Prevention of Deaths from Intentional Pesticide Poisoning

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Abstract. Ingestion of pesticides is the most common suicide method worldwide, accounting for one third of all suicides, predominantly in Asia, Africa, Central and South America. Case fatalities are high, particularly in rural areas. This high case fatality may explain the similar numbers of male and female suicides in Asia, since more women die from their attempts. In Asia, pesticide suicides are mostly impulsive acts with little advance planning and they are less often associated with mental illness than in Western countries. Pesticides are generally chosen for their easy access. Prevention strategies include treating the problems leading to suicidal behaviors involving pesticides; changing attitudes, knowledge, and beliefs about pesticides; controlling access to dangerous pesticides, including developing secure storage practices (which are currently being evaluated); and improving the medical treatment of poisonings. More research is needed to better understand suicides involving pesticides in their cultural contexts and to evaluate the effectiveness of intervention programs, including assessment of possible substitution of methods. Also, more knowledge about protective factors may help suggest innovative prevention strategies.

Keywords: pesticide, suicide, suicide attempts, prevention, poisoning

The ingestion of pesticides is the most common suicide method in the world with approximately one third of all suicide deaths being the result of self-poisoning with pesticides (World Health Organization, 2006). Pesticides include a variety of agricultural products, including those used to eliminate pests that eat crops (insecticides), kill harmful bacteria (fungicides), and destroy unwanted plants to help clear fields and protect crops (herbicides). The use of pesticides is an important part of agriculture and the availability of cheap and effective pesticides is greatly appreciated by farmers worldwide, in both wealthy and relatively poor agricultural communities. Pesticide poisoning is not frequently used as a suicide method in industrialized countries. However, in many agricultural regions of developing countries self-poisoning by pesticides is the most common suicide method (World Health Organization, 2006). This article summarizes what we know about pesticide suicides and presents an analysis of potential methods for prevention. We begin with a review of the extent of the problem.

Suicides Involving Pesticides Around the World

According to WHO reports, suicide accounted for 71% of violent deaths in China, Southeast Asia, and the Western Pacific Region (Krug, Dahlberg, Mercy, Zwi, & Lozano, 2002), with over 300,000 deaths occurring each year from ingestion of pesticides in China and Southeast Asia (World Health Organization, 2006). In Central and South America there are reports of pesticide suicides from several countries, although it is difficult to estimate the national incidence (London, Flisher, Wesseling, Mergler, & Kromhout, 2005, Murray, Wesseling, Keifer, Corriols, & Henao, 2002). Furthermore, pesticide poisoning is a common suicide method in many countries that do not report suicide data to the World Health Organization, including most of the African continent.

Asia and the Western Pacific

In rural China pesticides are used in over 60% of suicides (Phillips, Yang, Zhang, Wang, & Zhou, 2002) and 68% of suicides use pesticides in areas of rural India (Vijayakumar, 2006; Gupta, Peshin, Srivastava, Kaleekal, & Pandian, 2002). A community survey in the Cameron Highlands of Malaysia (Maniam, 2006) found that 94% of suicides were because of agricultural poisons in 1994. In several rural areas of Sri Lanka pesticides are used in 71% of suicides (Somasundaram & Rajadurai, 1995).

In Vietnam, 57.1% of rural suicide attempters use pesticides (Thanh, 2006; Thanh, Jiang, Van, Minh, Rosling, & Wasserman, 2005). However, the main method for suicide attempts in urban areas of Vietnam is ingestion of analgesics and antipyretics (55.6%). In Pakistan, organophosphate insecticides were responsible for 67% of all suicide fatalities, according to a review of 1,900 acute poisonings (Jamil,

1990). In Korea, pesticides and herbicides were used in 50.9% of all deaths by poisoning and constituted the majority of suicide poisoning deaths (Shin, Suh, Rhee, Sung, & Kim, 2004). However, the proportion of suicides involving pesticides in Korea is likely to be much higher since for 40.8% of deaths the toxic agent is listed as "unknown."

Vijayakumar (2006) indicated that in India, suicides by pesticides account for between 11% and 33% of all suicides, but up to 80% of suicides by farmers. For example, in 2004, the overall suicide rate was 20.6 per 100,000 population per year in the Maharashtra region, compared to the overall rate for India of 14. However the rate for farmers in Maharashtra was 53, and this rate had dramatically increased from a rate of 17 in 1995. In a prospective study in regions of South India (Prasad et al., 2006), poisoning with organophosphorus pesticides accounted for 40.5% of all suicides and these pesticides were found to be the only substance used in suicides by poisoning. A household survey in a coastal village in the Sundarban region of India found high deliberate self-harm rates of 728 per 100,000 for males and 356 per 100,000 for females, of which 42.9% of males and 66.7% of females used pesticides (Chowdhury et al., 2005)

In the Fiji Islands, 23.1% of suicide attempters seen in a Suva hospital used pesticides in their attempt (Aghanwa, 2000; 2001). Bowles (1995) documented that in 1976, when paraquat sales increased in Western Samoa, there was a dramatic increase in suicides involving paraquat and poisoning with this substance became the most common suicide method.

