The practices of spray operators in the Mpumalanga Malaria Control Programme using insecticides for residual indoor spraying.

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Masters of Public Health in the field of Occupational Hygiene

DECLARATION

I, Aart Booman declare that this research report is my own work. It is being submitted for the degree of Masters of Public Health in the field of Occupational Hygiene, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

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… th day of September, 2005

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ABSTRACT

Pesticide poisoning poses a health risk to individuals throughout the world although the reported global and local risk are not consistent in the literature. Mpumalanga Province has areas of epidemic malaria. Spray teams, applying local insecticides to indoor surfaces operate just prior to the rainy season (October to May) to control malaria. The purpose of this cross sectional study was to compare prescribed safe handling and application practices of Mpumalanga malaria spray operators mixing and applying insecticides versus actual practices in the field. All members of the spray operating teams were included in the study. A tick list and questionnaire was utilized to observe field practices and enquire about reasons for non-compliance. Only 28% of all operators complied with prescribed safety practices and differences in compliance between mixing (38%) and application (36%) were marginal. Gloves, face shields and dust masks were not utilized as recommended and contributed to the highest levels of non-compliance. Compliance was found to be dependent on gender, age, years of experience, education level and employment status. The low compliance rate necessitates further investigation of the malaria programme occupational safety management system. All stakeholders need to be aware of the consequences of pesticide poisoning and collaborate in efforts to work towards prevention rather than cure.

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1. BACKGROUND

1.1 The burden of malaria

Malaria is a public health problem in more than 90 countries in the world and threatens the lives of more than 40% of the world's population (WHO 1993). Ninety percent of malaria infections occur in Africa south of the Sahara, and 300 to 500 million clinical cases are reported annually (UNICEF 2000).

Malaria in South Africa remains a public health concern in the low altitude areas of the Limpopo Province, Mpumalanga Province and north eastern KwaZulu-Natal.

Table 1 illustrates that malaria risk in Mpumalanga is mainly confined to the eastern Ehlanzeni district with the highest risk in the Nkomazi municipal area, bordering Mozambique in the east and Swaziland in the south.

Table 1 Malaria incidence rate per 10 000 population by Municipality in Mpumalanga, 1999 – 2003

		Year				
Municipality	**District**	**1999**	**2000**	**2001**	**2002**	**2003**
Mbombela	Ehlanzeni	27.41	36.68	18.80	10.34	7.42
Nkomazi	Ehlanzeni	232.55	335.44	234.92	136.74	59.55
Thaba Chweu	Ehlanzeni	2.30	3.95	1.21	1.31	3.50
Umjindi	Ehlanzeni	16.98	23.80	4.32	3.76	4.38
Albert Luthuli	Gert Sibande	0.54	1.31	0.22	0.21	0.05
Dipaleseng	Gert Sibande	0.00	0.00	0.00	0.00	0.00
Govan Mbeki	Gert Sibande	0.10	0.10	0.00	0.00	0.00
Lekwa	Gert Sibande	0.00	0.00	0.00	0.00	0.00
Mkhondo	Gert Sibande	0.00	0.00	0.00	0.00	0.00
Msukaligwa	Gert Sibande	0.00	0.00	0.00	0.00	0.00
Seme	Gert Sibande	0.00	0.00	0.00	0.00	0.00
Delmas	Nkangala	0.00	0.00	0.00	0.00	0.00
Dr. JS Moroka	Nkangala	0.00	0.00	0.00	0.00	0.00
Emalahleni	Nkangala	0.00	0.04	0.04	0.00	0.00
Highlands	Nkangala	0.88	0.84	0.00	0.00	0.00
Middelburg	Nkangala	0.08	0.00	0.00	0.00	0.00
Thembisile	Nkangala	0.00	0.00	0.00	0.00	0.00

The highest case fatality rate was reported during 1999 (0.63%) and the lowest (0.19%) in 1997 (Mpumalanga Malaria Control Programme, unpublished data).

1.2 Malaria control interventions

The main goal of any malaria intervention is to reduce morbidity and prevent mortality caused by the disease.

The use of residual house spraying and impregnated bed-nets are the major vector control interventions implemented in the African region. The former has been evaluated as being more cost-effective in areas with low seasonal risk (Guyatt *et al*. 2002). In contrast to most of sub Saharan Africa, malaria in the area where this study is located is epidemic, rather than endemic, in nature. Thus residual indoor spraying is considered to be the most effective control intervention to reduce vector prevalence and longevity.

In South Africa pyagra (pyrethrum and kerosene) was used for indoor insecticide spraying in the 1930s (De Meillon 1936) and this practice preceded the introduction of organochlorines and dichlorodiphenyltrichloroethane (DDT) in the 1940's and 1950's. DDT was phased out in Mpumalanga in the mid 1990's and replaced with synthetic pyrethroids. Environmental and health concerns such as concentrations of DDT found in piscivorous tigerfish (Bouwman *et al.* 1990a), breast milk (Bouwman *et al*. 1990b) and body fat (Maharaj *et al.* 1998) contributed to the decision to change.

The rise in malaria cases from 1996 (Govere *et al*. 2002) and the resistance of *Anopheles funestus* to pyrethroids (Hargreaves *et al*. 2000) led to the reintroduction of DDT in August 2001. DDT is used for indoor application in traditional structures while deltamethrin, a synthetic pyrethroid, is currently reserved for western style structures. The nature of the inner-wall surface determines the category of the structures and type of insecticide to be used. Porous surfaces (traditional) for example mud, reeds and un-painted walls are ideal for the application of DDT due to the absorbency characteristic of DDT.

1.3 Mpumalanga Malaria Control Programme

Residual insecticide spraying is the mainstay of vector mosquito control of malaria in Mpumalanga Province and is the responsibility of the Malaria Control Programme within the Department of Health.

Figure 1 illustrates the Malaria Control Programme personnel structure. The spray coverage areas are determined by malaria incidence rates and these are divided into spray sectors (see Figure 2). A spray team is allocated to each sector and team supervisors oversee spray activities.

