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Pesticide exposure in the local community of Vehari District in Pakistan: An assessment of knowledge and residues in human blood

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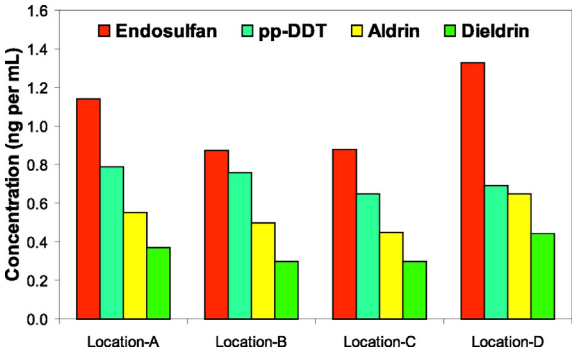
HIGHLIGHTS

- Farm workers showed little knowledge of using the recommended amounts of pesticides.
- Most farm workers were found using limited protective measures during pesticide use.
- Knowledge of pesticide risks on human health increased with education and training.
- Blood donors who sprayed had high levels of organochlorine residues in their blood.
- Blood donors living away from fields had low levels of residues in their blood.

GRAPHICAL ABSTRACT



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ABSTRACT

The present study is based on cross-sectional data collected from rural and market areas of Vehari District in Pakistan to assess public awareness of pesticide risks and determine the levels of exposure to organochlorine pesticides (OCPs) in the local community. Blood samples were collected from 56 volunteer donors (VDs) including children, female workers, farm workers involved in pesticide business, farm workers involved in pesticide spraying activities, and people who were living away from agricultural fields. Blood analysis showed that VDs who were involved in spraying activities had significantly higher levels of OCP residues in their blood samples than VDs from the other groups, with mean concentrations of 1.13, 0.92, 0.68 and 1.96 ng mL^{-1} for pp-DDT, aldrin, dieldrin, and endosulfan, respectively. However, VDs who were living away from agricultural fields had significantly lower levels of pesticide residues in their blood samples, with mean concentrations of 0.30, 0.19, 0.14 and 0.41 ng mL^{-1} for pp-DDT, aldrin, dieldrin, and endosulfan, respectively. A survey of 179 volunteer respondents (VRs) showed that a significant proportion of the VRs had little knowledge of using the recommended amounts of pesticides (65.9%). Furthermore, the majority of the VRs was found using limited protective measures during pesticide use (62.6%) and was practising unsafe storage of pesticides (87.7%). In addition, most farm workers (88.8%) reported an increasing trend in pesticide use in their farms each year. Knowledge of pesticide risks on human health increased with formal education and training. Poor knowledge regarding pesticide risks and handling among inhabitants of Vehari District contribute

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to high exposure levels to OCPs, particularly among farm workers. Findings are useful for policy formulation aimed at reduction of pesticide exposure in Pakistan.

1. Introduction

Pesticides are widely used in crop production to control harmful insects, weeds, and organisms that cause diseases (Damalas, 2009), but they can pose severe threats because they are poisonous substances and have adverse effects on the surrounding environment (Damalas and Eleftherohorinos, 2011). Pesticides are toxic substances and thus are harmful to living organisms at particular doses. They can enter into the human body, inhibit enzymatic function, and disturb the normal reactions required for metabolism (Yassi et al., 2001). Pesticide exposure mostly occurs through inhalation, skin contact, and ingestion (Damalas and Koutroubas, 2016). Farmers' poor knowledge of proper application practices, the lack of protective measures during application, and the ignorance of potential health risks often result in increased pesticide exposure (Arafa et al., 2013; Khan et al., 2015). Use of pesticides without information about their toxicity and usage devoid of any protective measures can lead to several health complications (Yassi et al., 2001).