The Caribbean, Central and South America

In the Caribbean, as well as Central and South America, pesticide poisoning is reported to be a frequent means of suicide (Bertolote, Fleischmann, Eddleston, & Gunnell, 2006). In a southern rural area of Trinidad 80% of suicides involved pesticides (Hutchinson et al., 1999; Hutchinson, 2005). In Surinam 55% of suicides use pesticides (Graafsma, Kerkhof, Gibson, Badeloe, & van de Beek, 2005). A study conducted in Jamaica found that 41% of fatal poisoning was attributed to pesticides according to coroners' autopsies from 1980 to 1999, and 64% of the poisonings were determined to be suicides (Escoffery & Shirley, 2004). An investigation of only "serious" suicide attempts involving hospital treatment in Campinas, Brazil, found that 56.6% of patients with "marked intent" used pesticides (Csillag, 1996). In the area of Leon, Nicaragua, 19.1% of suicide attempters admitted to hospitals used pesticides (Caldera, Herrera, Renberg, & Kullgreen, 2004), and most were young females.

Predominantly Moslem Countries

Although suicide rates in predominantly Moslem countries are generally low, intentional poisoning with pesticides accounts for a substantial proportion of suicides according to reports from several countries. In a study of 1,751 hospitalizations in Tehran, Iran (Moghadamnia & Abdollahi, 2002), where most patients come from the city, pesticides were the second most common substances used in self-poisoning. There are reports from Jordan (Abdullat, Hadidi, Alhadidi, AL-Nsour, & Hadidi, 2006) of an increase over 20 years from 25 to 35 fatal pesticide poisonings per year, of which at least 64% are suicides. In Turkey, although the Ministry of Justice has only determined the manner of death in 24% of the 843 deaths that were caused by agrochemicals and pesticides, 75% of the classified deaths from 1997 to 2001 were determined to be suicides (Nesime et al., 2004). In a study of suicide attempts in an urban teaching hospital in Karachi, Pakistan, organophosphate insecticides were found to be the second most commonly used substances in self-poisonings and they accounted for the majority of the deaths by this method (Khan & Reza, 2000).

Africa

Most African nations do not provide national statistics to WHO and published reports are generally limited to studies of patients seen in specific hospitals. For example, a study of poisoning cases admitted to eight major referral hospitals in Zimbabwe found that pesticides were the most frequent substances used in deliberate poisonings and pesticides accounted for 60% of all poisoning deaths (Tagwireye, Ball, & Nhachi, 2002). A study in Uganda of 100 suicide attempters seen in three Kampala hospitals found that 45% of attempts used pesticides, with 57.1% of men and 27% of women using pesticides (Kinyanda, Hjelmeland, & Musisi, 2004). In Blantyre, Malawi, pesticides are used in 80% of suicides (Dzmalala, Milner, & Liomba, 2006).

London and Bailie (2001) tested an improved surveillance program for pesticide poisoning in South Africa, the country with the largest market for pesticides in sub-Saharan Africa. They found that after they intensified surveillance of pesticide poisonings in the Western Cape Province of South Africa, there was a 10-fold increase in poisoning rates, when compared to routine notification procedures. However, it is interesting to note that they found suicide poisonings to be the least underreported, with most underreporting falling into the categories of "negligence," "accident," or "ignorance." Still, suicides accounted for 36% of the pesticide poisoning events.

Other Areas

Although pesticide suicides are generally infrequent in Europe and North America, there are local agricultural areas where pesticides are often used in suicide attempts. For example, between 1998 and 2004, 64.3% of suicides in Epirus, a region of northwest Greece, used pesticides

(Vougiouklakis, Boumba, & Mitselou, 2006). A study of a university emergency department in Adana, Turkey found that pesticides were used in 16.5% of suicide poisonings (Seydaoglu, Satar, & Alparslan, 2005).

Case Fatality Rates Are High

Case fatalities from pesticide poisoning are much higher than case fatalities for overdose of the substances most commonly used in suicide poisonings in industrialized nations, such as analgesics, tranquilizers, and antidepressants. For example, in England, case fatality for overdose of medications and poisons is 0.5%. However, in Asia, case fatality from pesticide poisonings ranges from 10% to 20% (Konradsen, van der Hoek, & Peiris, 2006). Eddleston and Phillips (2004) compared death rates for self-poisoning in Britain and in Asia. The British case fatality rate in hospitals for self-poisoning is very low (0.3%). This compares to case fatality rates of 22% in a teaching hospital in Andhra Pradesh, India (Rao, Venkateswarlu, Surender, Eddleston, & Buckley, 2005), 20% for self-poisoning in China and Sri Lanka, and 41.1% in hospital admissions for pesticide poisoning in Malaysia from 1989 to 1994 (Keir & Whiting, 1997). National case fatality rates for intentional self-poisoning with pesticides in Brazil was 9.1% in 1997–2001, but in the rural area of Mato Grosso do Sul pesticide case fatality was 27.7% in data from 1992 to 2002 (Recena, Pires, & Caldas, 2006).