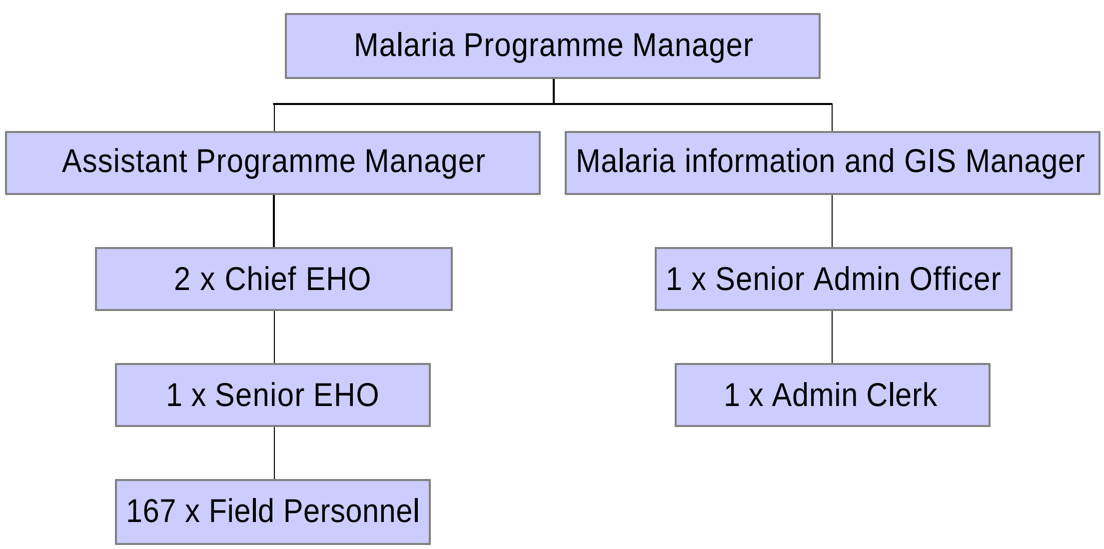

Figure 1 Malaria Control Programme personnel structure

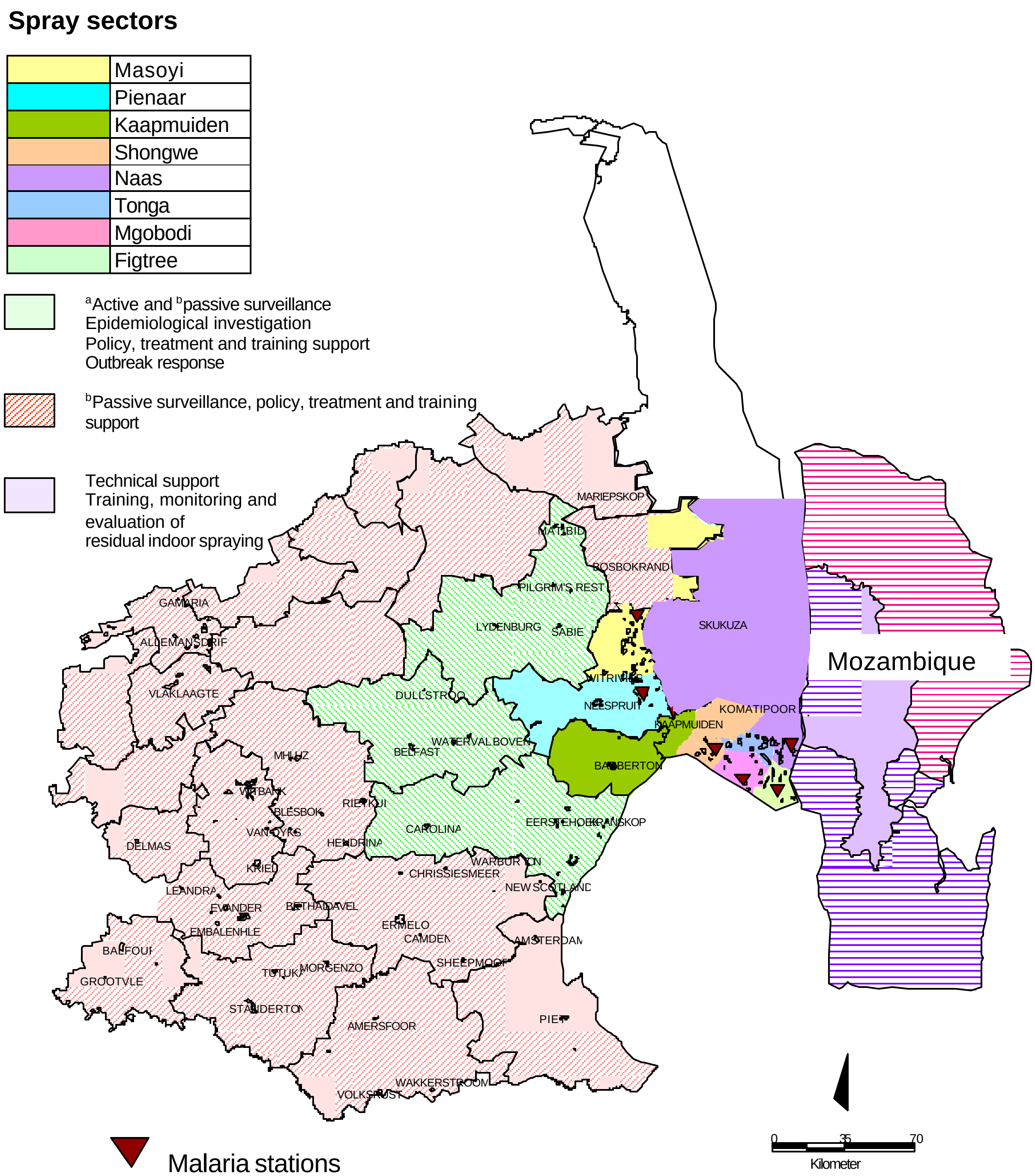

Figure 2 Malaria Control Programme work areas

[a] Active surveillance is the monitoring of malaria through the detection of malaria cases where case investigators from the malaria control programme actively do field investigations of malaria contacts (household members and neighbours). A malaria diagnostic test is performed and positive patients are referred to the nearest health facility for treatment.

[b] Passive surveillance is the monitoring of malaria using the routine malaria notification system. The patient reports to the health facility or health practitioner him or herself where he or she is diagnosed and treated. The case is notified through the malaria surveillance system.

The spray operators can either be permanent employees or temporary workers. Permanently employed workers account for 36%(45 people) and temporary 64%(79 people) of the spray personnel. Temporary workers are recruited from local communities and appointed from August to December of each year. This number increases each year to make up the required number as permanent staff resign, retire or become diseased. No permanent staff are being replaced. and temporary staff will eventually be the only personnel employed to perform spray activities. The same spray operators are usually employed each year if the individual's performance was satisfactory.

A two-week training period for all spray operators commences in August and includes theoretical and practical sessions on safe handling and correct application of insecticides.

Each permanent operator is issued with a compression sprayer (Figure 3) and the following personal protective equipment:

- 2 long sleeve overalls (issued before spray season commences);
- 1 pair of leather boots (issued before spray season commences);
- 1 spray cap (issued before spray season commences);
- 1 face shield (issued before spray season commences);
- 1 pair of rubber gloves (issued before spray season commences) and
- disposable dust masks (issued each day before spray activities commences).

Figure 3 Stainless steel compression sprayer

Insecticides are dispensed as required by the team supervisors, from the team vehicle. Water is transported in 210 litre drums and mixing of insecticides takes place at the vehicle.

Temporary operators are issued with the same as above with some exceptions:

- disposable dust masks (issued in bulk before spray activities commence).
- an initial supply of insecticides and a sling bag to carry insecticides are supplied before the spray season start.

Soap is issued to both groups of spray operators for regular washing of personal protective clothes and equipment so that a change of overalls can be effected every second day.

Insecticides are issued from a central store. Lockup storage facilities are available in every working sector. Temporary spray operators are issued limited amounts of insecticide, which is stored at home.

Permanent operators are transported from malaria sectors stations by truck to places of work and proceed by foot to the structures targeted for spraying. The truck follows to ensure insecticides and water are available when needed.

Temporary operators work from home and water for mixing insecticides is obtained from the local community households.

A compression sprayer is used by spray operators to cover the inner walls of structures with residual insecticide. Spray teams are directly supervised by the sector Field Officer assisted by foremen. Temporary spray operators are not directly supervised but senior staff regularly determine quality of work.

During the 2003 spray season 166 225 structures were sprayed using 6 tons of DDT and 2 tons of deltamethrin (Mpumalanga Malaria Control Programme, unpublished data).

2. LITERATURE REVIEW

2.1 Insecticides to control malaria vector populations

Insecticides are part of a group of agricultural chemical products that include primarily insecticides, fungicides, herbicides and biocides and are known as pesticides (GIFAP 1989).

Pesticides are tested extensively for safety and efficacy before approval for use (Brown 1999) and their application is, according to Harris (1978, p.218 – 228) and Chin (2000, p.556), inextricably related to the improvement of human prosperity. For example, by 1957 malaria was eradicated from large areas of South Africa through residual insecticide spraying of houses (Govere *et al.* 2002).

It is also true that ignorance and a laissez faire attitude towards possible health risks when using pesticides can have disastrous health consequences. The World Health Organization estimates 1.2 million cases and 2 500 deaths due to pesticide poisoning annually Salt (2000) . However significantly higher morbidity figures of 25 million have been reported (Awuonda 2001).

New pesticides are developed regularly and their hazard potential is not generally known to health professionals and the general public (Morgan 1989). In South Africa pesticides are widely used and between 100 and 200 cases of poisonings are reported annually. South Africa relies on notification for passive surveillance of acute pesticide poisoning. It is a notifiable medical condition in terms of Government Notice No 328 of 22 February 1991, promulgated under the Health Act and non-compliance is an offence (Republic of South Africa

1977). Underreporting of poisonings in South Africa however is a major concern (University of Cape Town 1997) and the extent of the problem including occupational risk is not known.

Clearly pesticide poisoning poses a health risk to societies and health workers throughout the world although estimation of global and local risk is not consistent in the literature. This provokes questions concerning the real magnitude of the problem.

DDT was registered for use in Switzerland and Britain in 1943 and in 1949 Paul Muller was awarded the Nobel Prize for his discovery (Müller 1948). DDT is a combination of chloride and chlorobenzene yielding dichlorodiphenyltrichloroethane, as a result of which DDT belongs to a broad class of insecticides known as organochlorines (Moriarty 1975). DDT is a contact insecticide that affects the nervous system and functions by means of sodium channel stimulation (Staetz 2004).

It can also be ingested to act as a stomach poison. However, human exposure to DDT has not been linked to mortality as a result of exposure (Mellanby 1992). The most recent studies have also ruled out the hypothesis of DDT derivatives being responsible for excess risks of cancer of the reproductive organs (Cocco 2002).

The International Chemical Safety Card for DDT stipulates that there is a potential risk of short and long-term exposure. Inhalation and ingestion is rated as the most common exposure routes. Health risks due to short-term exposure include eye, skin and respiratory tract irritation and possible effects on the central nervous system, resulting in convulsions and respiratory failure. The possibility of death cannot be excluded although such events have not yet been documented (NIOSH 1999).

Long term exposure can effect the central nervous system and liver (NIOSH 1999) but potential carcinogenic effects are still being investigated by scientists. The accumulation of DDT in breast milk (Bouwman *et al*. 1990b) and fatty tissue (Maharaj *et al.* 1998) is a cause for concern.

Synthetic pyrethroids are generally metabolized in mammals through ester hydrolysis, oxidation and conjugation. There is thus no tendency to accumulate in tissue after long-term exposure (WHO 1990).

Deltamethrin is a synthetic pyrethroid acting on the axons of the peripheral and central nervous system of mammals and insects. The routes of human exposure include inhalation, skin and eye contact and ingestion. Acute exposure can lead to respiratory tract, skin and eye irritation, a burning sensation, dizziness, headache, abdominal pain and vomiting (NIOSH 1999). Studies have shown cases of dermal deltamethrin poisoning after use where inadequate handling precautions have been taken. There are many cases of accidental or suicidal poisoning by the oral route, estimated intake 2 – 250mg/kg bodyweight. Doses of 100 – 250 mg/kg have caused coma within 15 – 20 minutes (EXTOXNET 1995).

Long term exposure to deltamethrin is not more hazardous than short term exposure although systemic toxicity can develop after substantial and prolonged exposure (Box and Lee *1996*).

Literature shows that there is a potential occupational risk to the health of spray operators working with and handling insecticides as part of their job description. No formal literature or statistics are available to indicate the frequency of pesticide poisoning among malaria spray operators.

