



# Potential health effects of pesticide use on farmworkers in Lesotho

**Author:**Tholang A. Mokhele<sup>1,2</sup>**Affiliations:**

<sup>1</sup>Population Health, Health Systems and Innovation, Human Sciences Research Council, Pretoria, South Africa

<sup>2</sup>School of Environmental Sciences, University of KwaZulu-Natal, Durban, South Africa

**Correspondence to:**

Tholang Mokhele

**Email:**

mokheleta@yahoo.co.uk

**Postal address:**

Private Bag X41, Pretoria 0001, South Africa

**Dates:**

Received: 03 Nov. 2010

Accepted: 28 Mar. 2011

Published: 08 July 2011

**How to cite this article:**

Mokhele T. Potential health effects of pesticide use on farmworkers in Lesotho. *S Afr J Sci.* 2011;107(7/8), Art. #509, 7 pages. doi:10.4102/sajs.v107i7/8.509

© 2011. The Authors.

License: AOSIS

OpenJournals. This work is licensed under the Creative Commons Attribution License.

This study examined the experiences of farmworkers during crop spraying in Lesotho. The main goal of this study was to determine the perceptions and awareness of farmworkers regarding the use of pesticides and the potential effects on their health. The data were obtained from farmworkers using a combination of an open-ended and a close-ended structured questionnaire in July 2006. Of the nine farms serviced by the Ministry of Agriculture and Food Security of Lesotho, Agricultural Research Division, six farms were randomly chosen and 27 farmworkers from these farms were interviewed. The data were analysed using descriptive statistics such as frequency tables. The results showed that farmworkers are relatively poorly educated and that a greater health risk is present when a lack of training and education on the use of pesticides also exists. That is, the majority (85%) of farmworkers did not have secondary education and most (93%) had no training on the use of pesticides, which poses a great health threat to the farmworkers. A lack of education makes it difficult for farmworkers to read and understand the information labels on pesticides and hence it is difficult for them to understand the health hazards of pesticides and the need for personal safety measures. When using and handling pesticides, 52% of farmworkers did not use rubber gloves and 93% did not use goggles or other forms of face cover. This lack of protection puts them at serious risk of skin exposure to pesticides. The farmworkers were quite aware of the harmful effects of pesticides, but were sometimes unable to translate this awareness into their own safety practices because of a lack of knowledge about the adverse effects. Therefore, training, extension services and various awareness programmes should be promoted in Lesotho in order to increase farmworkers' knowledge and awareness of the adverse effects of pesticides on human health and the environment.

## Introduction

In Lesotho, the cultivation of crops is commonly practised on the foothills and lowlands where most of the population reside.<sup>1</sup> Land that is suitable for crop production (arable land) accounts for 13% of the total land area of Lesotho. Major crops grown in Lesotho include maize, sorghum, beans, wheat, fruit trees and vegetables. Vegetables (such as cabbage, spinach, tomato, rape and carrots) are mostly grown in urban and peri-urban areas to meet the demand for local markets in towns.<sup>1,2</sup> Vegetable productivity in Lesotho, as in other countries, is affected by pests and diseases, necessitating the application of pesticides. The use of pesticides in Lesotho began in the early 20th century and rapidly increased during the implementation of the Food Self-sufficiency Programme (*Mants'atlala*) in 1970 (Sekhonyana T 2006, personal communication, date unknown). However, the use of pesticides in Lesotho remains minimal compared to countries like South Africa.<sup>2</sup>

In many developing countries like Lesotho most pesticides are associated with adverse effects on human health and the environment; these adverse effects have arisen as a result of inappropriate use and handling of pesticides by inadequately trained farmworkers.<sup>3,4,5,6,7</sup> Farmworkers can be exposed to pesticides through different routes, such as inhalation, ingestion and skin contact.<sup>7,8</sup> Exposure to pesticides can result in acute and chronic health problems which include eye irritation, immune system disturbances, chromosomal damage, respiratory distress, hormone disruption, male genital abnormalities, diminished intelligence and cancer.<sup>7,8,9,10,11,12</sup>

As a result of these health-threatening effects, The Pesticides Management Bill was developed in 1986 in Lesotho as a first attempt to regulate the general use of pesticides. However, this Bill made no provisions for the banning of pesticides and/or restricting the use of some pesticides. The National Environment Policy for Lesotho of 1998, the Environment Bill 2000 and the Environmental Impact Assessment (EIA) guidelines of 1999, do make the EIA a requirement for large-scale application of pesticides. However, there is a lack of enforcement of these laws in Lesotho.<sup>2</sup> Internationally, a globally harmonised system of classification and labelling of chemicals has been developed to improve the protection of human health and the environment during the handling, transport and use of chemicals.<sup>12</sup>



