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Farmer and retailer knowledge and awareness of the risks from pesticide use: A case study in the Wei River catchment, China

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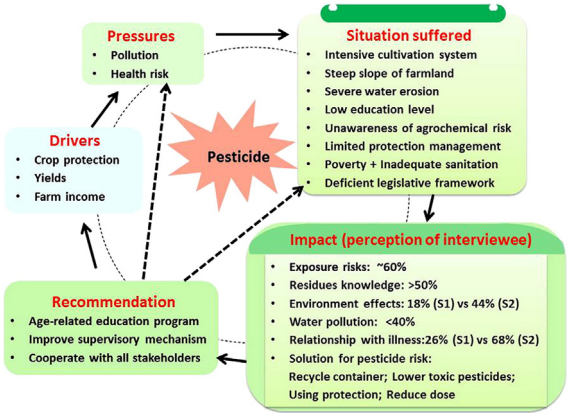
HIGHLIGHTS

- The status of income and expenditure on agriculture cultivation was investigated.
- Knowledge and awareness of risks from pesticide use in different places were estimated.
- The related factors affecting the perception of people on pesticide use was analysed.
- Efficiency programmes on pesticide safety use were recommended.

GRAPHICAL ABSTRACT



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ABSTRACT

Monitoring the educational level of farmers and retailers on pesticide use would be useful to assess the appropriateness of information for reducing or/and avoiding the risks from pesticides in rural regions. The levels of knowledge and awareness of the dangers to the environment and human health were investigated by questionnaires for farmers (209) and retailers (20) in two rural regions (Qianyang County (S1) and Chencang County (S2)) of the Wei River catchment in China where the modes of farming and the state of erosion are very different. The results showed that farmers learned the use and dangers of pesticides mainly by oral communication ($p < 0.01$). Protective measures were inadequate; 65% (S1) and 55% (S2) of farmers never used any protective measures during spraying ($p < 0.05$). Washing hands (>70%) was the most common mode of personal hygiene, relative to wearing masks, showering, and changing clothes, but no significant differences were observed between the selected regions. Most pesticide wastes were dumped directly onto the land or into water, suggesting that educational measures should be taken to address the potential risks from the residues in the wastes. Over 85% of farmers (S1 and S2) claimed to use illegal pesticides, but the reasons for their use varied ($p < 0.01$). Retailers were well-informed and highly conscious of their responsibility for the safe use of pesticides, especially in S2 ($p < 0.01$). A canonical correspondence analysis indicated that educational level and age differed between

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the two regions and contributed greatly to the risks from pesticide use ($p < 0.01$). Educational programmes targeted to age groups, proper disposal of pesticide waste, and sufficient supervision from authorities should consequently be considered for improving the levels of knowledge and awareness of the dangers of pesticides to human health and environmental pollution in the Wei River catchment, China.

1. Introduction

Intensively used pesticides, despite their ability to protect crops, threaten the environment and human health (Damalas, 2009; Damalas et al., 2008; Hvistendahl, 2013; Peshin and Dhawan, 2009; Verger and Boobis, 2013). These "poisons by design" are prevalent and serious occupational hazards faced by agricultural workers and farmers (Gomes et al., 1999; Gunnell and Eddleston, 2003; Hogstedt et al., 1997; Hvistendahl, 2013; Ibitayo, 2006; Yassin et al., 2002). The high levels of occupational exposure to pesticides are correlated with low educational levels, which would preclude the ability of farmers to follow the hazard warnings developed by the chemical industries and agencies (Ibitayo, 2006; Ngowi et al., 2007a,b; Recena and Caldas, 2008). Tragedies such as acute and chronic intoxication, and in some extreme cases, suicide, have frequently been reported, especially in rural regions (Cui, 2009; Gunnell and Eddleston, 2003; Hvistendahl, 2013; Karunamoorthi et al., 2011, 2012; Koh and Jeyaratnam, 1996; Konradsen et al., 2003; Kumar et al., 2012; Phillips et al., 2002; Yassin et al., 2002; Zhou et al., 2011). The lack of a legislative framework regulating the use of pesticides also contributes to the high incidence of poisoning in developing countries (Chen et al., 1998; Hvistendahl, 2013; Salameh, 2004; Yassin et al., 2002). Accountability system, from pesticide registration to supervision mechanism, taking China for instance, is unequipped (Chen et al., 1998; Zhang and Lu, 2007) which leads some big challenges to trace pesticides in market, environmental system and its consequences for human being via food chain(Enserink et al., 2013; Peshin and Dhawan, 2009; Verger and Boobis, 2013). Taking into account the interactions among mixed pesticides, it also increases the risk to human health and the environment (Pedlowski et al., 2012). Poverty, inadequate sanitation, and the standards of medical care are also obstacles to the safe use of pesticides. Those aware of the risks, however, may still misuse pesticides to avoid a lower crop production associated with a significant lower pesticide use (Enserink et al., 2013; Tucker and Napier, 2001). No awareness of alternative systems of production appears to lead to the idea that the use of agrochemicals is unavoidable.