The reality remains that as long as there are pests, there will be pesticides and as long as there are pesticides, there will be the threat of poisoning.

2.2 A safe working environment

In South Africa pesticides are regulated by a myriad of acts and regulations. The "right" to a clean and healthy environment for all South African's has been addressed in the Bill of Rights in the Constitution (Republic of South Africa 1996).

A total of 14 acts, administered by 7 governmental departments and a non-statutory committee control aspects of the manufacture, registration, distribution, use, transport, residual monitoring, disposal and trade of pesticides. The main acts (South Africa 1947, Republic of South Africa 1964, 1973, 1977) are listed in Table 2. Overlapping of legislation, gaps and a lack of enforcement are the main concerns identified.

Table 2 Major pesticide legislation

Law	Responsible Department	Jurisdiction
Fertilizer, Farm Feeds and Agricultural Remedies Act No. 36 of 1947	Agriculture	Registration of pesticides Toxicity classification Labelling, advertising, disposal, sale, importation, and use
Health Act No. 63 of 1977	Health	Notification of cases Control of health hazards Prevention of health hazards Investigation of poisonings
Hazardous substances Act No. 15 of 1973	Health	Classification of Hazardous Substances Disposal Storage Prohibited use of containers Licensing
Customs and Exercise Act No. 91 of 1964	Trade and Industry	Import and export of pesticides

By law, every employer shall provide and maintain, as far as is reasonably practicable, a working environment that is safe and without risk to the health of its employees in terms of section 8 of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993), (Republic of South Africa).

It is also stipulated that an employer shall ensure that the exposure of an employee is either prevented, or where this is not reasonably practicable, adequately controlled in terms of section 10 (1) of the Regulations for Hazardous Chemical Substances 1995 promulgated under the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993), (Republic of South Africa).
If it is not reasonably practicable to ensure that the exposure of an employee is adequately controlled as contemplated in regulation 10, the employer in case of an airborne hazardous chemical substance, must be provided adequate

respiratory equipment and protective clothing (Act No. 85 of 1993), (Republic of South Africa).

Insecticides have the potential to save lives by reducing the menace of insects that transmit diseases but they also have the potential to compromise the health of those who handle and apply the substance (Morgan 1989). Identifying potential risk practices to facilitate prevention is a much surer path to safety than reliance on treatment.

The use of synthetic pyrethroids and DDT to control mosquito vectors in Mpumalanga Province warrants the use of personal protection clothing, equipment and safe handling practices. This study, to determine compliance levels and reasons for non-compliance, was conducted during a time period where only a synthetic pyrethroid was available for spray operations. The insecticide poses a risk for poisoning but " with good work practices, measures of hygiene, and safety precautions, deltamethrin is unlikely to present a hazard for those occupationally exposed" (WHO 1990).

Table 3 describes the safe practices to comply with as recommended by the employer, manufacturer and the international safety cards when using deltamethrin. The recommendations vary marginally and the employer's recommendations are considered as the gold standard for the purpose of compliance estimates. A score for each factor has been indicated to a total of 27 marks. Full marks will constitute 100% and represent compliance.

Table 3 Prescribed safe practices

	Malaria Control Programme (employer)	Manufacturer	International Chemical Safety Cards	Score for com-pliance
Mixing	No eating, drinking or smoking. Wash hands before eating	No eating, drinking or smoking. Wash hands before eating	No eating, drinking or smoking. Wash hands before eating	2
	Personal Protective Equipment and Clothes			
	Protective gloves	Protective gloves (not recommended for mixing of DDT)	Protective gloves	1
	Protective clothing (long sleeve)	Protective clothing (long sleeve)	Protective clothing (long sleeve)	1
	Face shield	Face shield (optional for the mixing of DDT)	Face shield	1
	Peakless cap	Peakless cap	Not specified	1
	Dust mask	Dust mask	Dust mask	1
Application	Leather boots No eating, drinking or smoking. Wash hands before eating	Leather boots No eating, drinking or smoking. Wash hands before eating	Not specified No eating, drinking or smoking. Wash hands before eating	1 2
	Personal Protective Equipment and Clothes			
	Protective gloves	Protective gloves	Protective gloves	1
	Protective clothing	Protective clothing	Protective clothing	1
	Face shield	Face shield (optional for the mixing of DDT)	Face shield	1
	Peakless cap	Peakless cap	Not specified	1
	Leather boots	Leather boots	Not specified	1
	Washing of protective clothing			
	1 Clean set every second day	1 Clean set every second day	Not mentioned	1
Total score for 100% compliance				**27**

Spray operators can be protected from the potential toxic effect of residual insecticides by complying with prescribed safe practices (Najera and Zaim 2001). The monitoring and evaluation of compliance of malaria spray operators has never been attempted in South Africa and no literature was found to indicate that a similar study has ever been conducted in other malaria control programmes in Africa and the rest of the world.

3. STUDY AIM AND OBJECTIVES

The aim of the study was to identify unsafe working practices and make appropriate recommendations to prevent ill health.

The 3 major objectives of this study were:

1. to compare prescribed safe handling practices of spray operators mixing and applying insecticides versus actual practices in the field;
2. to identify the reasons for non-compliance as stated by the spray operators;
3. to determine the association between the level of compliance and
    a. years of experience
    b. education level
    c. employment status
    d. training received

The results of the study based on the prior mentioned objectives will assist the malaria programme management team to better understand the dynamics and challenges involved with safety compliance.

4. SUBJECTS AND METHODS

4.1 Study design

The study was a cross sectional study and had descriptive and analytical components. According to Last (1995), as adopted by the International Epidemiological Association, a descriptive study is "a study concerned with and designed only to describe existing distributions of variables, without regard to casual or other hypotheses." This does not exclude the use of statistical procedures of comparison although these are only seen as explorative and not confirmatory (Buettner *et al.* 2001).

The cross-sectional study design was suitable to identify unsafe practices that are inconsistent with prescribed insecticide handling norms. Additional data were gathered to explore relationships and associations. The primary unit of data capture and analysis were individuals and not groups or teams. Cross-sectional studies are economical and relatively easy to conduct (Buettner *et al.* 2001).

4.2 Characteristics of operational work area and subjects

The subtropical lowveld area of Mpumalanga is a popular tourist destination. The area is not only known for its abundance of wildlife and agricultural activities but also for its ideal climate. Temperatures range from 10°C - 40°C in summer and 10°C - 20°C in winter. Hot humid conditions typify summer months and dry more moderate conditions prevail during winter. The annual rainfall averages approximately 800mm (Mpumalanga Info 2003). It is ironic that these climatic factors directly contribute to the transmission of malaria in the area.

Malaria infections typically occur in the hot summer months and more so in years when there is abundant rainfall. Spraying begins just prior to the rainy season.

Spray operators employed by the Department of Health in Mpumalanga Province thus strive to reduce vector populations in these areas through residual indoor spraying and thereby reducing contact between infected vectors and humans. These spray operators were the subjects under study.

Figure 2 clearly illustrated the 8 geographical spray sectors where spray activities occur. These areas correspond with the malaria risk areas in the province. Occasionally spray operators will be deployed to areas outside the delineated spray sector boundaries when malaria outbreaks occur.

Spray operators are divided into two employment status categories: permanent or temporary employees.

Permanent staff comprise of 36%(45) and temporary of 64%(79) of the total spray operator workforce. They are all remunerated by the Department of Health. Temporary staff are recruited in June and appointed from August to December each year. The Malaria Control Programme management in the province maintains operational supervision and control.

4.3 Sampling of spray operators

All permanent spray operators (45) working for the Mpumalanga Malaria Control Programme as well as temporary spray operators (79) were invited to participate in the study. No sampling methods were applied and no exclusion criteria used. The risk of a non-representative sample was thus eliminated. It was practically possible to attempt to survey all spray operators and thereby reducing bias as recommended by Friis and Seller (1999).

4.4 Methods of measurement

An interview form/tick list (Annexure A), completed by the researcher, was designed to document actual field practices of spray operators when mixing and applying insecticides during spray activities. It accommodates mostly discrete nominal and categorical data answers. All open-ended questions, to determine reasons for non-compliance, were categorized after the administration process.

The interview form/tick list included five main sections:

A – General and demographical details including

- questionnaire number
- date
- age
- employment status
- experience in years
- insecticide being used
- education level
- training received
- communication language
- training language

B – Compliance during mixing and application of pesticides was noted by filling in a tick list documenting the use of:

- gloves
- face shield
- dust mask
- leather boots
- peak-less cap
- protective clothing
- if the individual was eating, drinking and/or smoking
- hand washing practise
- wearing of protective clothing (during application)

C – Reasons for non-compliance was elicited by talking to workers once they had been observed not complying with recommended practice

D – Operators were questioned about the handling of protective clothing and responses documented with relation to:

- removal of clothes
- storage of clothes
- washing of clothes

The interview forms and tick lists were piloted on the 7th of November 2003 prior to the commencement of the study. A total of 6 people participated in the pilot study. Previously (temporary employed) sprayers (3) and permanently employed spray operators (3), not involved with spray activities any longer were chosen to pilot the data collection tool. The interview form/tick list was well understood and no changes were made to the design and language structure except for minor notes made to ensure reasons for non-compliance are comprehensively documented for the purpose of categorization.

A spray activity schedule was obtained from the Malaria Control Programme before spraying commenced. The schedule contained the geographical location and day-to-day activities of each spray team and individual temporary spray operator. The operators were traced using the activity schedule. The researcher completed an interview form/tick list for each operator observed.