This higher case fatality from pesticides can be explained as being the result of several factors: First, many substances used in suicide attempts in the Western world have relatively low toxicity when ingested in small doses. However, many of the common pesticides used in suicide attempts in non-Western rural areas are highly toxic, even in low doses.

Second, differences in access to appropriate medical interventions account for a portion of the high mortality rates when pesticides are ingested by people in rural areas where access to a well-equipped hospital or even a doctor may take several days, if medical care is available and affordable. This contrasts with the treatment of poisonings in developed countries where emergency care in a hospital may be minutes away. Phillips (2006) reported that the case fatality rate for suicide attempters who used pesticides and rat poison and who received treatment in the community by a doctor was 61.5%, compared to a case fatality rate of 6.2% for attempters treated in emergency rooms. In Malaysia, Maniam (2006) reported that the case fatality rate for pesticide poisonings was only 1% in a university hospital, compared to 50% in a rural hospital.

Third, as Eddleston and Phillips (2004) point out, the high case-fatality rate from pesticide poisoning in some parts of Asia may be due to a lack of availability of essential antidotes, such as atropine for the management of organophosphate poisonings. They note that doctors in many small hospitals do not have the necessary equipment to treat patients for poisoning, such as having the ventilators that are needed to support heavily sedated patients.

Fourth, there is the issue of appropriate training in medical interventions for pesticide intoxication. Eddleston and Phillips (2004) feel that doctors in small hospitals may lack the skills to intubate. Rao and colleagues (2005), in a study of over 1,000 pesticide poisonings in a southern India teaching hospital, found that the high case-fatality may be explained in part by their findings that inappropriate antidotes were used in some patients and sometimes the doses of antidotes administered were too low.

Can High Case Fatalities Explain Gender and Age Differences?

In industrialized countries, men complete suicide three to five times more than women and suicide rates usually increase with age; it is usually the elderly who have the highest suicide rates. However, in developing countries, the ratio of men to women is much lower (World Health Organization, 2006). In India the official national data indicate similar numbers of male and female suicides; the official male to female ratio was 1.2 to 1 in 2002 (World Health Organization, 2006). A detailed investigation of all suicides in a region of Tamil Nadu in India found that the ratio of men to women was 3 to 2 (Prasad et al., 2006). Furthermore, there are higher suicide rates among young people in developing countries, with suicide peaks in people aged 15 to 24 (World Health Organization, 2006)

The higher death rates in Asia among young people and the greater proportion of women dying by suicide have been explained by the increased lethality of using pesticides as a common method in suicide attempts (Pearson, Phillips, Fengsheng, & Huiyu, 2002). Phillips (2006) has argued that in China, like other countries, suicide attempts by women are more common than men (2.9 to 1). However, because of the choice of pesticides as the most common method, a much larger proportion of attempters die because of the lethality of the method and the inability of the rural health-care system to resuscitate patients who are poisoned by pesticides. It has been argued that if young people and women, who make many more attempts than completed suicides in Western and Asian countries, use more lethal methods, as is the case in many areas of Asia, they will be more likely to die from their attempts. Thus, the use of pesticides in suicide attempts may result in the "excess" deaths among younger age groups and women in Asia. Or, one might consider that the lower lethality methods favored by younger people and women in the Western countries protect younger people and women from dying by suicide as often as the elderly and men.

The Context of Pesticide Suicides

Several studies conducted in Asia have found that pesticide suicides are mostly impulsive acts undertaken during stressful life events (often family quarrels) and they are committed mostly by persons who do not have a mental illness. A study of 326 people who were hospitalized for a suicide attempt, of which 83% had ingested pesticides, found that 35% reported that the first time they had considered suicide was 10 min or less before their attempt (Li et al., 2002). Another study in China, using psychological autopsy methods with a representative sample of suicides (Conner et al., 2005), found that the ingestion of pesticides was the most common method and 90% of ingestion suicides were carried out with pesticides. Low-planned suicides (suicides with little or no premeditation) were overwhelmingly committed by ingestion (86.4%) and a high proportion (38%) experienced a stressful life event in the 48 h before their suicide and 62% had high acute stress scores. Forty percent of the low planned suicides had no depressive symptoms and the low planned suicides (82.1%) usually ingested substances that were stored in the home.

A study of 147 women in rural areas of China under the age of 35 who were hospitalized for a serious suicide attempt, most (87.8%) with pesticides and dangerous organic fertilizers, found high levels of impulsivity and low levels of mental illness (Pearson et al., 2002). In their sample, 62.6% showed no signs of a psychiatric illness and 92% made the decision to harm themselves less than a day before the attempt. When asked how much time elapsed between the first time they had an idea of killing themselves and their attempt, 58.8% said they had considered harming themselves for 2 h or less before they acted, 40% for 10 min or less, and 11% acted within 1 min. Consistent with the impulsive nature of the attempt was the fact that they usually did not tend to isolate themselves after an attempt. In fact, 29% took the poison in front of someone else and 65% were found within 5 min of the attempt. Almost 60% of the attempters and family members who were interviewed gave the reason for the attempt as being a family conflict. When asked to identify life events preceding the attempt, the most frequent was an unhappy marriage (64.5%), financial problems (42.5%), being beaten by spouse (38.3%), changed routines (33.3%), conflict with mother-in-law (31.9%), and other family problems (27.0%).