In addition, the development of integrated pest management (IPM) strategies has been a way of reducing reliance on pesticides in pest management and is of great importance for both human health and the health of the environment.<sup>7,12,13,14,15,16</sup> Cultural control, the use of natural enemies and plant resistance are compatible and supportive tactics in the IPM strategy.<sup>12,13,14</sup> Previous studies have shown that IPM is an effective practice and leads to increased productivity.<sup>14,17,18,19</sup> For example, a joint Israeli–Palestinian and Jordanian programme was established to promote IPM and restrict ecosystem damage whilst maintaining or increasing cotton yield and the results showed that IPM was effective.<sup>17,18</sup> In Botswana, Obopile et al.<sup>14</sup> found that the majority (69%) of farmers used cultural control methods, such as crop rotation, sanitation, tillage and weeding, to successfully manage pests and diseases.

Only a few studies have been undertaken on pest management in Lesotho, with none investigating the health effects of exposure of farmworkers to pesticides. This study was therefore initiated to contribute towards filling this knowledge gap. More studies on the agricultural practices of farmworkers, IPM strategies employed and the use of pesticides as well as the consequent health and environmental impacts of pesticide usage, are needed to make informed policy decisions to promote safer and sustainable agricultural practices and to reduce the exposure of vulnerable farmworkers in Lesotho to potentially hazardous pesticides.

## Data and methodology

### Study area

The study area that was selected included farms in the Maseru district, as well as some farms in the Berea district that were included because they obtain their services (such as advice on which pesticides, fertilisers and ploughing methods to use) from the Ministry of Agriculture and Food Security of Lesotho, Agricultural Research Division, in the Maseru district. Only farms in the lowlands were selected as it has been previously shown that vegetable production is mostly practised in the urban and peri-urban areas of Lesotho (Figure 1).

### Data collection

The data were obtained from farmworkers using a combination of an open-ended and a close-ended structured questionnaire in July 2006. Of the nine farms serviced by the Ministry of Agriculture and Food Security of Lesotho, Agricultural Research Division, six farms were randomly chosen. There was a total of 30 farmworkers on these six farms, from which 27 farmworkers were available and willing to be interviewed. Permission was obtained from the farm owners for the study to take place. Farmworkers were visited at their farms, at their homes or at their place of alternative employment (as most of the farms were not planted at the time of the study). The following was obtained from the farmworkers during the interviews:

- social and demographic information
- knowledge of and skills in the usage of pesticides

- the methods employed for the application of pesticides
- perceptions on the advantages and disadvantages of using pesticides for crop production
- general comments on the use of pesticides on farms in Lesotho

### Data analysis

Information recorded in the questionnaires was coded for entry into a computer. The data analysed were the age, education, smoking history and previous pesticide use of the farmworkers, as well as the perceptions and awareness of the farmworkers on the use and handling of pesticides and the potential health effects of pesticides. Descriptive statistics (frequency tables, bar graphs and pie charts) are used to present the findings and were compiled using a Microsoft Excel 2003 spreadsheet. Themes in the responses to the questions were identified and recommendations are made based on the findings within these themes.