Permanent spray operators mix their first can of the day as a group. Groups varied from 5 to 10 persons per group. The researcher observed the group as a whole while mixing and operators not complying were identified by physical characteristics e.g. colour of t-shirt worn under protective clothing. This information was noted on the top of the questionnaire so that reasons for non compliance could be obtained later in the day. The identifying information, noted in pencil, was erased from the form to ensure anonymity. During application operators were individually observed. No operator was questioned about his/her practices in the presence of a supervisor or fellow colleagues. All operators perform their spray application individually and not as a group.

Temporary spray operators mix and apply insecticides individually and with minimal supervision. They were observed as individuals during mixing and application and thereafter prompted for reasons for non-compliance.

Observation methods and interview style were similar for permanent and temporary employed spray operators.

The survey commenced on the 17th of November 2003 and concluded on the 3rd of December 2003.

All spray operators were given the opportunity to participate in the study after the objectives and methods were clearly explained. The contents of the written consent form were explained and read to the spray operators where after he/she had the opportunity to read it himself/herself. An independent translator was made available to translate any part of the form not clearly understood. They had the choice to participate and sign the forms 7 days prior to the commencement of the study and it was made clear that they had the right to change their minds at any stage.

4.5 Data capture and storage

A database was designed in Microsoft Access 2000 to enter and store data from the interview forms/tick lists. The database consisted of a front-end form (1), look-up tables (13) and a data storage table (1). Each record was allocated a unique identification number corresponding to the questionnaire number. Answers to open-ended question were scrutinized and categorized before entry. The look-up tables were created to minimize data entry inaccuracies created by human error. The tab order of the form was identical to the hard copy form layout to ensure ease of entry and minimize data entry error. Field properties for compulsory fields were set accordingly to further ensure a complete data set.

4.6 Data analyses

The Access data storage table was imported into SPSS statistical software for Windows (version 9) for further data analyses.

All variable labels for categorical variables were defined for ease of data analysis and interpretation.

A score for compliance was developed. A 100% score for all components of safe handling behavior, as recommended by the employer (gold standard), indicated 100% compliance. There were 27 items (see Table 3) with which spray operators have to comply in order to handle pesticides safely. If a full score of 27 from a possible 27 marks was achieved it was referred to as a 100% compliance .

Reasons for non-compliance, according to spray operators, were open-ended questions and categorized before analysis. Proportions and percentages were used to present the reasons for non-compliance overall and for each separate component.

Tables and charts are useful data analysis and information communication tools (Centres for Disease Control 1992). They were used to summarise data during analysis and visually portray important information.

The chi-square statistical test was used to determine if:

education;

employments status;

age;

gender;

experience;

training and

communication and training language were associated with compliance.

The hypothesis that two variables are independent was challenged. If the association existed they were not independent from one another and the Null Hypotheses (H_0) was rejected. Two variables are by default independent referring to the H_0 until proven dependant (H_A) by statistical testing. The Alternative Hypothesis (H_A) will then be accepted.

Categories

Ages and years of experience were captured as numeric variables and later grouped for ease of interpretation and analysis.

Categorical variables include:

Compliance level

A = Complied

B = Did not comply

Age groups

A = <30

B = 30 – 39

C = 40 – 49

D = >49

Years of experience

A = 0 – 4

B = 5 – 9

C = 10 – 14

D = 15 – 19

E =20 – 24

F = 25 – 29

Education level

A = primary education

B = secondary education (1) grade 8 - 10

C = secondary education (2) grade 11 to 12

D = tertiary education

Employment status

A = permanent

B = temporary

Communication language

A = English

B = English and Siswati

C = Afrikaans and Siswati

D = Siswati

Training language

A = English

B = English and Siswati

C = Afrikaans and Siswati

D = Siswati

Training received

A = Yes

B = No

4.7 Ethics

No humans or animals were involved in experiments during the research project. The names of the spray operators being interviewed and observed were not documented. No action was or will be taken against individuals not complying with prescribed practices and procedures. The Malaria Control Programme approved the study in principle and agreed that the study would have been part of their own programme objectives if personnel and time were available to do so.

Ethical approval to conduct research study was obtained from the Department of Health and ethical clearance was obtained from the University of Witwatersrand Ethics Committee (Booman, R14/49, Annexure B) prior to the commencement of the study.

This research project is an evaluation of normal work practices and no one was required to perform any activity that is not part of his/her day-to-day activities.

5. RESULTS

5.1 Descriptive data

All operators were willing to participate in the cross sectional study. The total response rate was 91%, 96% for permanent and 90% for temporary staff. Ten operators who were not present at work to perform spray duties after two follow-up visits were excluded from the study. There is a possibility that these operators may have been absent from work as a consequence of occupational exposure to pesticides, however the response rate was high and it is unlikely that the exclusion of these workers might bias the study findings. Moreover they were not reported to have had pesticide poisoning so they were absent for reasons unrelated to pesticide use. Supervisors confirmed that some workers have resigned before commencing spray activities and others were absent due to family commitment reasons.

On average 8 spray operators were evaluated and interviewed per day.

Only deltamethrin insecticide was used for indoor residual spraying during the study period since no other insecticide was available. Demographic data are presented in Table 4. Ages ranged from 24 to 62 years. The mean age of permanent spray operators were older than that of temporary staff. This is also clear when observing percentages of staff in age groups. The majority (72%) of operators interviewed and observed were males. The length of employment of operators were documented in years and later grouped. In the event of a spray operator being employed for the first time during the spray season when the study was conducted a 0 was allocated to indicate that he or she had not yet completed a full spray season.

Table 4 Demographic data of spray operators

	Permanent staff	**Temporary staff**	**Total staff**
Age in years			
Mean, (standard deviation)	47 (7.0)	31 (4.9)	37 (9.8)
Age group			
<30	1 (2%)	31 (44%)	32 (28%)
30 – 39	4 (9%)	37 (52%)	41 (36%)
40 – 49	20 (42%)	3 (4%)	23 (20%)
>49	18 (47%)	0 (0%)	18 (16%)
Number (percentage)			
Gender male:female (Number)	(43:0)	(39:32)	(82:32)
Experience in years			
Mean, (standard deviation)	17 (6.2)	2 (1.0)	6 (7.9)
Experience group			
	0 (0%)	71 (100%)	71 (62%)
0 – 4	4 (9%)	0 (0%)	4 (4%)
5 – 9	14 (33%)	0 (0%)	14 (12%)
10 – 14	15 (35%)	0 (0%)	15 (13%)
15 – 19	4 (9%)	0 (0%)	4 (4%)
20 – 24	6 (14%)	0 (0%)	6 (5%)
25 – 29			
Number, (percentage)			
Education level			
Primary education	33 (77%)	1 (1%)	34 (30%)
(grade 8 - 10)	10 (23%)	2 (3%)	12 (11%)
Secondary education			
Secondary education	0 (0%)	55 (78%)	55 (48%)
(grade 11 - 12)			
Tertiary education	0 (0%)	13 (18%)	13 (11%)
Number, (percentage)			
Training received			
Number , (percentage)	41 (95%)	69 (97%)	110 (96%)
Communication language			
English	1 (2%)	52 (73%)	53 (46%)
English and Siswati	8 (19%)	18 (26%)	26 (23%)
Afrikaans and Siswati	1 (2%)	0 (0%)	1 (1%)
Siswati	33 (77%)	1 (1%)	34 (30%)
Number, (percentage)			
Training language			
English	0 (0%)	0 (0%)	0 (0%)
English and Siswati	2 (5%)	70 (97%)	72 (63%)
Afrikaans and Siswati	0 (0%)	0 (0%)	0 (0%)
Siswati	41 (95%)	1 (2%)	42 (37%)
Number, (percentage)			

Years of experience ranged from 0 – 29 years. Sixty eight percent of permanent staff had experience that ranged from 10 to 19 years. The practice of employing temporary community staff was only initiated recently thus all temporary operators have less than 5 years experience.

The histogram in Figure 4 clearly shows a frequency distribution that deviates from a normal distribution curve. Years of experience is not normally distributed in the study population and display a double peak (bimodal).