In a study of 166 self-inflicted pesticide poisonings in the Uda Walawe area of southwestern Sri Lanka (van der Hoek & Konradsen, 2005; Konradsen, van der Hoek, & Peiris, 2006) 32% were under the influence of alcohol and alcohol misuse was mentioned as the reason for the suicide attempt in one third of all cases, usually the alcohol misuse of the father or husband of the victim. Unhappy love affairs; unwanted pregnancies; forced marriages; jealous husbands; physical, sexual, or psychological abuse by a husband or parent; or a combination of these events were reported to be the main reasons for suicide attempts. Other less frequent explanations included loss of a close family member, disease and disability, problems at school, financial hardships, and trivial arguments among sisters and brothers. The authors concluded that self-poisoning is often a means of communicating one's feelings or coping with stressful situations with unclear levels of an intention to die. Often the behavior was reported to be impulsive and 90% of the pesticides used were located close at hand. Similarly, a household survey of suicidal behavior in a coastal village in India found that family quarrels were given as the reason for the suicide in 71.4% of males and 50% of females, mostly quarrels with a spouse (Chowdhury et al., 2005). Prasad and colleagues (2006) found that suicide victims in South India were mostly under age 44 and women more often committed suicide following acute precipitating events. Those precipitating events were most often a single episode of a quarrel at home or falling in love but not being able to marry the person.

Studies in China and India suggest that the majority of persons who die from pesticide poisonings do not have a mental illness (Gururaj & Isaacs, 2001; Phillips et al., 2002). In Pakistan, the most common psychiatric diagnosis of suicide attempters seen in a Karachi hospital was "acute situational/stress reaction," and the most common reason for the suicide attempt was conflict with a spouse or in-laws, followed by conflict with family, and conflict with girl/boyfriend. Reported suicides in Pakistan are generally explained as being the result of "domestic problems" and mental disorders are infrequently reported (Kahn & Reza, 2000).

A study of 101 persons admitted to a hospital for self-harm in Kampala, Uganda, where pesticides were the most frequent method, found that the most common diagnosis was an adjustment disorder secondary to a stressor (Kinyanda et al., 2004). They identified a disturbed interpersonal relationship as being the precipitant of the self-harm in 65% of cases, usually with a partner or a parent.

The above findings contrast with research in Western countries where the proportion of persons who die by suicide who have a mental illness is often reported to be near 90% and the most common diagnosis is a depressive disorder. This suggests that pesticide ingestion is more frequently an impulsive act committed during an acute crisis where easy access to potentially lethal pesticides results in higher rates of death by suicide.

An alternative and intellectually tantalizing hypothesis was proposed by London et al. (2005), who postulated that exposure to organophosphate insecticides may be a causal factor in suicides. Their review of animal studies of the effect of exposure of organophosphates on serotonin levels, studies of human long-term and toxic exposure, and epidemiological data suggesting that people who work with these chemicals may have higher suicide rates, led them to suggest that organophosphate exposure can be a causal factor in suicidal behavior by increasing depression and impulsivity. The empirical data they cite focuses upon the possible link between exposure to organophosphates and depressive symptoms. However, this hypothesis goes against the data from China

(Phillips et al., 2002), which indicates that people who commit suicide with pesticides are less likely to suffer from depression and other mental health problems than people who commit suicide by other means and, overall, mental disorders are less common among suicide victims than in Western countries where pesticide poisonings rarely occur. Research to test the hypothesis by London and colleagues would have to compare suicide rates during periods of exposure to pesticides with rates when exposure is minimal and also compare rates among farmers who were and were not exposed to pesticides, while controlling for confounding factors such as stressful life events and the ready availability of pesticides in the home.

Strategies to Reduce Suicides Using Pesticides

The World Health Organization has announced a global public health initiative with the overall goal of reducing the morbidity and mortality related to pesticide poisoning (Bertolote et al., 2006). This initiative has the objectives of reviewing and recommending pesticide regulatory policy, implementing surveillance and monitoring of pesticide poisoning, improving the medical management and mental healthcare of people with pesticide poisoning, providing training in the safe handling of pesticides, and developing community programs that minimize the risk of pesticide poisoning. In 2006, the World Health Organization signed a collaboration agreement with the International Association for Suicide Prevention, which focused on the development and promotion of best practices in community action for safer access to pesticides, with the overall goal being the reduction of both the mortality and morbidity related to pesticide poisoning. This collaboration began with a meeting of experts held in Geneva on May 2006, which resulted in the publication of a document (World Health Organization & International Association for Suicide Prevention, 2006) that includes the following recommendations:

1. Review the list of authorized agricultural products in their country and eliminate those that do not meet the Basel, Rotterdam, and Stockholm Conventions;
2. Explore suicidal behavior in the national mortality and injury profile and the specific role of pesticides;
3. Where pesticide poisoning represents a public health problem, interested parties (governments, regions, communities, NGOs, etc.) should initiate a series of specific steps to assess the feasibility and effectiveness of the proposed community interventions and to adapt them to local conditions, implement them and evaluate the outcomes and their sustainability.