## Results and discussion

### Social and demographic analysis of respondents

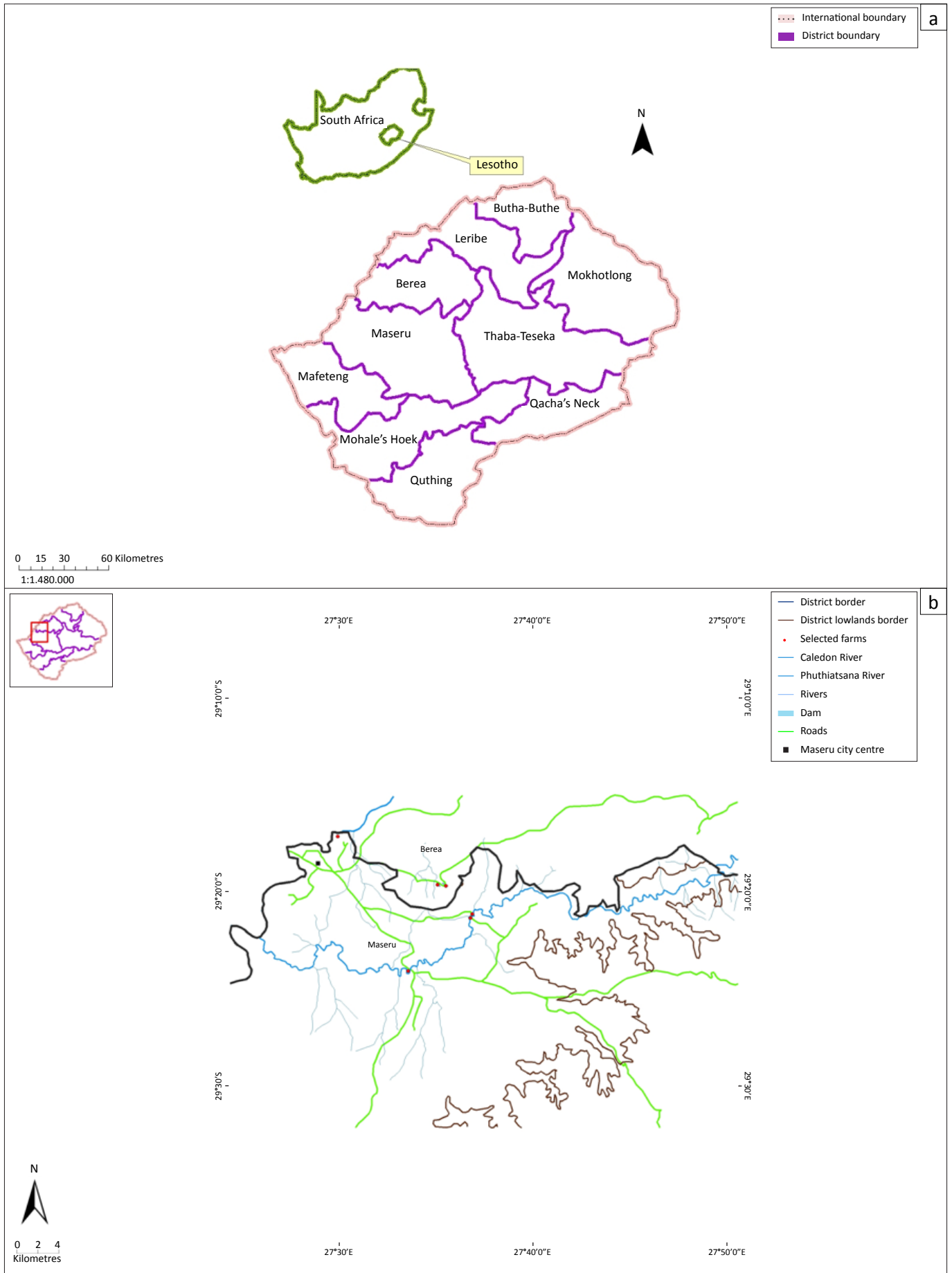
Those younger than 30 years old accounted for only 4% of farmworkers, whilst those between 30 and 59 years of age accounted for 85% and those over 60 years old accounted for 11%. There were more male farmworkers than female farmworkers – a situation which seems to be common in many countries, including Botswana and Ghana.<sup>14,20</sup> This finding may be as a result of the fact that, at the time of the study, South African mines were retrenching international mine workers and hiring only South African citizens, resulting in Basotho men seeking employment in Lesotho, many of whom would have relied on the agricultural sector for employment. It was noticed that the number of young farmworkers was particularly low and it can only be assumed that farming is not an attractive career option for young people.

The majority (85%) of farmworkers terminated their educational studies at the end of primary school. These results indicate that the farmworkers were relatively poorly educated, which might result in an inability to properly read the instructions related to pesticide usage, especially if they were not translated into Sesotho, the native language of the farmworkers.

Only one-third of farmworkers were smokers and indicated that they smoked more than four cigarettes per day and had been smoking for more than 3 years. Smoking increases the risk of exposure to pesticides (through the inhalation route), if farmworkers smoke whilst using pesticides.

### Farmworkers' knowledge, skills, awareness and perceptions on the use of pesticides

Knowledge of and skills in the use of pesticides are related to many factors, including the length of time that the farmworker has been using pesticides, the training provided and the availability of extension agents in the area. Figure 2 illustrates that most of the farmworkers had been using