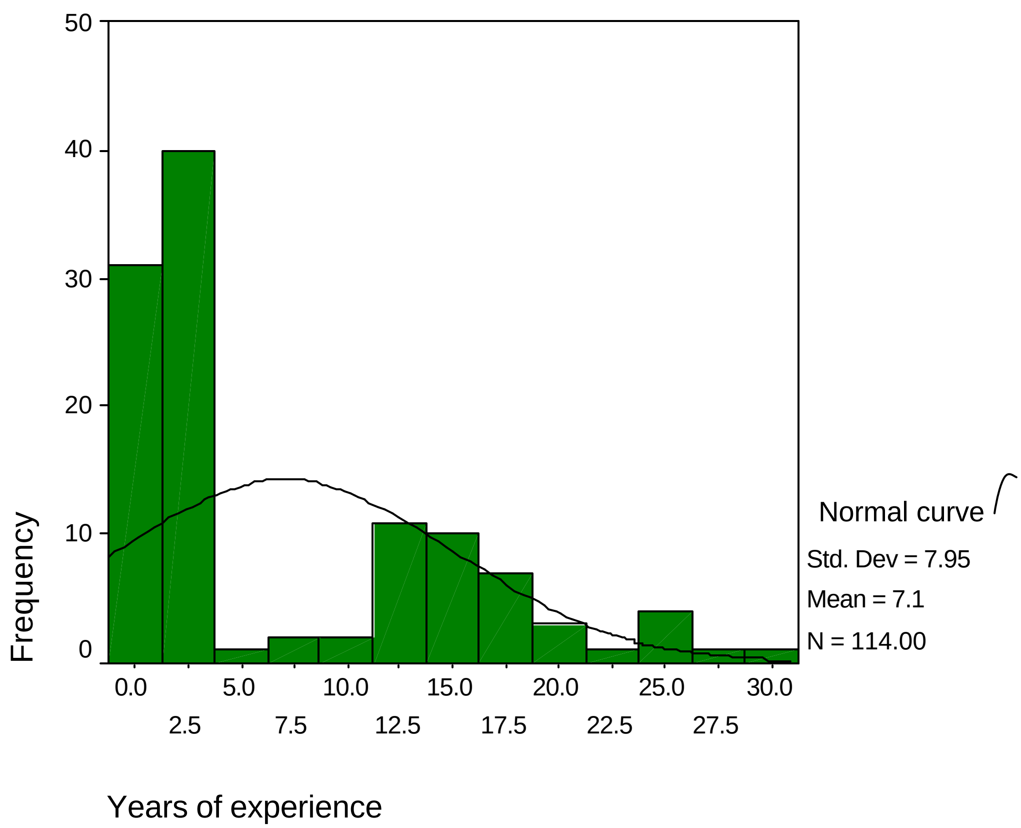

Figure 4 Frequency distribution histogram of years of experience of spray operators

Although all operators reported that they were able to read and write, the majority of temporary staff were better educated than the permanent staff. Ninety six percent of temporary spray operators had completed their secondary education compared to permanent staff of whom none had secondary level education, most of the permanent staff (77%) only managed to acquire a primary education level.

The pie chart (Figure 5) shows the percentages of operators having different levels of education.

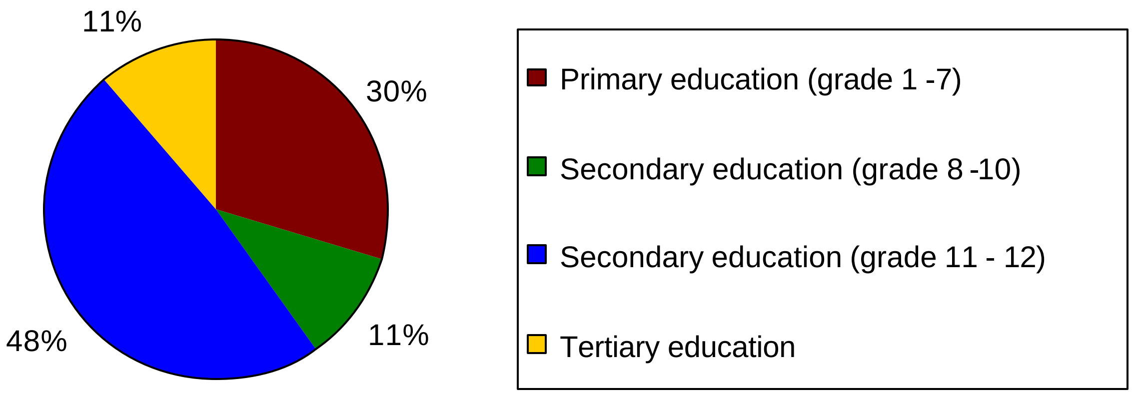

Figure 5 Education levels of spray operators

A total of 110 (96%) spray operators indicated that they received training regarding the safe handling and mixing of insecticides during the past 12 months prior to the commencement of their duties.

The majority (77%) of permanent staff preferred Siswati as their official communication language and Siswati was used to train most (95%) of these operators. Nearly all temporary staff (73%) preferred English as the official communication language and 98% were trained in English and Siswati (see Table 4).

5.2 Scope of non-compliance

All operators complied with hand washing principles and very few people ate drank or smoked during the mixing process. Most operators wore a dust mask, boots, cap and protective clothing. Half (51%) of the spray operators did not wear gloves and 40% were observed not wearing a face shield during mixing. Only 38% of spray operator achieved a full score for compliance during mixing.

Table 5 Non-compliance of spray operators by specific activity

Specific activity	Number of non-compliers	Percentage of non-compliers
Mixing		
Glove use during mixing	58	51%
Face shield use during mixing	45	40%
Dust mask use during mixing	33	29%
Boots use during mixing	8	7%
Cap use during mixing	13	11%
Protective clothing use during mixing	10	9%
No eating, drinking and smoking during mixing	4	4%
Hand washing when required during mixing	0	0%
Application		
Glove use during application	47	41%
Face shield use during application	44	39%
Dust mask use during application	13	11%
Boots use during application	7	6%
Cap use during application	13	11%
Protective clothing use during application	4	4%
No eating, drinking and smoking during application	13	4%
Hand washing when required during application	0	0%
Clean set of clothing every second day or less	5	4%
Total non-compliance with any one of the prescribed activities	**82**	**72%**

Application commenced after the mixing of insecticide. Hand washing was not a concern during this process. Temporary operators do not eat until they complete their daily duties. Permanent staff eat together as a group. The team leader provided clean water for hand washing. However 41% and 39% of workers did not use gloves and face shields respectively. There was poor compliance with other protective practises. During application there was an improvement with reference to gloves, face shields, dust mask and protective clothing compliance when compared to compliance during mixing. However if compliance is measured as adherence to all safe handling practise the overall comparison indicates a 2% decrease comparing safe handling practise during mixing with application.

It is noted that more workers (14) not only complied with the clothes washing recommendations but in fact washed their clothes more often than recommended in comparison to a small number (5) who did not comply with the minimum clothes washing recommendations.

5.3 Reasons for non-compliance

5.3.1 Gloves

Most of the spray operators who did not comply with prescribed guidelines reported that they forgot their gloves either at home (7), at the malaria camp (5) or on the truck (2) that transported them from the camp to the work area.

Table 6 gives a comprehensive summary of all other factors influencing compliance. A total of 13 operators' gloves were broken and most workers did not report this. A small percentage was not aware that they should wear gloves.

Less than 50% of spray operators complied with the prescribed guidelines when combining mixing and application practices.

when combining mixing and application practices.

Table 6 Reasons for non-compliance with reference to wearing gloves

		Mixing		Application	
Reason		**Frequency**	**Percent**	**Frequency**	**Percent**
Forgot	at home	7	12%	7	15%
	at camp	5	8%	5	11%
	on truck	2	3%	2	4%
Broken	and reported and not reported	12 1	21% 2%	12 1	26% 2%
No grip		10	17%	7	15%
Not required for K-othrine		8	14%	1	2%
Lost		5	9%	5	11%
Too warm and sweaty		2	3%	1	2%
Lost and wear other Gloves	leather	1	2%	1	2%
	rubber	1	2%	1	2%
Did not know to wear Gloves		2	3%	2	4%
Injury to hand		1	2%	1	2%
Washed and still wet		1	2%	1	2%
Total		58	100%	47	100%

5.3.2 Face shield

A large percentage of spray operators who did not comply with the prescribed guidelines that specifies the utilization of a face shield during mixing and application of insecticides were not aware that they should indeed comply with this recommendation to safeguard them against unnecessary contact with the insecticide. Some, 29%, think that K-othrine is a safe insecticide and no face shield is required during mixing. The practice of not lowering the face shield before mixing (25%) and application (30%) was regularly observed.

Proportionally more operators reported broken face shield than broken gloves.

It is clear from Table 7 that more operators found a scratched face shield to be more of an inconvenience during application than mixing.

Two operators mentioned that they do not lower the face shield due to spray mist contact from the back. Only 47% of all spray operators complied with the recommendation to wear a face shield during both mixing and application of insecticides.

Table 7 Reasons for non-compliance with reference to wearing a face shield

		Mixing		Application	
Reason		**Frequency**	**Percent**	**Frequency**	**Percent**
Forgot to lower shield		11	25%	13	30%
Scratched		9	20%	14	32%
Broken	reported	6	13%	6	14%
	not reported	1	2%	1	2%
Not needed for K-othrine		13	29%	0	0%
Forgot	at camp	1	2%	1	2%
	on truck	1	2%	0	0%
Not issued		1	2%	1	2%
Not necessary to Wear		2	5%	1	2%
Spray contact from back – don't lower		n/a	0%	2	5%
Can't see too dark in room		n/a	0%	4	9%
Uncomfortable		0	0%	1	2%
Total		45	100%	44	100%

5.3.3 Dust mask

The majority of spray operators (69%) complied with the recommendation to wear a dust mask during mixing and application. The two reasons most commonly mentioned as reasons for non-compliance during mixing, as illustrated in Table 8, are that they don't need to wear a dust mask when mixing K-othrine insecticide and the fact that they forgot to position the mask over their mouth and nose before mixing. The latter reason was also a common practise during application.