In the following sections we review potential community interventions and national policies that may be proposed to prevent suicides involving pesticides.

Treatment and Prevention of the Root Problems Leading to Suicidal Behaviors Involving Pesticides

Since a large proportion of suicides involving pesticides in rural areas are associated with family conflicts and economic troubles, prevention activities that address these problems should be effective in reducing the number of suicides. These problems may be addressed by increasing the level of social support in the community and micro-financing initiatives to help with financial difficulties (Pearson et al., 2002). In areas where alcohol use is involved in pesticide suicides, measures to reduce alcohol consumption should reduce suicides (Eddleston et al., 2006). However, there is no evidence to date of the effectiveness of efforts to decrease alcohol consumption in the countries where intentional pesticide poisoning is a problem. Also, the political will to initiate intensive programs to decrease drinking is often lacking.

The identification of conflicts with family members as the most frequent trigger events for suicide attempts poses an important challenge for suicide prevention efforts and may help explain the contextual risks of suicides involving pesticides during crisis situations. When suicidal behavior is initiated as the result of family conflicts, the family members who are supposed to provide social support during difficult situations are themselves the source of the problem. The risk associated with a family conflict is increased by the lack of availability of these family members to provide help and support when the conflicts occur. Within a suicide prevention framework, one may either work with families to decrease potential problems that are associated with pesticide suicides or one may try to develop alternative sources of social support. Primary prevention of suicide may involve developing alternative culturally acceptable sources of social support within communities, such as using respected elders in the community to provide support or developing volunteer-based suicide prevention resources, such as telephone helplines, friendly visits, and making counseling more available to persons in distress.

Changing Attitudes, Knowledge, and Beliefs About Pesticides

We know very little about the beliefs, knowledge, and attitudes of people who attempt suicide with pesticides. However, there are a great number of case reports of people who say that they did not know that ingestion of a small quantity of pesticides can be very dangerous or that prompt medical treatment may not always be effective in preventing a lethal outcome. For example, Maniam (2006) told of a young man who "pretended" to commit suicide in front of his family, saying "look, I am committing suicide," then

taking a mouthful of pesticide and spitting it out. Unfortunately the small quantity of concentrated pesticide ingested during this mock attempt was enough to result in his death. It has been suggest that in Sri Lanka many people believe that pesticides do not cause pain when ingested and there is a need for public education campaigns to warn of the effects of pesticide poisoning (Bolz, 2002; Desapriya, Joshi, Han, & Rajabali, 2006). However, Eddleston and colleagues (2006) contend that there is little point in making people aware of the dangers of pesticides, since they feel that rural people know that pesticides are "generally dangerous" (p. 336). They feel that the focus of education should be on appropriate first aid, destigmitization of self-harm, and appropriate use of health care after an attempt. We conclude that it is important to verify the nature of existing knowledge and beliefs before initiating educational activities.

In addition to underestimating the lethality of pesticides, many people may not realize that it is important to store pesticides securely in order to prevent accidental and intentional poisonings. Because of the possibility of inaccurate knowledge about pesticide safety, and attitudes and beliefs concerning the storage of pesticides and their potential as a "good" method for suicide, educational programs concerning the dangers of pesticides, the need for safe storage, and alternative sources of help in times of difficulties could potentially reduce suicides involving pesticides, if it is demonstrated that the current state of knowledge is deficient.

Several educational activities have focused on calling attention to the dangers of pesticide ingestion and informing farmers about safe storage and use of pesticides. Marin (2006) described a workshop training program in the Matagalpa and Jinotega regions of Nicaragua in which 2,124 workshops on the proper use and storage of pesticides were conducted for 28,939 agricultural workers between 2002 and 2005. During this period, there was a 65% decrease in acute pesticide intoxications in those regions, of which most intoxications were from suicide attempts. During this period there was also a significant increase in the proportion of households in the regions who kept pesticides in a locked storage compartment, from less than 50% in 2002 to over 95% in 2005. These educational activities were accompanied by the development of a suicide prevention program and telephone hot line in Jinotega City and the development of a Help Commission by the Mayor, police, Church, and psychology school to provide assistance to suicidal individuals. However, without comparison data on suicide rates from other agricultural regions without those educational activities, one must interpret their findings with caution.

Pearson et al. (2002) suggest that in China public education programs about suicide are an important component of pesticide-suicide prevention programs. They suggest that public education should focus on convincing the public that suicide is an important public health problem and that suicide can be prevented. Educational activities should aim at changing the prevailing attitudes, which are deeply rooted in Chinese traditions that suicide is an "acceptable" method for rural women to deal with social stresses.

The possible disadvantage of educational strategies that describe the dangers of pesticides is that this may call attention to and inform potential victims about what constitutes a lethal dose of pesticides and may inform people that pesticides could be used to effectively kill oneself (Gunnell & Eddleston, 2003). Although this is a theoretical possibility, to date, there is no empirical evidence that this is the case.