China has a long history of cultivation and has the highest application, exportation, and production of pesticides (Zhang et al., 2011b). The annual mean rate of pesticide application in China is 14.8 kg ha^{-1} (DRSE (NBSC), 2013) but the application rate is likely higher in hotspots. Some highly toxic, persistent, and bioaccumulative pesticides such as the chlorinated pesticides have been completely banned since 1983, but some of these are still commercially available (Zhang and Lu, 2007), and high levels of residues are still detected in soils and water (FAO, 2013; Zhang et al., 2011a). Not all regulations and provisions for pesticide management are respected and accepted in rural regions (Li et al., 2002; Zhang et al., 2005). The Wei River catchment is an important region of agricultural development, and the Wei River contributes strongly to the local economy and society. Due to severe anthropogenic activities, however, the water quality in this river has been degraded by over 85% to class IV of the national standards (GHZB 1–1999), indicating that the water cannot be used for either drinking or irrigation (Guo, 2011; Li et al., 2011; Liu et al., 2007; Zhang and Lu, 2007). Many measures and policies, such as the Program of Integrated Management of Pollution in the Wei River [G2005-99], have addressed the direct discharge of pollutants into the Wei River, however, the quality of the water is still deteriorating (Guo, 2011). Li et al. (2011) suggested that agrochemicals (fertilizers) were a source of pollution contributing to the high concentrations of nitrogen and phosphorous in the Wei River. The levels of knowledge and awareness of the stakeholders, especially farmers and retailers, of the hazards of pesticides should be taken into account to enhance the integrated management of agricultural pollution and agrochemical supervision in rural regions. Such studies are unfortunately limited in China (Huang et al., 2000, 2003; Zhang and Lu, 2007) and the poisoning and suicide case from pesticides are reported frequently (Cui, 2009; Zhou et al., 2011). As end users and distributors, farmers and retailers of pesticides are directly exposed to pesticides, and their behaviours for the safe use of pesticides play an important role in reducing point and non-point sources of pollution, hazards, and acute or chronic intoxication to pesticides in agricultural regions. The levels of knowledge and risk awareness and the practices of farmers and retailers are essential elements for increasing the efficiency of devising to protect these stakeholders. The objectives of this study were thus (1) to determine the levels of knowledge and awareness and the practices of farmers and retailers of pesticide use in regions with different modes of farming and terrains, (2) to evaluate the related risks to the environment and human health and to analyse the most relevant factors for the security of pesticide use, and (3) to recommend programmes for reducing pollution and the risks from pesticide use based on the comparative results of a survey in two regions of the Wei River catchment in China.

2. Materials and methods

2.1. Study site

This study was conducted in two typical rural regions in the middle region of the Wei River catchment (107°04′–107°59′E and 34°31′–34°74′N) (Fig. 1). One region (S1) is located in Qianyang County along the Qian River, a branch of the Wei River. S1 has an area of 2290 ha and has approximately 50,000 inhabitants scattered in hilly regions where arable land is terraced and fruit trees are commonly grown. Wheat and maize are also cultivated and irrigated on the limited flat land. The steep slopes of the land and the concentrated rainfall (June to September) have led to serious losses of soil and nutrients and to the degradation of the land. Most of the younger farmers (<40 years of age) also work outside this area due to the difficulty in procuring an adequate income. The other selected region (S2) is located at the junction of the Chencang and Qishan County on the north shore of the Wei River. S2 has an area of 1560 ha and approximately 45,000 inhabitants. The farmland is flat, and the irrigation system is well developed. S2 has a convenient transportation system and good farming conditions. Mushrooms and vegetables are grown in small-scale greenhouses, and traditional crops such as wheat and maize are intensively cultivated. Both study sites are far from large urban areas and are thus not strictly supervised by authorities. The practices of agrochemical use are thus determined by the level of knowledge of the local farmers.

2.2. Survey

A questionnaire was designed to survey the farmers in the selected regions. The local pesticide store was the only direct source of pesticides for the farmers, so a related questionnaire was designed to survey the levels of knowledge of pesticides and the attitudes and practices of the retailers. The questionnaires focused on: 1) basic information about the interviewee, such as gender, age, educational level, and their farming practices (crop types and yields, agrochemical products used, expenditures, and income); 2) the practices of pesticide application and the pesticides commonly used; and 3) the level of awareness of the