Table 8 Reasons for non-compliance with reference to wearing a dust mask

	Mixing		Application	
	Frequency	**Percent**	**Frequency**	**Percent**
Lost	2	6%	0	0%
Forgot to position	11	33%	9	69%
Difficult to breath due to heat	1	3%	1	8%
Difficult to breath due to flue	1	3%	1	8%
Not necessary for K-othrine	13	40%	0	0%
Not issued	2	6%	2	15%
Forgot on truck	2	6%	0	0%
Not necessary	1	3%	0	0%
Total	33	100%	13	100%

5.3.4 Boots

Table 9 Reasons for non-compliance with reference to wearing boots

	Mixing		Application	
	Frequency	**Percent**	**Frequency**	**Percent**
Feet problems	4	50%	3	50%
Prefer other shoes due to comfort	2	25%	2	25%
Washed boots and still wet	1	12.5%	1	12.5%
Not issued	1	12.5%	1	12.5%
Total	8	100%	7	100%

Most operators did wear boots . Reasons for non-compliance are similar for mixing and application. Feet problems contributed to 50% of non-compliance reasons. One operator indicated that he was never issued with boots (see Table 9). Boot comfort does not seem to be a major problem since only two operators found it to be a constraint.

5.3.5 Cap

Table 10 Reasons for non-compliance with reference to wearing a cap

		Mixing		Application	
		Frequency	**Percent**	**Frequency**	**Percent**
Lost		2	14.3%	2	15.4
Flap rolled up for heat		2	14.3%	2	15.4
Forgot	at home	3	21.4%	3	23.1%
	at camp	1	7.1%	1	7.7%
Not necessary		3	21.4%	2	15.4%
Washed and wet		3	21.4%	3	23.1%
Total		14	100%	13	100%

Only 14 operators did not wear caps. The operators tend to forget their caps either at home or at the camp. Two operators rolled up their flaps at the back because of heat. Other reasons for non-compliance are described in Table 10.

5.3.6 Protective clothing

Table 11 Reasons for non-compliance with reference to wearing protective clothing

	Mixing		Application	
	Frequency	**Percent**	**Frequency**	**Percent**
Too hot	4	40%	2	50%
Zip broken	1	10%	1	25%
Not necessary	4	40%	1	25%
Tattered	1	10%	0	0%
Total	10	100%	4	100%

Operators are issued with two sets of protective clothing. The clothing consists of a two piece overall. The reasons for non-compliance differ between mixing and application. A definition of non-compliance includes circumstances where clothing that is tattered, for example torn and the observation that the operator did not wear one or both pieces of recommended clothing. The greatest proportion of operators who did not comply during mixing mentioned heat as a reason (40%) or that they did not believe that it was necessary (40%). During application more operators complained of heat (50%) but less viewed compliance as unnecessary (25%). One operator had a broken zip and could thus not close his jacket. Table 11 above provides more detail.

5.3.7 Eating, drinking and smoking

Table 12 Reasons for non-compliance with reference to eating, drinking and smoking during mixing and application of insecticide

	Mixing		Application	
	Frequency	**Percent**	**Frequency**	**Percent**
Forgot	1	25%	2	50%
Touched mouth frequently	3	75%	2	50%
Total	4	100%	4	100%

It was observed that the majority of operators did not eat drink or smoke when they were mixing and applying insecticide . The two reasons for non-compliance were the frequent touching of the mouth and the fact that they forgot that they were not meant to eat drink and smoke during mixing (1) and application (2).

5.3.8 Hand washing

Hand washing was not a problem since most operators did not eat, drink or smoked during mixing and application. Those who participated in these activities during breaks and lunch times complied with had washing recommendations.

5.3.9 Clean set of clothing

All operators not complying with a clean set of clothing at least every second day indicated that they did not think it was necessary to wear a clean set as prescribed.

All the operators reported that they took off their clothes directly after work and the majority (96%) washed it themselves.

Fridays are also a preferred day for washing. Eleven operators who previously indicated that they wore a clean set of clothes every second day or less preferred to wash only during weekends. This contradicts their previous statement as they are issued with only 2 sets of protective clothing.

5.4 Relationship between variables and compliance

5.4.1 Compliance by age group

Non-compliance, as defined by not complying with any single expected practise during either mixing or application, was investigated by age group.

Compliance was found to be highest in the 30 – 39 year old age group (39%), followed by the less than 30 years of age group (38%). Table 13 describes compliance by age group. Non-compliance in the two oldest age groups was much higher than the two younger age groups and this was found to be statistically significant.

Table 13 Compliance by age group

Age group	Number of non-compliers	Number of compliers	Total	% compliers by age group
<30	20	12	32	38%
30 – 39	25	16	41	39%
40 – 49	21	2	23	9%
>49	16	2	18	11%
Statistic: (χ^2 = 10.68 df = 3, *P*=0.014)				

5.4.2 Compliance by gender

Table 14 compares compliance between males and females and indicates that the percentage compliance for females was double that of males. This difference was found to be statistically significant.

Table 14 Compliance by gender

Gender	Number of non-compliers	Number of Compliers	Total	% compliance by gender
Female	18	14	32	44%
Male	64	18	82	22%
Statistic: (χ^2 = 5.41, df = 1, *P*=0.02)				

5.4.3 Compliance by employment status

More temporary staff (38%) complied with prescribed practice compared to permanent staff (12%) and this difference was found to be statistically significant (see Table 15).

Table 15 Compliance by employment status

Employment status	Number of non-compliers	Number of compliers	Total	% compliance by employment status
Permanent	38	5	43	12%
Temporary	44	27	71	38%
Statistic: (χ^2 = 9.24, df = 1, *P*=0.002)				

5.4.4 Compliance by education level

Table 16 describes compliance practice by education level, as can be seen in each education level there were low levels of compliance, about half the workers who had some level of secondary education complied with prescribed practice and this was the highest level of compliance. Interestingly there were very low levels of compliance in both those with primary (3%) and tertiary (8%) education.

Table 16 Compliance by education level

Education level	Number of non-compliers	Number of compliers	Total	% compliance by education level
Primary education	33	1	34	3%
Secondary education (grade 10)	6	6	12	50%
Secondary education (grade 12)	31	24	55	44%
Tertiary education	12	1	13	8%
Statistic: (χ^2 = 22.76, df = 3, P<0.001)				

5.4.5 Compliance by years of experience

Years of experience was investigated by looking at 5 and ten year categories (see Tables 17 and 18). Using either of these methods it was found that the greater the number of years of experience on the job, the less likely it was that workers adhered to prescribed safe handling practice. These findings were statistically significant.

Table 17 Compliance by years of experience - five year categories

Experience group	Number of non-compliers	Number of compliers	Total	% compliance by experience groups
0 - 4 years	44	27	71	38%
5 - 9 years	3	1	4	25%
10 - 14 years	11	3	14	21%
15 - 19 years	14	1	15	7%
20 - 24 years	4	0	4	0%
25 - 29 years	6	0	6	0%
Statistic: (χ^2 = 11.11, df = 5, P=0.049)				

Table 18 Compliance by years of experience – ten year categories

Experience group	Number of non-compliers	Number of Compliers	Total	% compliance by experience groups
0 - 10 years	47	28	75	37%
> 10 years	35	4	39	10%
Statistic: (χ^2 =9.31, df = 1, P=0.002)				

5.4.6 Compliance by training status

Table 19 highlights that only 28% of the operators who did receive training complied with prescribed safe handling practice compared to 25% of people who did not attend training and that this difference was not statistically significantly different.

No association between training status and compliance can be identified.

Table 19 Compliance by training status

Training received	Number of non-compliers	Number of compliers	Total	% compliance by training status
No	3	1	4	25%
Yes	79	31	110	28%
Statistic: (χ^2 =0.019, df = 1, P=0.889)				

5.4.7 Compliance by communication language

Workers were asked which language they prefer to communicate in at work. Communication in English was favoured by the operators closely followed by Siswati. At work training and communication is done in English and a combination of English and Siswati. As illustrated in Table 20, the highest compliance rate occurred in the group who preferred to communicate in English followed by those who preferred both English and Seswati. The trend implies that compliance may be higher if people communicate in their language of choice.. However ,overall the rate of compliance is nonetheless low.

Table 20 Compliance by communication language

Communication language	Number of non-compliers	Number of compliers	Total	% compliance by experience groups
English	31	22	53	42%
Siswati and English	20	6	26	23%
Siswati and Afrikaans	1	0	1	0%
Siswati	30	4	34	12%
Statistic: (χ^2 = 9.92, df = 3, P=0.019)				

5.4.8 Compliance by training language

Compliance is higher in the group that was trained using Siswati and English than the group where only Siswati was used as the training language. Compliance is associated with the training language as reflected in the p value of less than 0.05 (see Table 21 below).

Table 21 Compliance by training language

Training language	Number of non-compliers	Number of compliers	Total	% compliance by training language
Siswati and English	44	26	70	37%
Siswati	35	5	40	13%
Statistic: (χ^2 =6.25, df = 1, *P*=0.012)				

5.4.9 Predictors of compliance

In order to investigate which of the various predictors from the bivariate analysis are related to compliance, a regression model was built. The variables age, years of experience, gender, training language and employment status was entered into a regression model with criterion of entry probability of F of 0.05 and removal probability of F of 0.10. The only explanatory variable that remained in the model with stepwise removal was employment category ($p<0.0001$). It is interesting to note that employment category may be a proxy for some of the other findings, for example, there are more women in the temporary workers and women were found to be more compliant than men. Similarly, temporary workers were more likely to have higher levels of education than permanent workers and education was related to compliance. Temporary workers were more happy to communicate in English than where permanent workers and language was found to be related to compliance.