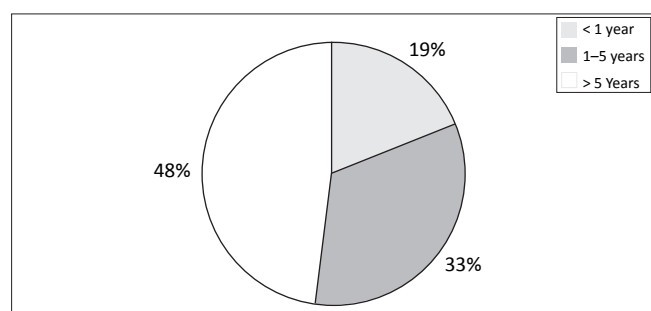
**FIGURE 1:** Maps showing the location of (a) Lesotho and its districts and (b) the study area and selected farms.



pesticides for many years. Only 19% of farmworkers had been using pesticides for less than a year. Surprisingly, 93% of farmworkers, including those that had been using pesticides for many years, had received no training in the use of pesticides. Those who had received some form of training (7% of farmworkers) indicated that the training was short term, that is, it ranged from only 2 days to 2 weeks. Previous studies have found a similar lack of training in the use of pesticides.<sup>6,10,21,22</sup> In this study, extension agents and the government were responsible for providing training on the safe use of pesticides, for those that received training. Isin and Yildirim<sup>15</sup> emphasised the need for increased education of farmworkers in order to avoid long-term problems associated with the use of pesticides. The basic objectives of education in pesticide usage are to ensure that farmworkers understand the health hazards of the pesticides that they use and are familiar with and adopt proper safety practices, use protective equipment properly, practise personal safety measures, recognise early symptoms of overexposure and obtain first aid, if necessary, as soon as possible.<sup>16</sup>

In terms of extension agents, more than half (56%) of farmworkers indicated that there were extension agents in their area. Only about half (53%) of these farmworkers indicated that the skills taught by these extension agents were useful, especially in keeping farmworkers well informed about application measures. The main problems identified were that extension agents only came to the farmworkers when national shows were held and that extension agents only requested information they needed for their own benefit, all of which was irrelevant to pesticide use. This finding indicates that there is a lack of training given, and insufficient skills and knowledge acquired by the farmworkers on the use and handling of pesticides, and hence they are more vulnerable to the health risks associated with the use of pesticides. Ngowi<sup>23</sup> found that farmers did not receive extension services at all. There is therefore a need to concentrate efforts on education and extension activities which will make farmworkers aware of the precautions to be taken during and after pesticide application.<sup>15</sup>

All farmworkers stated that they read the information label and followed the instructions for applying the pesticides. This finding was surprising because the majority (85%) of farmworkers terminated their education at the end of primary school. In contrast, results shown in Table 1 indicate that only



**FIGURE 2:** A pie chart showing the length of time that farmworkers in Lesotho have been using pesticides.

8% of the farmworkers were familiar with the rule of reading labels carefully. This finding is in agreement with that of Naidoo et al.<sup>6</sup>, whose study on farms in rural KwaZulu-Natal in South Africa found that only 18% of farmworkers read the labels. It is possible that the farmworkers in this study may be responding untruthfully, in fear of exposing themselves to the authorities or government officials responsible for law enforcement. The information contained on the pesticide label is very important for the safe handling and use of pesticides; failure to follow the instructions could result in serious risks to the health of the farmworkers and the environment.<sup>24</sup>

The majority (56%) of farmworkers always used protective clothing and equipment, whilst 44% of farmworkers sometimes used them. Naidoo et al.<sup>6</sup> found similar results in their study in which 57% and 55% of farmworkers reported using some form of protective equipment when mixing and spraying pesticides, respectively. Clearly more could be done to raise the awareness of farmworkers and also farm owners about the dangers of pesticides so that the use of protective clothing and equipment increases. It was interesting to find that some items of protective clothing and equipment were used by many farmworkers. Examples included long pants and long-sleeved shirts, with 89% of farmworkers reporting that they were frequently worn (Table 2). In comparison, 67% of farmworkers reported using respirators or masks frequently. The next most commonly used items were rubber boots and waterproof hats, with 59% and 70% of farmworkers, respectively, stating that they made moderate use of them.

A total of 52% of the farmworkers never wore rubber gloves when using or handling pesticides, thus increasing their risk of skin exposure. The majority (93%) of farmworkers never used goggles or other form of face cover. The finding that most farmworkers did not use protective face cover when using pesticides concurs with those obtained by Ntow et al.<sup>20</sup> and Ntow et al.<sup>22</sup> in Ghana, Salameh et al.<sup>16</sup> in Lebanon, Chitra et al.<sup>7</sup> in South India, Isin and Yildirim<sup>15</sup> in Turkey and Williamson et al.<sup>25</sup> in Senegal. A lack of protective face cover poses a serious risk of facial exposure to pesticides, especially for the eyes; if the eyes are exposed to pesticides, damage occurs immediately. There is a need to create greater awareness among both farmworkers and the authorities responsible for enforcing the law to ensure the proper use of protective equipment when using and handling pesticides.<sup>7</sup> For most of the pesticides, taking protective measures