Any educational programs must consider the current state of knowledge, attitudes, and beliefs in the target population and take into consideration traditional practices in the community as well as agricultural practices, such as current pesticide storage practices.

Related to education campaigns is the possibility that changes in the labeling of pesticides may have an impact upon practices. At the present time, there is no empirical data to indicate that changes in labeling would or would not be helpful. However, it might be worth evaluating if changes in labeling, particularly providing more information about the dangers or need for safe keeping, will have a preventive effect. For example, one could examine whether adding to the label "drinking this product can cause a slow and painful death" would prevent intentional pesticide poisonings, or merely be ignored or increase the risk of suicides using pesticides. Empirical investigations are needed to help clarify the usefulness of changes in labeling.

Control of Access to Dangerous Pesticides

The conclusion of many researchers who have studied pesticide poisoning in the developing world is that the easy access to highly lethal substances increases the risk of self-poisoning, particularly in acute crisis situations (Gunnell & Eddleston, 2003; Konradsen et al., 2003). However, it is not evident which methods to control access are the most effective, feasible, and cost effective. Suggestions include:

Stop or reduce pesticide use in agricultural practice. This can be criticized since it may reduce agricultural yield and may be more labor intensive, thus, industry and individual farmers' profits could be reduced. Furthermore, it may simply be impractical to implement. Nesime and colleagues (2004) reported that from 1997 to 2001 there was no decline in deaths from pesticide poisoning in Turkey despite government measures to reduce pesticide use by offering alternatives to control pests and insects.

Reduce the availability of the pesticides most lethal in humans after ingestion. Konradsen and colleagues (2003) ar-

gue that reducing the availability of the most dangerous pesticides is imperative and they present potential avenues to potentially reduce the availability of pesticides: (1) voluntary guidelines, safe use initiatives, and international policy instruments; (2) changes in farming practice using integrated pest management and plant biotechnology; (3) direct restrictions of pesticide use and the development of a Minimum Pesticide List (Eddleston et al., 2002) of pesticides that should satisfy most farmers' needs most of the time. Eddleston, Buckley, Gunnell, Dawson, and Konradsen (2006) report that, following an epidemic of self-poisoning with paraquat in Samoa, the government restricted the availability of this pesticide and suicide rates declined afterward. Bowles (1995) presented data on suicide deaths in Western Samoa from 1956 to 1988 that show a relationship between annual paraquat sales and the number of deaths by suicide involving paraquat.

Although it is not possible to conclude that any reduction in suicides that occurred at the same time as government restrictions on pesticides was not related to other factors that could have influenced suicide rates, government regulations may appear to be a simple solution. However, regulations must be enforced, and many poorer countries do not have the necessary resources for successful enforcement. Also, there is always the possibility of substitution of methods. A study of pesticide poisoning deaths in Jordan (Abdullat et al., 2006) found that since legislation was passed restricting the import and manufacturing of the most potent organophosphate that accounted for 94.4% of fatal poisonings, self-poisoning rates and suicides using pesticides have increased. A different class of pesticides, carbamates, now accounts for 78.6% of poisoning mortality, most of which are suicides. Gunnell and Eddleston (2003) suggest that a disadvantage to government bans may be that, in some instances, replacement pesticides may be less effective agriculturally. Also, when governments are unable to enforce bans, black market sales of banned pesticides may appear. The simple act of banning pesticides by government regulation may be ineffective in many areas of the world since the ban may not be practically enforceable.

Subsidize or reduce the cost of pesticides that are less toxic to humans or modify existing pesticides to make them less toxic or less likely to be used for self-poisoning. Several pesticide manufacturers have developed products in which the formulation has been changed to reduce their toxicity. For example, they may add emetic agents (to induce vomiting) or antidotes, reduce the concentration available, add agents that reduce the product's absorption once ingested or to give the pesticide an extremely unpleasant odor or taste. There is certainly the potential to increase the safety of many pesticides by modifications to their formulation. In addition, provision of more dilute preparations of pesticides may reduce injuries (Eddleston et al., 2006), either by having more dilute preparations sold by manufacturers or by having dealers dilute pesticides when they are sold to farmers.

Restrict the purchase of pesticides by people who are intoxicated. In Sri Lanka over half of the men who engage in suicidal behavior with pesticides are intoxicated. In some instances they purchase pesticides to use in a suicide while in an intoxicated state. It has been suggested that a potential means of suicide prevention would be to inform pesticide dealers to refrain from selling pesticides to persons who appear to be intoxicated (Konradsen et al., 2006). Although restricting sales to people who are intoxicated may save some lives, the authors feel that the long term solution to preventing suicidal behavior may rest in providing support for families with domestic violence and male alcohol misuse.

Secure storage. Since a large proportion of suicides involving pesticides are impulsive acts with little premeditation, it has been hypothesized that if pesticides were stored under lock and key and were not readily available in the home, fewer pesticide poisonings would occur. Most of the secure storage practices that have been tested to date involve providing locked storage boxes to farmers for the storage of their pesticides (e.g., Konradsen, Dawson, Eddleston, & Gunnell, 2007). An alternative that is less convenient for farmers would be to store all pesticides in a central, secure, village location where farmers would go to obtain pesticides when needed. Research is currently being conducted on the effectiveness of providing lock boxes to farmers and the variables that may influence the effectiveness of such programs.

One of the issues in providing locked storage boxes is the extent to which this results in a shift from the practice of storing pesticides in the fields to storage in the home where pesticides may be more readily available for impulsive self-poisoning. This issue was raised in a study in Sri Lanka conducted by Konradsen, Peiris, Weerasinghe, van der Hoek, and Eddleston (2007) in which they found that providing boxes with a lock resulted in an increase in keeping pesticides under lock from 2% to 82%. However, before providing the boxes, 46% of the farmers stored pesticides in the fields, and this was reduced to 2% when the boxes were provided. Although the authors speculate that there may be more suicide risk when pesticides are stored in the home, even though they are in locked boxes, it is not evident that this is the case. In their study there were two cases of self-poisoning in the village where farmers were given the boxes. In one case a young woman forced open the locked box. In the other case a drunken elderly man was unable to open the box and bought pesticides from a shop. There were two cases in the control village where no boxes were provided. However, this study raises the issue of how strongly the boxes are constructed and who has access to the keys. In pilot tests in another area of Sri Lanka (Ratnayeke, 2006), the boxes were constructed more solidly and attached to an outside wall of the

house, and some boxes have two locks, with the husband and wife each having the key to just one lock. To date those researchers have not reported anyone breaking into the boxes. However, this is an important issue that needs further investigation.

Ratnayeke (2006) reported on a pilot study conducted by the psychosocial help charitable organization Sumithrayo in Sri Lanka in which 50 families in two study villages in the North Western Province and 50 families in two villages in the Southern Province were provided with solid metal locked boxes secured to an outside wall for the storage of pesticides. In each region these "study" villages were compared to similar villages where no lock boxes were provided. The boxes had the following messages printed on them: "Poison is not the answer for anger, pain of mind, or despair. Talk to a trusted friend about your feelings of anger or sadness. Remember to keep all remnants of agrochemicals and poisons out or reach, safely locked in this box."

In the 2 years after the lock boxes were provided, there was one death by suicide in the North Western Region study villages, compared to three deaths in the control villages. In the Southern Province there were no deaths by suicide in the study villages after the lock boxes were provided, compared to six deaths in the control villages. Although these results may seem encouraging, a much larger, longer term, and better controlled study is needed to determine the effectiveness of providing lock boxes in preventing suicides. A larger study with minimum intervention, involving the collaboration of Sumithrayo and the Centre for Suicide Research at Oxford University, has recently been completed and results are expected to be disseminated in the near future.

The use of lock boxes may depend upon the quality of the boxes themselves as well as the educational activities that are provided and the ability to coordinate distribution of the boxes. A program by Croplife at Polonnaruwa, Sri Lanka, which provided wooden boxes with no means of attaching the boxes, and with no padlocks provided, had mixed success. In villages where an individual actively followed up with all farmers who received boxes, the boxes were kept locked. However, when boxes were provided without a strong educational component and follow-up, boxes were less often used or kept unlocked (Pieris & Weerasinghe, 2005).

Improving medical treatment of pesticide poisonings. Pearson and colleagues (2002) observe that in China many suicide attempts using pesticides result in death because of inadequate emergency treatment. They feel that the primary focus should be on village doctors. In many countries a large number of deaths can be prevented by providing local first-aid kits, better training of physicians, faster transportation to hospitals, and ensuring that adequate supplies of antidotes and essential hospital equipment are readily available (Srinivas-Roa, Venkateswarlu, Eddleston, & Buckley, 2005).

Conclusions

The use of pesticides as a suicide method differs from other methods that are the result of a premeditated planning in which the means is intentionally sought out for its perceived lethality. Pesticide suicides are most often impulsive acts with little or no advance planning. We do not know what proportion of pesticide suicide victims were aware at the time of the attempt that they had a high risk of dying. This contrasts with methods such as firearms, hanging, jumping from a high place, and placing oneself in front of a metro (subway) train, where the victims almost invariably believe at the time of their attempt that they will die from their actions. Unlike many other methods, pesticides do not appear to be chosen for their lethality, but are generally chosen for their convenience; they are easily available in the home.

Some other methods are both lethal and convenient, such as firearms kept in the home. However, whereas people who shoot themselves know that they will most probably die, this knowledge is not always present in pesticide suicide attempters. Pesticide suicides are probably more akin to poisoning with medications found in the home, a common suicide attempt method in Western countries with low case-fatality rates. People often ingest pesticides during an acute crisis, often a quarrel with a family member, similar to many situations where people (mostly women) in Western countries attempt suicide with medications they find at home. The crucial difference is that pesticides are generally much more dangerous than medications found in the home and death is a much more frequent outcome. The high case-fatality rate with pesticides exists despite the fact that pesticide suicide attempters often ingest the pesticide in the presence of others, where the potential for rescue may appear to be high.

The greater lethality of pesticides has been invoked to explain the almost equal proportions of men and women who die by suicide in Asia, compared to the preponderance of men in Western countries. More Asian women die from their attempts because they more often use pesticides, a more lethal method than the attempt methods chosen by women in Western countries. This portrait of suicides involving pesticides implies that the restriction of access to this dangerous means of impulsive suicides should be able to prevent a substantial proportion of intentional deaths from pesticide poisoning. Methods to reduce access to dangerous pesticides include: reducing the danger of the pesticide products themselves by restrictions on the sale of more dangerous pesticides, modifications of the formulation of pesticides to render them less dangerous or less easy to ingest, changing agricultural practices to use less pesticides, restricting sales of pesticides to persons who are intoxicated, and encouraging secure storage of pesticides. Also, many lives can be saved by providing better medical treatment of pesticide poisoning by educating physicians, increasing the availability of antidotes and necessary medical apparatus, and improving transportation to hospitals.

One method to reduce access to pesticides that is the subject of much attention, some controversy, and is the focus of several current research projects is to provide locked storage boxes to farmers. Despite some promising findings from pilot programs (Ratnayeke, 2006), these programs have been the subject of severe criticism. Konradsen and colleagues (Konradsen, Dawson et al., 2007) have argued that providing lock boxes may not decrease suicide risk since they may result in a greater number of households storing pesticides in the home rather than farther away in the fields and there is little proof that people with boxes always keep the boxes locked or that the boxes cannot be broken into. They also express scepticism about safe-storage initiatives that are supported by the pesticide industry since "industry-led initiatives will probably be affected by corporate priorities for shareholders and profits . . ." (p. 169). These concerns about possible increased danger as a result of moving pesticides from unlocked storage in the fields to lock boxes in the homes warrant careful consideration. To date there are no indications that the risk of pesticide suicides is increased by providing locked storage boxes and there are preliminary indications that in some instances lives may be saved (Ratnayeke, 2006). However, their concern underlines the importance of determining where pesticides were traditionally stored before attempting to change storage practices and the need to carefully evaluate the effects of any interventions aimed at reducing pesticide poisonings. Also, one must consider the design and security of boxes that are provided, whether the boxes are locked with one or two separate locks, and who possesses the keys. Furthermore, it may be that the way in which locked storage boxes are provided, by whom and in what social context within the cultural traditions of village life, may be important determinants of the effectiveness of safe storage programs. Konradsen and colleague's second concern is that the pesticide industry involvement implies that profits will take priority over human lives, presents a negative stereotype of the industry that needs to be evaluated in the light of the empirical evidence.

It is also possible to prevent pesticide deaths by educating people about the risks and attempting to change attitudes toward the use of pesticides in suicide attempts. There are some indications that education may influence safe storage practices and may even save lives (Marin, 2006). However, we need to conduct better evaluation studies to determine the effectiveness of education programs and to understand the importance of educational activities as complements to safe storage programs.

As several researchers clearly point out (Bertolote et al., 2006; Eddleston et al., 2006) more research is required to determine the effectiveness and practicality of different strategies for the prevention of suicides by pesticide poisoning. Most suggestions have concerned restricting or eliminating the availability of dangerous pesticides or improving the medical treatment of pesticide poisonings, but few published studies have focused upon reducing the distress that leads people to commit suicide using pesticides. The emphasis on restriction of means is based upon the untested hypothesis that it is easier or more cost efficient to control access to pesticides than to decrease the incidence of the stressful life events that are associated with the majority of suicides involving pesticides, or to help people better cope with stressful life events so that they will not try to end their distress by attempting suicide by ingesting pesticides.

The cultural context must be taken into consideration when developing any suicide prevention programs. Khan (2002) points out that in India and Pakistan attempted suicide is illegal and punishable by a jail term. Within this cultural context there is also a social stigma of suicide for the family and cultural traditions of managing problems within the family. Therefore, it is often difficult to provide help in the form of services that are identified as involving "suicide prevention." For this reason, it may be better to provide general help focusing on risk factors, such as prevention of the marital and family conflicts that are associated with suicide attempts involving pesticides.

A research agenda for preventing suicides involving pesticides should involve the identification of a number of both risk and protective factors. We need to know more about attitudes, knowledge, and beliefs concerning pesticides and their use in suicide attempts within different cultural contexts. Before programs to control access to pesticides are tested, we need to better understand existing storage practices, informal networks for obtaining knowledge about pesticides, and the extent of knowledge about the lethality of pesticide poisoning. Furthermore, it is important to understand attitudes and beliefs concerning alternative means of suicide in order to assess the potential of substitution of means when pesticide suicide prevention programs are initiated. The most unexplored questions warranting further investigations concern the role of protective factors in preventing suicides involving pesticides. Explorations of protective factors would involve studying not only suicide attempters and completers but also investigating people who experience similar stressful situations and problems, have pesticides readily available, but who do not attempt suicide.

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