In recent years, crop production has increased rapidly in Pakistan because of the native feeding demands. For the protection of crop production, various pesticides are widely used throughout the country for the control of common pests. There are 108 types of insecticides, 30 types of fungicides, 39 types of herbicides, five types of acaricides, and six different types of rodenticides that are registered for use in Pakistan (Zia et al., 2009; Anwar et al., 2011). Pesticide use was 7,000 metric tonnes per annum in 1960, which increased to 16,226 metric tonnes in 1976–1977, 14,848 metric tonnes in 1987, and reached 78,132 metric tonnes in 2003 (Syed and Malik, 2011). High amounts of pesticides are applied in Punjab province (88.3%), followed by the provinces Sindh (8.2%), Khyber Pakhtunkhwa (KPK) (2.8%) and Baluchistan (0.76%). Out of these pesticides, a proportion of 11.9% is used on vegetables and fruit crops (Khan et al., 2010a). Cotton, vegetables, and fruits are considered labor intensive crops in terms of farming practices and pesticide applications, so farm workers are highly exposed to pesticide residues in the fields. Bakhsh et al. (2016) estimated serious health costs of women cotton pickers because of numerous health problems among this group of farm workers. Of the above chemicals, the organochlorine pesticides (OCPs) have been banned in Europe and America during 1960s and 1970s, but are still being used for agricultural and health control programs in many countries, including Pakistan (Ali et al., 2014), because they are cost-effective and good against controlling insects (Zhou et al., 2013). The South Asia region is a place where primarily emissions are still taking place and thus it is important to assess the status of OCPs pollution (Ali et al., 2014).

In Pakistan, the control of pesticide residues in the food chain is not meticulous because there is no or only weak relative legislation for the management of pesticides and other hazardous chemicals and for monitoring their residues. Common malpractices of farm workers involved in spraying activities, such as ignoring basic safety measures when handling pesticides, trigger numerous concerns, such as occurrence of pesticide residues and accumulation in the higher trophic level. In Pakistan, there is no official training on pesticide use and pesticides are commonly used without safety measures due to lack of effective legislation and lack of knowledge of potential risks of these hazardous chemicals and their side effects (Latif et al., 2012). Quantifying pesticide exposure in farming systems is of special interest for the estimation of potential health risks from the use of pesticides, especially in the developing countries, where usually there is considerable lack of occupational hygiene regulations (Khan and Damalas, 2015). Therefore, the need to evaluate pesticide load in the local rural communities and the surrounding environment, particularly in the developing countries, is urgent. In general, pesticide exposure history among farmers is obtained almost exclusively via self-report information because farmers are self-employed and there are limited alternate sources of information regarding their exposure to pesticides (Hoppin et al., 2002). As the people involved in pesticide handling activities have maximum chances to receive pesticides from dermal contact, the blood evaluation gives proof of pesticide exposure of the body and provides signs of body load of pesticide residues.

Like in many other countries, pesticides are commonly used in Pakistan to protect crops from harmful pests and gain more production. However, the excessive use of pesticides contaminates the environment, causing health hazards for the local community. Therefore, the objective of the current study was to determine public awareness of pesticide risks and the levels of exposure to pesticides in the rural community in Pakistani Punjab. Although some studies are available considering pesticide exposure among farmers and farm workers, these studies are mainly based either only on cross-sectional data or only on blood samples of the population. The present study is different from previous studies as it employs both cross-sectional data and blood samples from different locations. So, in this study, we have combined information obtained from blood samples of volunteer donors and information based on the recall ability of volunteer respondents. The results of the study will be useful for the government as well as for the public and private sectors to tackle the problem of heavy pesticide use in the area.

2. Materials and methods

2.1. Site selection

The study was carried out at COMSATS Institute of Information Technology in Vehari District of Pakistan. The selected locations (named A, B, C, and D) have intensive agriculture activities with cultivation of different vegetables and field crops. Location-A was selected because of the cultivation of vegetables (e.g., potato, spinach, carrot, okra, and onion). Location-B included farmers mainly cultivating field crops, such as cotton, rice, maize, wheat, and sugarcane. Location-C included farmers cultivating both vegetables and field crops, including cabbage, potato, cotton, rice, maize, wheat, and sugarcane, whereas location-D was the major business market of pesticides and the native community involved in agro-based industry.

2.2. Collection of blood samples

Blood samples were collected from 56 volunteers donors (VDs) from the following five specific subgroups: i) children <14 years of age, ii) female workers involved in fruit, vegetable, and cotton harvesting, iii) farm workers involved in pesticide business, iv) farm workers involved in pesticide spraying activities, and v) people who live away from the agricultural fields. Blood samples were collected in butterfly syringes from the four locations of Vehari District as mentioned above and kept in decontaminated labelled glass vials, preserved in iceboxes for laboratory analysis.

Quota sampling (subgroups) was used to collect the data in the four locations of Vehari. Quota sampling, apart from cost-effectiveness and time-effectiveness, allows researchers to sample specific subgroups of the population that are of great interest to the study and observe relationships between subgroups. Quota sampling is a non-probability

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