**TABLE 1:** The number and percentage of farmworkers who followed each guideline on the use of pesticides.

Guideline	n	%
Avoid crops for 14–21 days after spraying	15	58
Dispose of an animal that died from eating pesticides	7	27
Prevent animals from gaining access to sprayed crops	5	19
Use protective clothing and equipment properly	4	15
Refrain from touching food or any part of your body after spraying until you have washed your hands	8	31
Read the information label on the pesticide very carefully	2	8

n, Number of farmworkers.

%, Percentage of farmworkers.



**TABLE 2:** The number and percentage of farmworkers who indicated their use of protective clothing and equipment during each application of pesticides as frequent, moderate, infrequent or never.

Item	Frequently used		Moderately used		Infrequently used		Never used	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Long pants and long-sleeved shirts	24	89	3	11	0	-	0	-
Goggles or face cover	0	-	0	-	2	7	25	93
Rubber boots	11	41	16	59	0	-	0	-
Respirator or mask	18	67	9	33	0	-	0	-
Waterproof hat	0	-	19	70	8	30	0	-
Rubber gloves	1	4	7	26	5	19	14	52

*n*, Number of farmworkers.

%, Percentage of farmworkers.

results in a decrease in exposure of more than one order of magnitude.<sup>16</sup> The issue of infrequent use of protective clothing and equipment during the application and handling of pesticides in SADC countries such as Lesotho has also been reported by Miller<sup>3</sup>. Miller<sup>3</sup> gave a lack of protective measures as one of the five factors that result in an increase in the vulnerability of farmworkers to pesticide poisoning. This negligence is attributed to little or no training of farmworkers on the safe practices of pesticide use. The reasons given by farmworkers in this study for not using protective equipment and clothing ranged from a lack of availability of equipment, discomfort in hot and humid weather conditions and poor farm owner–farmworker relations, to an absence of regulations that require their use.<sup>5,7,15,26</sup>

All farmworkers in this study used a knapsack sprayer, yet only 59% stated that they would postpone spraying if the weather conditions were unfavourable, specifically windy. Of those who continued spraying in windy conditions, 91% sprayed with their backs to the wind, whilst 9% were unsure of their direction of spraying. For those who may have sprayed facing the wind, the wind could blow the pesticides onto their bodies, including their faces, presenting a great potential for exposure via both skin contact and inhalation.<sup>20</sup> Similarly, Isin and Yildirim<sup>15</sup> found that 75% of farmers did take wind direction into consideration when spraying. The use of knapsack sprayers poses another potential danger of exposure, regardless of the wind direction, because these sprayers are prone to leaking. Therefore there is a need to provide high-quality equipment at an acceptable cost that will be more durable in a hot and humid environment like Africa.<sup>27</sup>

In terms of determining their general awareness of the dangers of pesticides, farmworkers were asked if they were aware of any other farmworker that had been affected by pesticides and also if their children had access to the pesticides. Almost all (93%) farmworkers indicated that they were not aware of any farmworker having been affected by pesticides. Only two reported having witnessed others being affected by pesticides: one reported that the affected farmworker was taken to the hospital and treated, whilst the other reported that the affected farmworker was taken to the hospital but unfortunately died. All farmworkers were aware that children should not touch anything associated with pesticides and none of them allowed their children to go to the farms when pesticides were being applied. In addition,

none of the farmworkers allowed their children access to the pesticide storerooms. The majority (81%) of farmworkers stated that they bathed and washed their clothes and equipment after application. This finding is similar to those of Isin and Yildirim<sup>15</sup> and Salameh et al.<sup>16</sup>, who reported that 95% of farmers in Turkey and 90% of farmers in Lebanon, respectively, bathed after applying pesticides. The farmers' general awareness of the dangers of pesticides is greatly encouraging and if the above precautions are practised throughout the country, the harmful effects of pesticides on human health can be minimised.

The majority (96%) of farmworkers were familiar with at least one of the by-laws or guidelines that exist on pesticide use. The guidelines that were known to and followed by the farmworkers are given in Table 1. It is encouraging to note that many farmworkers were familiar with some of the guidelines that apply to the safe use of pesticides as following these rules will reduce the potential for adverse health effects. However, there is a lack of enforcement of these by-laws in Lesotho.<sup>2</sup>

The farmworkers' perceptions on the benefits of pesticides showed that the majority (78%) believed that the use of pesticides helped them by killing and controlling pests and thus preventing pests from destroying their crops (Figure 3). A total of 63% of farmworkers indicated that pesticides were useful in improving the quality of their crops, whilst 59% stated that pesticides helped to improve the overall crop yield (Figure 3).

When asked to choose one disadvantage of pesticide use in crop production, 44% of farmworkers stated that pesticides need to be handled with great care, 26% stated that pesticides are dangerous, especially if one does not use protective clothing and equipment, 15% stated that pesticides are poisonous and that one should not eat without first washing one's hands after using pesticides and 11% stated that crops could die from excessive use (Figure 4). The remaining 4% of farmworkers complained that pesticides are expensive to buy and that they did not increase yields. These results indicate that farmworkers are aware of the dangers of pesticides, which is in contrast to most findings in developing countries. Farmworkers aware of the harmful effects of pesticides are expected to behave differently, that is, to practise safe application methods. However, these farmworkers are sometimes unable to translate their knowledge or awareness





of the correct procedures into practice, and thus they may not act consistently.<sup>15,25</sup> In contrast, in developed countries, greater awareness of the harmful effects of pesticides has led to better regulation and, in some countries, compulsory training of spray operators and/or routine checks on spraying equipment.<sup>15</sup>

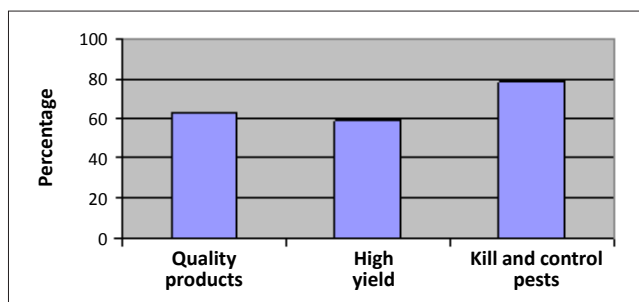
The suggestions and comments of farmworkers on the use and handling of pesticides are given in Table 3. Many farmworkers were concerned about unenthusiastic extension agents (37%) and a lack of training (30%). It is interesting to note that 11% of farmworkers raised the issue of health check-ups after applications, in that this highlights the fact that farmworkers are aware of adverse health effects of pesticides. There are many advantages to keeping records of pesticide use. For example, records are useful for checking if the requisite 14 to 21 days have passed after spraying. Furthermore, if a person is affected after eating a crop from the farm, then a doctor is able to check the records to determine which pesticides were used and if the person ate the crop before the period of 14 to 21 days after spraying had elapsed.

In general, findings from this preliminary study showed that farmworkers were aware of possible problems associated with exposure to pesticides, as they would not allow their children near the pesticides, they were aware of the by-laws governing pesticide use and they were aware of the potential harmful effects of pesticides. Yet they did not employ safe practices in their application of pesticides. This discrepancy shows that farmworkers are sometimes unable to translate their awareness into practice. In addition, a high proportion of farmworkers was not educated and did not have any training on the use of pesticides – a combination that poses an even greater threat to the health of farmworkers because they cannot read and understand the information labels and therefore the potential health hazards if the necessary personal safety measures are not followed.

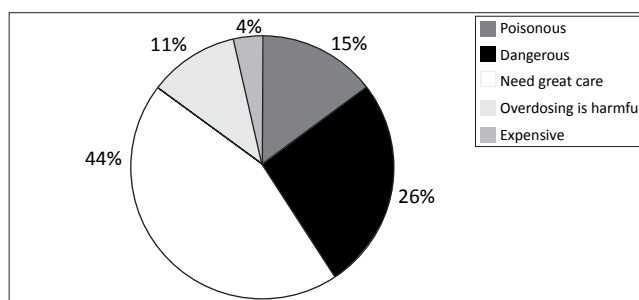
The findings of this study are limited by its small sample size, which reduces statistical power and, to some extent, the generalisations that can be made to other farmworkers who live outside of the Maseru district lowlands and Berea district.<sup>22,28</sup> But this study is a first step towards filling the research gap that exists on the knowledge of farmworkers in Lesotho of the potential health effects of pesticides. A second limitation is the possibility that farmworkers responded untruthfully to the questions in fear of exposing themselves to the authorities or government officials responsible for law enforcement.