6. DISCUSSION

There is a tension between the public health imperatives of malaria control and the occupational health imperatives of protecting workers. The aim of the malaria control programme is to decrease malaria related morbidity and mortality. In the context of vector control for infectious diseases, although there is a global move towards integrated vector management strategies, the move away from chemical insecticides are currently not perceived as a realistic option in malaria control. Thus the use of insecticides for vector control is and will remain a reality. Control of malaria, where malaria is epidemic in nature, has been shown to be effective by applying residual indoor insecticides where operators move from house to house. This requires that spray operators mix and apply insecticide over a wide geographical area moving continuously from house to house. It is therefore hard to imagine any form of protection for workers that does not involve the use of personal protective equipment. Simultaneously it is essential to protect workers from occupational hazards at work and it is well recognised that the use of personal protective equipment should only be considered when other control measures are not practical to implement (SafetyLine Institute 1998). However, the use of personal protective equipment, to minimize the risk of exposure in this situation, seems to be the only viable option. This study aimed to describe malaria spray operators' practices in mixing and applying insecticide.

In this study I demonstrated that spray operators in Mpumalanga have a low compliance with prescribed safe handling practise. Only 28% of spray operators complied in full followed by 49% whose compliance with standard safe handling practise ranged between 75 – 99%, 22% of spray operators had compliance rates between 50 – 74% and less than 1 percent between 25-49%. Eight factors that describe compliance were evaluated during mixing and application as well as the frequency of wearing a clean set of clothing. There was a marginal difference between compliance during mixing (38%) and application (36%).

The greatest concerns regarding compliance included not using gloves, face shields and dust masks at all, or appropriately.

In relation to glove use the most common reason for not using them was that workers did not have the gloves with them or they were broken (with almost equal frequency of 23%) followed by complaining that they had no grip when using the gloves (17%) and by thinking they were not needed for the chemical they were using that day (14%). The basic requirements for gloves include durability, comfort, flexibility, affordability, impermeability and non-slip qualities (AVCASA 1998). These data suggest that if workers were properly motivated to use gloves – not forgetting them and knowing they had to wear them, then at least part of the problem would be solved. The issue of durability and comfort and flexibility are also a problem. Operators battle with grip when opening the insecticide sachets if they wear gloves during mixing.
These data suggest that these particular gloves may not be the best option if they impair the ability of the operators to open containers or insecticide sachets. The gloves also seem to break easily. Most of the broken gloves were reported but it is evident that replacements were not issued timeously.

Overall interventions that suggest themselves to address the issue of glove use include improving worker knowledge on when to use the gloves, motivating them to use the gloves and having a system in place if workers forget gloves and investigating if alternative gloves may be more durable and more appropriate to the task.

The importance of glove use is demonstrated by the fact that non-fatal poisonings due to direct skin contact have been recorded in the literature. The symptoms include numbness, itching, tingling and burning of skin (WHO 1990).

The three most common reasons for not utilizing face shields as recommended, were: the fact that they were scratched (32%);operators forgot to lower the shield (30%) before commencing their duties and almost a third (29%) of the operators were not aware that they should actually were a face shield during the mixing of the specific insecticide.

Scratched shields impair vision and promote non-compliance. The fact that operators forgot to lower their shield is a clear indication that they are not motivated and reminded to do so by team leaders. The fact that only 14% of the operators reported broken face shields to team leaders should also be addressed through training and the initiation of proper procedures and communication channels.

Appropriate training and supervision are imperative for improvement.

If insecticide gets into contact with eyes it can cause itching, burning, watering and blurred vision and should be prevented at all times (GIFAP 1989). Low-grade conjunctival irritation was observed during experiments with rabbits when eye contact was enforced (Coquet 1976).

Correctly positioning dust masks over the nose and mouth is a problem. More than a third (33%) of operators not complying during mixing and 69% of non-compliers during application forgot to lower the dust mask. It is necessary to highlight the fact that once again a large number (40%) of operators were not aware that a dust mask is compulsory when mixing the specific insecticide.

A small number (2) of operators complained about the difficulty in breathing due to heat and illness. If an operator is physically not able to comply with prescribed measures due to illness he or she should not be allowed to commence with their mixing and application duties.

Operators should repeatedly be reminded to lower their masksand to use them not only for application but for mixing as well. Proper supervision and training are once again important issues for corrective measures.

Inhalation of insecticide can cause coughing, chest pains and tightness as well as difficulty in breathing and wheezing (GIFAP 1989).

Foulhoux (1981) concluded that after conducting extensive field studies, adequate precautionary measures such as wearing gloves and masks provides protection from exposure to pesticides. In general the skin of the face is mostly affected during spray activities as reiterated by the United Nations Environmental Programme and sweating and exposure to sun or heat can enhance the effects of poisoning (Morgan 1989).

Heat was indicated as one of the important reasons for non-compliance referring to gloves, dust masks and protective clothing.

Malaria only occurs in areas where the climatic conditions allow the vector to reproduce and feed. Unfortunately the vector and the parasite within the vector

favour hot and humid conditions. These factors are difficult to control in field conditions and should be discussed during training sessions.
The misconception of disparity in risk of different insecticides was evident in reasons for non-compliance for wearing of gloves, face shields and dust masks. Yet another issue to focus on during training of spray operators.

Results indicate that proportionately more females (47%) complied with prescribed measures than males (22%). Females have only recently been utilized in spraying programmes in South Africa following the drive towards equity in government employment . Thus it may be that even more women may be employed in future.
Older spray operators, specifically referring to 40 years and above had a lower compliance rate than the younger group. Most (93%) of the younger group below 40 were also temporary staff. Only 12% of permanent staff compared to 38% of temporary staff complied and the significant association between employment status and compliance were determined ($p<0.1$). Utilizing temporary community operators is favoured above the practice of employing permanent staff. Several permanent staff (16%) are older than 49 years of age. Spray activities are physically strenuous to the elderly and might have contributed to the low compliance. Alternatively workers may have become lax because they themselves have not experienced related health problems.
The operators who had a secondary education status had higher compliance rates than those with primary and tertiary education and it was clear that more experienced staff did not necessarily have higher compliance levels.

The compliance was highest in the group with the least experience (<5 years). All temporary operators fall in this category. This may be because they are keen to keep their jobs, or that they are new to the work and are more open to the advice given during training.

Only 28% of trained operators complied with prescribed measures and this fact emphasizes the importance of evaluating training methods and curriculum used in the malaria control programme. Only 47% of operators were trained in their language of choice, however, only 15% of the latter complied.

In general the situation is not optimal and interventions to improve workers understanding of risks and methods of encouraging compliance should be considered.

7. CONCLUSION AND RECOMMENDATIONS

The fact that malaria control programmes have never embarked on the evaluation of compliance of spray operators clearly indicates that it is not perceived as a major priority. This study indicated that compliance levels are very low and need urgent attention and intervention. The risk of poisoning, even though mostly non-fatal, can be increased due to non-compliance. The incorrect storage of insecticides at home can also contribute to an increased risk of poisoning and needs to be monitored.

Team leaders and supervisors should ensure that all spray operators are issued with the necessary equipment. Even though a minority of operators were not issued with face shield, dust masks and boots this practice is not acceptable.

It was clear that operators were allowed to commence and continue spray duties without the necessary protective clothing and equipment.

The replacement of tattered and lost equipment was not timely and needs to be addressed.

The misperception that prescriptions for the safe handling of insecticides differ according to insecticide in use was clear. Not lowering dust mask and face shields to an acceptable position over the nose and face may indicate a nonchalant attitude towards the risk of poisoning or a lack of understanding of the route of exposure.

Discomfort of boots, gloves and protective clothing due to feet problems, grip and climatic conditions should be investigated to identify alternatives if possible.

The contents and methods of the existing training course need to be evaluated.

This study identified two major issues that need to be addressed namely the use of appropriate personal protection equipment and appropriate training. Personal protective equipment is compulsory and should be selected on the basis of efficiency to protect the individual, comfort, acceptability and durability. All these factors should, as far as possible, be considered when procuring the equipment and clothing. In this study lack of comfort and a poor match (for example gloves making it hard to grip and open containers) were reported to be reasons for non compliance. These complaints should be handled in a serious manner, followed up and discussed with supervisors and programme management when justified. Communication back to the operators is important when dealing with these aspects. Supervisors and management are advised to complete a full day of spray duties using current protective clothing and equipment to understand complaints and to be more objective when evaluating complaints and suggestions from operators. Gloves, dust mask and face shields should receive special attention when referring to appropriateness as they were identified as problem issues during the evaluation of compliance.

Appropriate training can never be overemphasised in the field of occupational hygiene. Training curriculum, materials, methods, training language, training environment, active participation and assessment methods are important building blocks to take into consideration.

It is important to create conditions where operators are eager and motivated to learn. Feedback from operators regarding the current training course will assist with the remoulding and improvement of training.

The benefits of and methods how to work "safe" should be an integral part of the objectives for improvement specifically referring to the use and importance of gloves, dust masks and face shields.

Supervision is an important activity when referring to the establishment and maintenance of a safe working environment and practices. Supervisors should make sure workers comply with recommendations. They should remind operators to take all their equipment at the camps and from the trucks. As soon as unacceptable practices are observed e.g. lowering of face shield before mixing, operators should be reminded of the risk of poisoning and the practice must be rectified immediately under the guidance of the supervisor.

