sections: PPE practices and other safety measures.

3. Additional information, rights and assurances?

Participation is voluntary. There will be no personal costs to you if you participate in this project, you will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. The interview will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. I will be using a pseudonym (false name) to represent your participation in my final research report. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

My name is Manare Yvonne Molema. I can be contacted during office hours at Tel (011) 226-8300 or on my cell phone number on 0832880545, email address yvonne.manare@gmail.com. My supervisor's name is Derk Brouwer, email address derk.brouwer@wits.ac.za.

If you have any concerns or complaints or any questions regarding the ethical aspects of the study, feel free to contact Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 0117172301, or by e-mail at Clement.Penny@wits.ac.za. Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

This study will be written up as a research report which will be available online through the university library website. The data collected from this research project will be stored in password protected cloud account and will be kept for 2 years and thereafter it will be destroyed accordingly.

The study has been approved by the Human Research Ethics Committee (Medical) of the University of Witwatersrand, Johannesburg. A principal function of this committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

I hereby request your participation in the study.

Respondent:

Here the respondent must indicate what was understood about the contents of this form and confirm that it was understood.

- I, ………………………………………..., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

  I agree to the following:

  (Please circle the relevant options below).

  I agree that my participation will remain anonymous.

  YES NO

  I was given time to read it, or had it read to me, in the language I best understand.

  YES NO

I believe I fully understand why the study is being conducted and what the intended outcomes will be

YES NO

I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment, conversely, participation will not cost me anything but my time.

YES NO

I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons, if that happened, any data collected about me for the purposes of the study would be destroyed immediately, unless I give consent for it to be retained.

YES NO

I agree that the researcher may use anonymous quotes in his / her research report.

YES NO

I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study, I am free to speak to any of these contacts.

YES NO

Principal Investigator Manare Yvonne Molema can be contacted during office hours at Tel (011) 226-8318 or cell phone number 0832880545 or by email at yvonne.manare@gmail.com. Supervisor's, Derk Brouwer, on telephone no. 011 7172387 or by email at derk.brouwer@wits.ac.za.

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 0117172301, or by e-mail at Clement.Penny@wits.ac.za. Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of participant Signature Place

Date

Name of interviewer Signature Place

APPENDIX B

Pest control operator's demographic, knowledge on pesticide exposure and personal protective clothing and equipment (PPE) which is an equipment or device designed to be worn to minimize exposure to a variety of hazards (OSHA,2004), practices regarding PPE and other safety measures.

QUESTIONNAIRE

Introduction

Thank you for taking your time to participate. This survey is conducting questions on demographics and questions to assess knowledge on personal protective equipment, knowledge on pesticides exposure and practices regarding personal protective equipment and other safe measures.

Your responses to the questions will be treated as private and confidential.

Study identification number:

Date:	__ __ / __ __ / 20 __
	D/ M /Y
Site:	Region:
	Name of the building/ Address

Instructions

Please respond to the questions, by indicating the options in answer as provided.

Thank you for your kind participation.

SECTION A: DEMOGRAPHIC INFORMATION

Please answer from the questions.

1. **How old are you: _______________**

2. **What is your sex?**

Gender	
Male	
Female	
Other	

3. **Which ethnicity group do you belong to?**

Ethnicity group	
African	
White	
Coloured	
Indian	
Other (Please specify)	

4. **What is your highest level of education completed from the following options?**

What is your education status?	
No formal education	
Primary	
Grade 8-11	
Matric	
University	

5. **How many years have you been employed in your current occupation?**

Work experience	
< 1 year	
1- 5 years	

6 -10 years	
11-15 years	
16-20 years	
21+ years	

6. **Have you ever attended any training related to the use of pesticides?**

1. Yes ☐
2. No (skip to question 7) ☐

6.1. **If yes, when was it?**

1. ☐ last 3 months
2. ☐ last 6 months
3. ☐ last (1) year
4. ☐ last 2 years
5. > 2 years ago

7. **Have you ever received any training on the use of PPE?**

1. Yes ☐
2. No (If no, skip to question 7.2) ☐

7.1 **If yes, when was it?**

Last 3 months	
Last 6 months	
Last (1) year	
Last (2year)	

Skip to question 8.

7.2 **If no, why?**

1. No training offered by employer ☐
2. Not interested in training ☐
3. Not allowed to attend training ☐
4. Other ☐

SECTION B: KNOWLEDGE ON PESTICIDE EXPOSURE.

Please answer to the best of your knowledge from the questions.

8. **Is there a need for pesticides to be labeled?**

1. Always
2. Sometimes
3. Never

9. **Is it important for pest control operators to read pesticide labels and follow the instruction of the labels?**

1. Yes
2. No

10. **How can pesticides enter the body? (You can mention more than one)**

1. Skin	
2. Nose	
3. Mouth	
4. Eye Contact	

11. **Do you know other ways for pest control rather than chemical pesticides use?**

1. Yes
2. No

12. **Do you know if pesticides can cause ill health or even death?**

1. Yes
2. No

13. **What are the signs or symptoms of pesticides poisoning you know?**

………………………………

14. **What can cause pest control operators to be exposed to pesticides? (Please answer with yes or no).**

1. Not washing hands before eating after handling pesticides	Yes	No
2. Not following health and safety measures	Yes	No

15. **Does bathing or taking a shower immediately after using pesticides decrease pesticide exposure?**

1. Yes
2. No

16. **Can you name at least one pesticide you use?...**

SECTION C: KNOWLEDGE ON PERSONAL PROTECTIVE CLOTHING

Please answer to the best of your knowledge.

17. **What do you understand by PPE?..**

18. **What are reasons to use PPE? (Please answer with yes or no).**

1. To prevent Injuries	Yes	No
2. To prevent pesticides exposure	Yes	No
3. To prevent insects/animal bites	Yes	No
4. To prevent diseases	Yes	No

19. **Who is supposed to wear PPE?**

1. Pest control supervisor	
2. All workers in the pest control unit	
3. Only workers that are spraying, fumigating, or handling pesticides	
4. Manager	

20. **Does a respiratory mask protect against lung problems?**

1. Yes
2. No

PRACTICES: SECTION D AND SECTION E

SECTION D: PRACTICES REGARDING PERSONAL PROTECTIVE EQUIPMENT

Please answer from the questions.

21. **Is wearing PPE important to you?**

1. Yes ☐
2. No (skip to question 23) ☐

21.1**. If yes, why?...**

22. **How often do you use PPE?**

1. Always ☐
2. Sometimes ☐
3. Never ☐

22.1 **If never use of PPE, why? (Can mention more than one reason)**

1. Not available ☐
2. Too Hot ☐
3. Uncomfortable ☐
4. Wrong size ☐
5. Other ☐

22.2 **If other specify……………………………………………**

23. **How often are you supplied with PPE?**

1. Every 6months ☐
2. Every year ☐
3. When necessary ☐
4. Never ☐
5. Sometimes ☐

24. **Which of the following PPE are used in your pest control unit? (Please answer with yes or no).**

1. 2-piece overalls	Yes	No
2. Chemical gloves	Yes	No
3. Respiratory masks	Yes	No
4. Goggles	Yes	No
5. PVC apron	Yes	No
6. Safety Boots	Yes	No
7. Face Shield	Yes	No

25. **Have you ever had pesticide poisoning/ symptoms whilst on duty?**

1. Yes
2. No (Skip to question 26)

25.1 **If yes, were you wearing PPE during this event?**

1. Yes
2. No

26. **Who is responsible to check the condition (e.g., if it's torn/broken) of the PPE before wearing?**

1. Pest control operator	
2. Pest control supervisor	
3. Operations manager	
4. Manager	

27. **What do you do if your PPE is torn or damaged?**

1. Throw away and wait till a new one is available	
2. Collect a new one immediately	
3. Use even if its torn or damaged	

28. **Who encourages you to wear PPE? (Can mention multiple)**

1. Pest control supervisor	
2. Self	
3. Operations Manager	
4. Nobody	

29. **Do you use respiratory mask when using or handling pesticides?**

1. Yes
2. No

SECTION E: PRACTICES: OTHER SAFETY MEASURES TO PREVENT OCCUPATIONAL PESTICIDE EXPOSURE

30. **Where do you store pesticides when not in use?**

1. Refrigerator	
2. In the open field	
3. Locked chemical store	
4. Office space	
5. Other, specify	

31. **What do you do with empty pesticide containers?**

1. Place them in a bin	
2. Reuse them for other purposes	
3. Hazardous waste collection site	
4. Discard them in an open field	
5. Other, specify	

32. **What do you do with the unused left over (mixed and diluted) pesticides?**

1. Dispose of in the field	
2. Dispose in the sewer	
3. Hazardous waste collection site	
4. Apply on other area till it's finished	
5. Mix only needed pesticide	

33. **When working with pesticides (spraying/fumigating) in an enclosed room, do you check if there is an exhaust fan or open windows?**

1. Yes
2. No

34. **Do you always have first aid kit on-site when working with pesticides?**

1. Yes ☐
2. No ☐
3. Do not know ☐

35. **Do you follow pesticide labels/manufactures prescription/instructions?**

1. Yes ☐
2. No ☐

36. **During pesticide use, do you do the following?**

1.	Smoke	Yes	No
2.	Drink	Yes	No
3.	Eat	Yes	No
4.	Gum	Yes	No
5.	Engage in discussions	Yes	No

37. **Do you take a shower or bath before engaging in any activities after pesticide use?**

1. Yes (Go to question 38) ☐
2. No ☐

37.1 **If no showering or bathing, why?**

1. No wash up facilities	
2. Wash up facilities available however no hot and cold running water	
3. Not provided with soap	
4. It is not necessary	
5. Other, specify.	

38. **Where do you wash your work clothes/ PPE?**

1. At home with other clothes	
2. At home separately	
3. Dedicated laundry area for PPE at the office	
4. Other, specify.	

39. **Is there any standard operating procedure for use of pesticides in your region?**

1. Yes	
2. No	
3. Don't know	

40. **There are other ways that can be used to kill rodents. Which other non-chemical control measures or alternatives do you use to minimize pesticide use? (Please answer with yes or no as I read out the listed possible answers).**

1. Non-toxic humane trapping	Yes	No
2. Snap traps	Yes	No
3. Rat hunt	Yes	No

<Dear Operator: Thank you for participating.>

APPENDIX C: Research Committee of Johannesburg Health District approval letter

a world class African city

GAUTENG PROVINCE

RtP\JSU(Or- 50Jnt AFRl(A

Research Committee of
Johannesburg Health District

Enquiries: Ms. Busisiwe Sikhosana
Tel: 011 694 3909
Email :Busisiwe.Sikhosana1@ autena.cov.za
Hillbrow CHC: Administration Building,
Cnr Smith Str. & Klein Street
Private Bag X21, Johannesburg,
South Africa, 2017

15th July 2021
529 PHASE SB
Whitehouse,
Buhle Park
Germiston
1401

Email: yvonne.manare@gmail.com

Dear: Ms Manare Molema

TITLE: KNOWLEDGE AND PRACTICES ON PESTICIDE EXPOSURE AMONGST PEST CONTROL OPERATORS IN THE CITY OF JOHANNESBURG METROPOLITAN MUNICIPALITY

DRC Ref: 2021-04-010

NHRD Ref no: GP_202104_039

OFFICIAL APPROVAL

The Johannesburg Health District Research Committee (DRC) has reviewed your application. This letter serves as approval to access the Districts Health facilities (mentioned below) for the above research.

The **following conditions must be observed:**

- The facilities in which the research will be conducted are CITY OF JOHANNESBURG
- These facilities will be visited from: 15/07/2021 to 15/07/2022.
- Participants' rights and confidentiality will be maintained all the time.
- No resources (Financial, material and human resources) from the above facilities will be used for the study. Neither the District nor the facility will incur any additional cost for this study.
- The study will comply with Publicly Financed Research and Development Act, 2008 (Act 51 of 2008) and its related Regulations.

- You will submit a copy (electronic and hard copy) of your final report. In addition, you will submit an annual progress report to the District Research Committee.
- Your supervisor and the University of The Witwatersrand will ensure that these reports are being submitted timeously to the District Research Committee.
- The district must be acknowledged in all the reports/publications generated from the research and a copy of these reports/publications must be submitted to the District Research Committee.
- You will liaise with the manager/s before initiating the study.

Contact	**Sub District**	**Sub District Manager/ Area Manager**	**Contact No.**	**Cell phone**
ABCEF	Ms Lombuso Matlala	0114401259	082 307 0267	ABCEF
D	Ms Maria Mazibuko	0116741200	082 7819919	D
G	Mr Peter Mathole	011213 9603	072 483 6839	G
CoJ A	Ms Nelly Shongwe	011237 8010	082 467 9276	CoJ A
CoJ B	Ms Zanozuko Mbane	0117189656	082 5515804	CoJ B
CoJ C	Mr Tebogo Motsepe	0117610200	084 655 5420	CoJ C
CoJ D	Ms Busi Phiri	011986 0164	082 467 9316	CoJ D
CoJ E	Mr Vusi Mazibuko	0115821504	082 464 9547	CoJ E
CoJ F	Mr M Monyamane	0116818130	082 467 9423	CoJ F
CoJ G	Ms Olga Kruger	0112118936	083 286 0388	CoJ G
X	CoJ Offices	Mr Bheki Sibeko	011407 7122	0815751165

We reserve our right to withdraw our approval, if you breach any of the conditions mentioned above. Please feel free to contact us, if you have any further queries.

On behalf of the District Research Committee, we would like to thank you for choosing our District to conduct such an important study.

Regards,

Pi1f S. Moosa

Chairperson: District Research Committee Johannesburg Health District

Date: 15th July 2021

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Cpef Director
/4hannesb 1;1? Jstrict
Date: /? /OJ '209y

Dr Baski Desai
Executive Director (Acting)
City of Johannesburg
Date: l,,Z/ 0 12{)?,,f

APPENDIX D: Human Research Ethics Committee (Medical) Clearance Certificate

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R49 Ms MY Molema

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M210362

NAME: (Principal Investigator)	Ms MY Molema
DEPARTMENT:	School of Public Health Medical School University
PROJECT TITLE:	*Knowledge and practices on pesticide exposure amongst the City of Johannesburg Metropolitan Municipality's pest control operators*
DATE CONSIDERED:	2021/03/26
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Professor D Brouwer
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2021/10/07

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in March and therefore reports and re-certification will be due in the month of **March** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

____
Signature of Principal Investigator

____
Date

APPENDIX E: Turnitin Report

[redacted]

Knowledge and practices updated for submission (edit).docx

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