## Conclusions

The majority of farmworkers had no secondary education (85%) and most did not have any training on the use of pesticides (93%) – in combination posing an even greater threat to the health of farmworkers because they cannot read and understand the information labels on the pesticides and thus the potential health hazards if the necessary personal



**FIGURE 3:** The percentage of farmworkers who responded that the use of pesticides was beneficial to increase the quality of the crop, increase the crop yield and kill and control pests.



**FIGURE 4:** A pie chart showing the percentage of farmworkers indicating the disadvantages of pesticides.

**TABLE 3:** Suggestions and comments from farmworkers in Lesotho on the use of pesticides on their farms.

Suggestion or comment	n	%
Other farmers should be encouraged to use pesticides	10	37
Other farmers should follow the instructions	4	15
Pesticides should be stored properly	3	11
Pesticides should be handled with great care	2	7
Protective clothing and equipment should be provided	6	22
Health check-ups after the use of pesticides should be undertaken	3	11
Extension services should be provided and performed effectively	10	37
Training of farmworkers on the use of pesticides should be provided	8	30
Proper records on the application of pesticides should be kept	3	11

n, Number of farmworkers.

%, Percentage of farmworkers.

safety measures are not followed. A total of 52% of the farmworkers did not use rubber gloves and 93% did not use goggles or face cover when using and handling pesticides, putting themselves at risk of skin exposure. Although the farmworkers were aware of the possible harmful effects of pesticides, as well as the by-laws governing their use, they did not translate this awareness into practice. Therefore training and extension services should be provided and various awareness programmes (through television, newspapers, live drama and open media) should be promoted in Lesotho in order to educate farmworkers on the potential adverse effects of pesticides on human health and the environment.

## Recommendations

In light of the above findings, several recommendations for the use of pesticides by farmworkers in Lesotho are given:

- Adequate and continuous training on the use of pesticides should be provided for farmworkers.
- Government intervention to promote law enforcement of



best practice in pesticide use should be provided.

- Various awareness programmes, making use of print media, radio, television and open-air theatre, should be employed to enhance the awareness of farmworkers on the potential adverse health effects of the use and handling of pesticides.
- The implementation of IPM to reduce reliance on pesticides, as a way of minimising exposure, should be encouraged.
- Protective clothing and equipment for farmworkers should be provided and the sprayers should be properly maintained by the farm owners.
- Extension agents should be monitored and evaluation systems put in place to ensure that they perform effectively.

## Acknowledgements

I thank the Lesotho Government for funding, the farmworkers and farm owners for their cooperation, the Plant Protection Officers from the Ministry of Agriculture and Food Security (Agricultural Research Division and Department of Crops) for the information they provided and Prof. Roseanne Diab for her principal investigation of this research study.

## References

1. Ministry of Agriculture, Cooperatives and Land Reclamation. District-economic strategy. Maseru: Ministry of Agriculture, Cooperatives and Land Reclamation; 2002.
2. Ministry of Tourism, Environment and Culture. Development and harmonization of toxic and hazardous chemicals legislation: Findings report; toxic and hazardous chemicals (control and management) draft bill and draft regulation. Maseru: Mophethe-Nkuebe Chambers (Pty) Ltd; 2005.
3. Miller GT. Living in the environment: Principles, connections and solutions. 10th ed. Belmont: Wadsworth Publishing Company; 1998.
4. Clarke EEK, Levy LS, Spurgeon A. The problems associated with pesticide use by irrigation workers in Ghana. *Occup Mod.* 1997;47(5):301–308. doi:10.1093/ocmed/47.5.301, PMID:9302813
5. Ngowi AVF, London L. Action on pesticides under the Programme on Work and Health in Southern Africa (WAHSA). *Afr Newslett Occup Health Safety.* 2006;16:15–19.
6. Naidoo S, London L, Rother HA, et al. Pesticide safety training and practices in women working in small-scale agriculture in South Africa. *Occup Environ Med.* 2010;67(12):823–828. doi:10.1136/oem.2010.055863, PMID:20576924
7. Chitra GA, Muraleedharan VR, Swaminathan T, et al. Use of pesticides and its impact on health of farmers in South India. *Int J Occup Environ Health.* 2006;12(3):228–333. PMID:16967829
8. Ngowi AVF, Mbisea TJ, Ijani ASM, et al. Smallholder vegetable farmers in Northern Tanzania: Pesticides use practices, perceptions, cost and health effects. *Crop Prot.* 2007;26:1617–1624. doi:10.1016/j.cropro.2007.01.008, PMID:18528532, PMCID:2410092
9. Mourad TA. Adverse impact of insecticides on health of Palestinian farm workers in the Gaza Strip: A hematologic biomarker study. *Int J Occup Environ Health.* 2005;11(2):144–149. PMID:15875890
10. McCauley LA, Anger WK, Keifer M, et al. Studying health outcomes in farmworker populations exposed to pesticides. *Environ Health Perspect.* 2006;114:953–960. doi:10.1289/ehp.8526, PMID:16760000, PMCID:1480483
11. Hoppin JA, Valcin M, Henneberger PK, et al. Pesticide use and chronic bronchitis among farmers in the agricultural health study. *Am J Ind Med.* 2007;50(12):969–979. doi:10.1002/ajim.20523, PMID:17975796, PMCID:2806052
12. Abhilash PC, Singh N. Pesticide use and application: An Indian scenario. *J Hazard Mater.* 2009;165:1–12. doi:10.1016/j.jhazmat.2008.10.061, PMID:19081675
13. Cumming SG, Spiesman JB. Regional problems need integrated solutions: Pest management and conservation biology in agroecosystems. *Biol Conserv.* 2006;131(4):533–543. doi:10.1016/j.biocon.2006.02.025
14. Obopile M, Munthali DC, Matilo B. Farmers' knowledge, perceptions and management of vegetable pests and diseases in Botswana. *Crop Prot.* 2008;27:1220–1224. doi:10.1016/j.cropro.2008.03.003
15. Isin S, Yildirim I. Fruit-growers' perceptions on the harmful effects of pesticides and their reflection on practices: The case of Kemalpaşa, Turkey. *Crop Prot.* 2007;26:917–922. doi:10.1016/j.cropro.2006.08.006
16. Salameh PR, Baldi I, Brochard P, et al. Pesticides in Lebanon: A knowledge, attitude, and practice study. *Environ Res.* 2004;94:1–6. doi:10.1016/S0013-9351(03)00092-6
17. Richter ED, Safi J. Pesticide use, exposure, and risk: A joint Israeli-Palestinian perspective. *Environ Res.* 1997;73:211–218. doi:10.1006/enrs.1997.3717, PMID:9311550
18. Richter ED, Gasteyer S, El Haj S, et al. Agricultural sustainability, pesticides exposure, and health risks: Israel, the Palestinian National Authority, and Jordan. *Ann NY Acad Sci.* 1997;837:269–290. doi:10.1111/j.1749-6632.1997.tb56880.x, PMID:9472346
19. Kogan M. Integrated pest management: Historical perspectives and contemporary developments. *Annu Rev Entomol.* 1998;43:243–270. doi:10.1146/annurev.ento.43.1.243, PMID:9444752
20. Ntow WJ, Gijzen HJ, Kelderman P, et al. Farmer perceptions and pesticide use practices in vegetable production in Ghana. *Pest Manag Sci.* 2006;62:356–365. doi:10.1002/ps.1178, PMID:16532443
21. Arcury TA, Quandt SA, Barr DB, et al. Farmworker exposure to pesticides: Methodological issues for the collection of comparable data. *Environ Health Perspect.* 2006;114(6):923–928. doi:10.1289/ehp.8531, PMID:16759996, PMCID:1480495
22. Ntow WJ, Tagoe LM, Drechsel P, et al. Occupational exposure to pesticides: Blood cholinesterase activity in a farming community in Ghana. *Arch Environ Contam Toxicol.* 2009;56:623–630. doi:10.1007/s00244-007-9077-2, PMID:19112562
23. Ngowi AVF. A study of farmers' knowledge, attitude and experience in the use of pesticides in coffee farming. *Afr Newslett Occup Health Safety.* 2003;13:62.
24. Lekei EE, Mununa FT, Uronu AB. Pesticide labels and risk reduction in developing countries. *Afr Newslett Occup Health Safety.* 2004;14:57–60.
25. Williamson S, Ball A, Jules Pretty J. Trends in pesticide use and drivers for safer pest management in four African countries. *Crop Prot.* 2008;27:1327–1334. doi:10.1016/j.cropro.2008.04.006
26. Cole DC, Sherwood S, Crissman C, et al. Pesticides and health in highland Ecuadorian potato production: Assessing impacts and developing responses. *Int J Occup Environ Health.* 2002;8(3):182–190. PMID:12358074
27. Matthews G, Wiles T, Baleguel P. A survey of pesticide application in Cameroon. *Crop Prot.* 2003;22:707–714.
28. Farquhar S, Shadbeh N, Samples J, et al. Occupational conditions and well-being of indigenous farmworkers. *Am J Public Health.* 2008;98:1956–1959. doi:10.2105/AJPH.2007.124271, PMID:18799774, PMCID:2636431