Supervisors should receive more stringent training regarding their specific supervisory functions, acceptable and unacceptable occupational health practices, conflict management, equipment control and replacement strategies. Their proactive assistance when monitor field practices are imperative and they should be made aware of this important fact by means of participation and training.

The drive towards a safety culture within the malaria control programme is of great importance and should be seen as a priority. A safe culture can be defined as "…the set of beliefs, norms, attitudes, roles and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious" (Turner et al. 1989).

The concepts of a safety culture are well reflected in Bandura's model of reciprocal determinism (Cooper *et al.* 1995, Cooper 1997). Figure 6 illustrates the interaction within and between components in the model. This study investigated components A and B but it's clear that a thorough investigation of the safety management system is required. Interpretation of responses for non-compliance have indicated shortcomings in the current safety management system e.g. replacement of equipment, inadequate supervision and lack of knowledge regarding safe practices. The study outcomes have clearly indicated a need for further investigation and intervention. A thorough audit is advisable.

A safety culture should be achieved through a holistic, multi-faceted approach. Individual problems have been highlighted and need to be addressed as soon as possible but the non-compliance rate (78%) warrants investigation and intervention of all levels including: training curriculum, training methods, supervision, communication channels, procedures for replacement of equipment and protective clothing, programme occupational safety policy and management system.

A safety culture within the malaria control programme will deal with all issues relating to low compliance and thus protect the workers who's job it is to protect us.

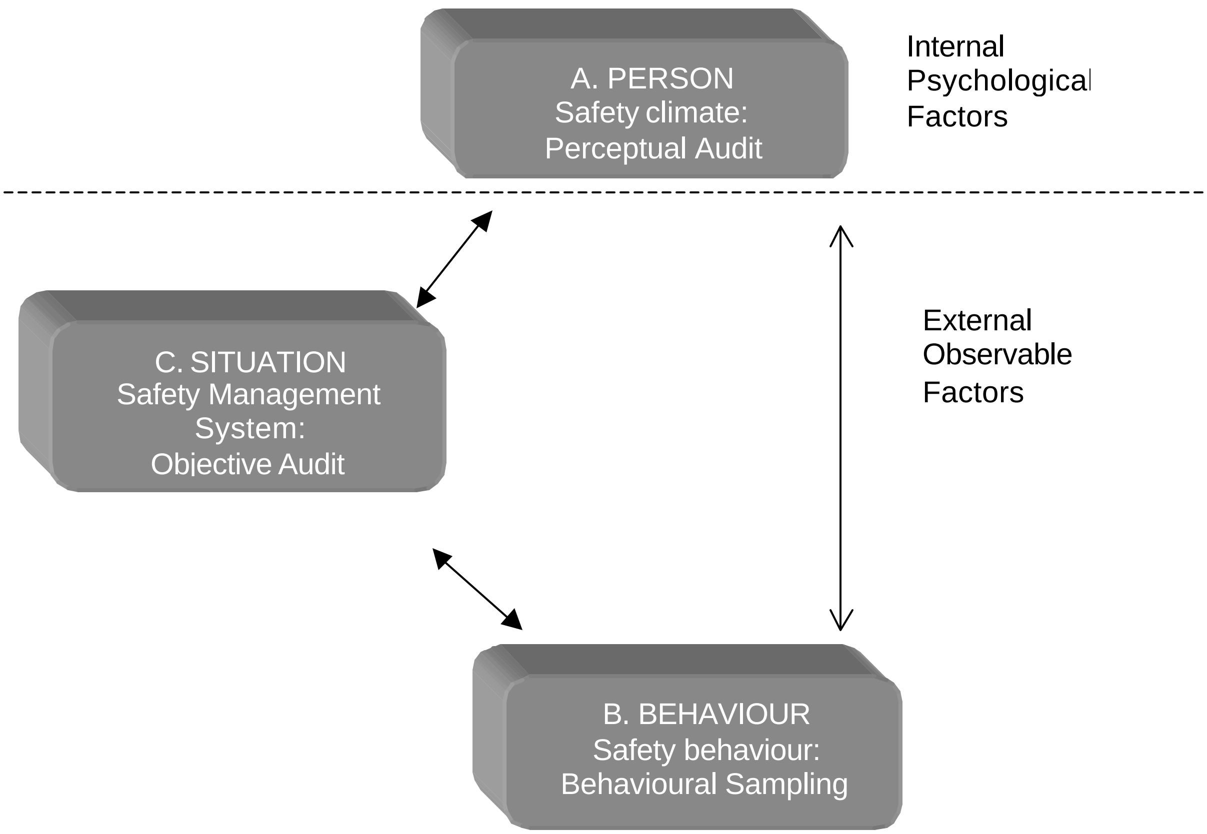

Figure 6 Reciprocal safety culture model

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Annexure A

Field Tick List & Interview Form for Spray Operators

Section A

Spray operator number:_____ Date:____/____/2003

Age:_____ Employment status: Permanent ☐ Temporary ☐

Experience(years) ______ Insecticide being used: DDT ☐ Deltamethrin ☐

Education level:
- A = primary education ☐
- B = secondary education up to grade 10 level ☐
- C = secondary education (from grade 11 to 12) ☐
- D = tertiary education ☐

Has the operator attended any training regarding the save handling and mixing of insecticide during the past 12 months. Yes ☐ No ☐

What language is the operator comfortable communicating in?

____

What language/s was the training conducted in?

____

Section B

Mixing

1. Gloves Yes ☐ No ☐

Is the operator wearing protective gloves?
If yes, is the gloves in a desirable condition or worn in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

____

____

____

2. Face shield Yes ☐ No ☐

Is the operator wearing a face shield?
If yes, is the face shield in a desirable condition or worn

in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

____

____

____

3. Dust mask Yes ☐ No ☐

Is the operator wearing dust mask?
If yes, is the dusk mask in a desirable condition or worn
in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

____

____

____

4. Leather boots Yes ☐ No ☐

Is the operator wearing leather boots?
If yes, is the boots in a desirable condition or worn
in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

____

____

____

5. Peak-less cap Yes ☐ No ☐

Is the operator wearing a peak-less cap?
If yes, is the cap in a desirable condition or worn
in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

____

____

____

6. Protective clothing Yes ☐ No ☐

Is the operator wearing long sleeve protective clothing?
If yes, is the clothing in a desirable condition or worn
in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

____

____

7. Eating, drinking and smoking

Yes No

Is the operator complying to the rule that he should not drink, eat or smoke while mixing insecticide?

If no ask the operator for a reason/reasons.

8. Hand washing

Yes No

Ask the operator if he/she washes his hands before eating.
If no ask the operator for a reason/reasons.

Section C

Application

1. Gloves

Yes No

Is the operator wearing protective gloves?
If yes, is the gloves in a desirable condition or worn in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

2. Face shield

Yes No

Is the operator wearing a face shield?
If yes, is the face shield in a desirable condition or worn in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

3. Dust mask

Yes No

Is the operator wearing dust mask?
If yes, is the dusk mask in a desirable condition or worn

in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

4. Leather boots

Yes ☐ No ☐

Is the operator wearing leather boots?
If yes, is the boots in a desirable condition or worn
in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

5. Peak-less cap

Yes ☐ No ☐

Is the operator wearing a peak-less cap?
If yes, is the cap in a desirable condition or worn
in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

6. Protective clothing

Yes ☐ No ☐

Is the operator wearing long sleeve protective clothing?
If yes, is the clothing in a desirable condition or worn
in such a manner to protect the operator.

If no, to any of the above questions, ask the operator for a reason/reasons.

7. Eating, drinking and smoking

Yes ☐ No ☐

Is the operator complying to the rule that he should not drink, eat or smoke while applying insecticide?

If no ask the operator for a reason/reasons.

8. Hand washing

Yes No

☐ ☐

Ask the operator if he/she washes his hands before eating.
If no ask the operator for a reason/reasons.

Section D

Ask the operator how often does he wear a clean set of protective clothing.

Every 3 days or more ☐ = A

Every 2 days ☐ = B

Every day ☐ = C

Annexure B

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

COMMITTEE FOR RESEARCH ON HUMAN SUBJECTS (MEDICAL)
Ref: R14/49 Booman

CLEARANCE CERTIFICATE **PROTOCOL NUMBER** M03-07-04

PROJECT The Practices of Spray Operators in the Mpualanga Malaria Control Programme Using Insecticides for Residual Indoor Spraying

INVESTIGATORS Mr A Booman

DEPARTMENT School of Public Health, Wits Medical School

DATE CONSIDERED 03-07-25

DECISION OF THE COMMITTEE Approved unconditionally

Unless otherwise specified the ethical clearance is valid for 5 years but may be renewed upon application
This ethical clearance will expire on 1 January 2008.

DATE 03-09-01 CHAIRMAN.......................................(Professor P E Cleaton-Jones)

* Guidelines for written "informed consent" attached where applicable.

c c Supervisor: Prof S Fonn
Dept of School of Public Health, Wits Medical School
Works2\lain0015\HumEth97.wdb\M 03-07-04
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DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and ONE COPY returned to the Secretary at Room 10001, 10th Floor, Senate House, University.

I/~~we~~ fully understand the conditions under which I am/~~we are~~ authorized to carry out the abovementioned research and I/~~we~~ guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/~~we~~ undertake to resubmit the protocol to the Committee. I agree to a completion of a yearly progress form. I/~~we~~ agree to inform the Committee once the study is completed.

DATE 09/09/2003 ......SIGNATURE ....

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES