Challenges for improving surveillance for pesticide poisoning: policy implications for developing countries

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Background  Surveillance is a critical public health tool for the control of pesticide poisoning. However, surveillance activities in developing countries are bedevilled by multiple problems, and inferences made from review of flawed data may lead to mistaken policy decisions.

Methods  Results of intensified surveillance from an intervention project in the Western Cape Province of South Africa were compared to the pattern of poisonings reported in routine notifications to the health authorities for a control farming district and in the study district over a 5-year period preceding the study. Intensified surveillance data results were also contrasted with policy approaches based on routine notifications and on Regional Poison Centre reports.

Results  Poisoning rates reported in the study area increased almost 10-fold during the intervention period. Compared to intensified surveillance, hospital and health authority sources greatly underestimate the proportion of cases due to occupational poisoning, and overestimate suicide as a proportional cause. In addition, the risks for women appear underestimated from routine notifications. Assumptions that a lack of awareness is responsible for most poisonings are not borne out by the empirical data when reporting is intensified.

Conclusions  Current policy assumptions are faulty, may result in inappropriate blame being attributed to victims and, by relying on information as the main element of education, may shift responsibility onto the individual. Improvements in the surveillance system should aim to restructure the types of data collected, and facilitate intra-governmental and inter-sector collaboration. The culture of monitoring based on report writing must change to one of surveillance that leads to intervention.

Keywords  Pesticide poisoning, surveillance, policy, gender, suicide, occupational poisoning, public health intervention

Pesticide poisoning is a major public health problem in developing countries\textsuperscript{1–5}, particularly in settings of low education and poor regulatory frameworks.\textsuperscript{6,7} Pesticides usage in South Africa, both agricultural and non-agricultural, has increased substantially in the past decade\textsuperscript{8,9} and this country is the largest market for pesticides in sub-Saharan Africa.\textsuperscript{7}

Expansion of the small-scale farming sector is a key government strategy for future economic growth in the country.\textsuperscript{10–12}

However, this strategy does not address the need for measures to prevent hazardous exposures in the most vulnerable of farming sectors.\textsuperscript{9}

In this context, key to the control of pesticide-related morbidity and mortality is the need for accurate, timely and effective surveillance systems.\textsuperscript{13,14} Above all, for a surveillance system to be effective, it has to demonstrate usefulness of the data generated—appropriate action needs to follow reporting of the data.

This paper examines the monitoring and surveillance system in South Africa from three perspectives: (1) policy inferences in government publications and other documents; (2) review of previous research findings related to completeness of reporting; and (3) implications of the findings of an active surveillance project for current policy.

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**Surveillance for pesticide poisoning in South Africa**

In South Africa, surveillance for pesticide poisoning occurs across a number of different information systems (Figure 1) involving at least three different government departments. The major sources of surveillance data lie in the health sector, relying on statutory notification by medical practitioners in terms of the Health Act. Follow-up investigation and remediation is the responsibility of environmental health officers employed at the local authority level. Other potentially important sources of data reside with the Department of Labour (work-related morbidity and mortality), and the Department of Home Affairs (cause of death data derived from death certificates). The typical pattern that emerges from such routine surveillance is that approximately 100–200 cases of human pesticide poisoning are reported nationally, of which about 10–20 are fatal. Government control activities are integrated at national level in an inter-departmental committee responsible for pesticide safety. In theory, this structure co-ordinates surveillance for the human health impacts of pesticides although most weight is attached to Department of Health surveillance data.

**Examination of policy inferences of government and other publications**

Two government publications and four reports from Poison Centres were identified for the period 1980–1998. Consistently inferences identify the causes of pesticide poisoning as related to ignorance, carelessness or negligence. For example, in reviewing notifications reported to the national office, the Department of Health in 1992 stated that: ‘Local studies, based on these records, show that ignorance is the main cause of pesticide poisoning in South Africa. This is followed by suicide, accidents and lastly negligence. It is clear that very few people are aware of the toxicity of pesticides.’ (Authors’ emphasis italicized.)

An assessment from a major Poison Centre framed the critical causal pathway for pesticide poisoning as follows: ‘These agents (pesticides) are freely available in shops and convenience stores, and there exist no special measures to inform the buyer of the dangers of the pesticide they will use. This can give rise to careless and negligent use of these agents. ... An education programme is urgently needed.’ (Authors’ emphasis italicized.)

This conclusion implies that the source of the problem rests with the end-user, for which the solution lies in individualized strategies aimed at behaviour change. For example, in reflecting on notifications of pesticide poisoning since inception of the system, the Department of Health concluded that ‘the urgent need for very specific training and education is reflected in the “ignorance factor” taking on such a dominant role’.

Routine surveillance also generates a picture that most cases of poisoning are predominantly male (67%) and that over 50% of all cases are suicide attempts. Occupational causes are therefore seen as relatively less important in the scale of causation: ‘Contrary to popular belief, acute organophosphate poisoning as a result of exposure of farm labourers during the spraying season is relatively uncommon. In fact, surprisingly few serious acute pesticide poisonings occur as a result of exposure during farming activities. Those reported from farming areas usually fall within the household category, e.g. in cases where the pesticide has been brought into the house in an unmarked container.’

Key policy inferences regarding pesticide poisoning of current surveillance procedures and information are summarized in Table 1.

**Examination of the surveillance system**

Review of existing research into reporting of pesticide poisoning in South Africa reveals serious flaws in the surveillance system.
Firstly, there is inadequate capture and inadequate sharing of data between databases. A review of deaths registered at mortuaries in rural towns in the Western Cape province from January 1990 to July 1992 found that 10% of work-related deaths were due to pesticides, of which none had been reported to the Department of Labour or to the Department of Health.23

All these deaths had been registered with the Department of Home Affairs. The study highlighted the lack of co-ordination of different information systems.

Secondly, under-notification of pesticide poisoning is repeatedly identified in the literature.16,22,24,25 Estimates of the percentage of hospitalized cases notified range from 10%24 to 20%,22 and the percentage of fatal cases at mortuaries notified is estimated at around 5%.16,25

The third problem, generic to health information systems throughout South Africa, relates to data quality. Too many data are collected, with little reference to relevance or to any prioritization of what is important data to collect.26,27 For example, the toxicological investigation form used by local environmental health officers contains the categories of ‘suicide’, ‘accident’, ‘carelessness’ and ‘other’ to categorize cause of the poisoning, and has over 50 variables for completion, few of which are ever used in reviewing public health action. This results in a situation where the data on which public health policy on pesticides is used in reviewing public health action. This results in a situation where the data on which public health policy on pesticides is based may be potentially flawed, raising questions around how true are the inferences contained in Table 1 for South Africa.

### The impact and findings of intensified surveillance

A community-based project to determine the impact of a public health intervention on poisoning notification in a rural district of South Africa suggests several deficiencies of current routine surveillance. The intervention included the provision of free cholinesterase testing to local GPs, and provision of information, training and educational materials to all local health care providers. The intervention28 and its impact on GP behaviour29 are described in more detail elsewhere. The annual mean rate of notification of cases per 100,000 population in the study area for the 5-year period 1987–1991 was 4.2 while the rate for the study year was almost 10-fold greater at 40.5 per 100,000. By comparison, the rate in all surrounding areas together was more or less unchanged (3.1 per 100,000 per year in the period 1987–1991, and 3.9 per 100,000 in the study year). The increase in the study area before and after the intervention and the difference between study area and control were both statistically significant.

The categories ‘negligence’, ‘accident’ or ‘ignorance’ were cited by environmental health officers as the main cause of poisoning in 42% of cases. Table 2 summarizes the circumstances of the poisoning cases detected in the intervention area. Poisonings directly related to occupation involved 86% of the cases and 43% of the poisoning events, whereas suicide involved 9% of the cases and 36% of the poisoning events. Two events were mass poisonings, affecting 20 and 24 people, respectively, and these occupational poisonings were also more likely to affect women.

All other poisoning events but one involved one person only, predominantly on farms. Cases 10 and 11 occurred on the same farm, separated by a period of 6 weeks. The farm store was the most common source of the poison (77% of cases). The age of victims ranged from 13 to 59 years (median 29 years). Table 3 compares patterns in the circumstances of poisoning in the intervention findings to data from routine reporting.16,22 Large discrepancies in the gender profile and in the circumstances of poisoning are evident.

### Table 1 Key policy inferences from current surveillance procedures and information concerning pesticide poisoning in South Africa

<table>
<thead>
<tr>
<th>Main cause</th>
<th>Occupational exposures insignificant; suicide is what public health authorities should be concerned with</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Pesticide poisoning is a greater problem amongst men</td>
</tr>
<tr>
<td>Solution</td>
<td>Education of the ‘ignorant’; Measures to change ‘careless’ behaviours</td>
</tr>
</tbody>
</table>

### Table 2 Profile of circumstances of cases of pesticide poisoning detected

<table>
<thead>
<tr>
<th>Event</th>
<th>Demographics</th>
<th>Farm status</th>
<th>Circumstance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24-year-old man</td>
<td>Rural town resident</td>
<td>Attempted suicide with gamma-BHC purchased from commercial source</td>
</tr>
<tr>
<td>2</td>
<td>Adult, male, age unspecified</td>
<td>Rural town resident</td>
<td>Accidentally ingested chlorpyrifos under influence of alcohol</td>
</tr>
<tr>
<td>3</td>
<td>36-year-old woman</td>
<td>Rural town resident</td>
<td>Attempted suicide following domestic argument</td>
</tr>
<tr>
<td>4</td>
<td>39-year-old man</td>
<td>Farm manager</td>
<td>Accidentally ingested aldicarb at bedside, mistaking it for medication</td>
</tr>
<tr>
<td>5</td>
<td>Unemployed 45-year-old man</td>
<td>Rural town resident</td>
<td>Attempted suicide with an organophosphate</td>
</tr>
<tr>
<td>6</td>
<td>29-year-old women</td>
<td>Farm worker</td>
<td>Attempted suicide with agrochemical normally only used for pest control</td>
</tr>
<tr>
<td>7</td>
<td>22-year-old man</td>
<td>Farm worker</td>
<td>Poisoned with mevinphos while applying pesticide using backpack</td>
</tr>
<tr>
<td>8</td>
<td>Two adult men, age unspecified</td>
<td>Farm workers</td>
<td>Poisoned with mevinphos while applying pesticide in a vineyard</td>
</tr>
<tr>
<td>9</td>
<td>17-year-old woman</td>
<td>Rural town resident</td>
<td>Attempted suicide with ant poison following exam failure at school</td>
</tr>
<tr>
<td>10</td>
<td>Adult man, age unspecified</td>
<td>Farm worker</td>
<td>Poisoned while applying pesticide from behind the tractor</td>
</tr>
<tr>
<td>11</td>
<td>19 women and one man</td>
<td>Farm workers</td>
<td>Poisoned by organophosphate drift from adjacent orchard while weeding in adjacent field</td>
</tr>
<tr>
<td>12</td>
<td>Adult man, age unspecified</td>
<td>Farm worker</td>
<td>Pesticide was decanted by co-worker in the field and the subject accidentally ingested the pesticide</td>
</tr>
<tr>
<td>13</td>
<td>13-year-old girl</td>
<td>Farm resident</td>
<td>The girl’s father brought home pesticide from the farm for domestic use, which the girl accidentally ingested</td>
</tr>
<tr>
<td>14</td>
<td>12 women and 12 men</td>
<td>Farm workers</td>
<td>Poisoned by consuming alcohol contaminated with aldicarb</td>
</tr>
</tbody>
</table>
In one case, 20 workers (but one of whom was female) were poisoned when spray from a tractor-driven unit drifted over workers in an adjacent field. Unlike countries in the developed world, South African legislation makes no provision for posting to keep workers out of sprayed areas. In another case that affected 24 people, workers had unintentionally ingested alcohol from a container contaminated with the nematicide aldicarb as part of the ‘dop’ system, a practice whereby workers are paid in kind or a supplement with wine. While the ongoing application of the ‘dop’ system is in itself a public health challenge, this case also illustrates how diverse and sometimes bizarre are the routes of pesticide exposure experienced by farm workers, which are not adequately addressed by current policy.

Many of the poisonings in this study occurred under circumstances of ‘normal use’ (cases 7,8,10–12) or under circumstances over which subjects had effectively no control (case 14). In other cases, lack of awareness played a role only as the final part of a sequence of social factors. For example, family members of farm workers poisoned by pesticides taken home for domestic use (as in case 12) are subject to an environment of easy availability of chemicals, experience poor household sanitary conditions leading to domestic pests, and lack easy movement off their farms to acquire safer means of pest control.

Completeness of reporting was assessed from other databases in the Departments of Health and Labour. Review of the database of the regional Department of Health found one case had reached the Provincial Office and by-passed the database of the regional Department of Health found one case had reached the Provincial Office and by-passed the study.

Table 3 Circumstances of pesticide poisoning: Routine\(^a\)\(^,\)\(^,\)\(^b\) compared to intensified\(^b\)\(^,\)\(^c\) surveillance

<table>
<thead>
<tr>
<th>Pattern of poisoning</th>
<th>Routine(^a)</th>
<th>Intensified(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage female</td>
<td>33</td>
<td>30</td>
</tr>
<tr>
<td>Percentage occupational</td>
<td>Not given</td>
<td>12</td>
</tr>
<tr>
<td>Percentage suicide</td>
<td>22</td>
<td>35</td>
</tr>
</tbody>
</table>

\(^{a}\) Denominator for cases with known circumstances: Routine surveillance: n = 1007 for study 16; n = 203 for study 22; Intensified surveillance: n = 57 cases in 14 events for study 28.

\(^{b}\) Cases are based on counts of individuals. Events are based on episodes and may involve multiple individuals.

Underreporting is consistent with results of other local studies that have suggested that between 5% and 20% of hospitalized cases are reported. Moreover, the study may underestimate real underreporting because it does not take into account milder cases that do not reach hospitals, and which are untreated or treated by primary care workers without referral. These results are similar to international findings with regard to underreporting.

Underreporting appears worst for poisoning in occupational settings (Table 3). Presumably, suicide attempts with pesticides are more likely to achieve rapid hospitalization because of the associated distress and attention. Once hospitalized, the greater severity of illness may increase the chances of patient transfer to a tertiary service where the chances of notification may be increased. Evidence from Nicaragua suggests that the nature of the clinical presentation may well influence the likelihood of reporting of cases of pesticide poisoning. Hence, it is not surprising that the contribution of suicide as the major cause of pesticide poisoning may be underestimated in developing countries where surveillance generally underreports cases.

The relative significance of suicide in the incidence of pesticide poisoning is a point of international contention. Data from Asia identify suicide as the main circumstance for poisoning with pesticides, while equivalent data from countries in the Americas point to occupational causes as the priority. There is also evidence from research in Costa Rica and Mexico (personal communication, Dr Luis Lujan, El Colegio de Michoacan, Mexico, 1998) that occupational poisonings with pesticides may be systematically misrepresented as suicide to avoid compensation claims.

In terms of preventive strategies, the implications of these differences in pattern are substantial. If suicide is the major cause of poisoning with pesticides, industry arguments for ‘safe use’ can place the responsibility for poisoning on the individual. Notions of ‘ignorance’ as commonly expressed by public health policy documents in South Africa, effectively relieve industry of accountability for the impacts of widespread pesticide use. Critics have argued that industry ‘safe use’ campaigns have paradoxically increased health hazards for residents in developing countries by successfully promoting greater market penetration by pesticides.

The use of such categories as ‘negligence, ignorance and carelessness’ in surveillance nomenclature appear to reflect more the health system’s attitude to patients (often blaming victims)
than providing any helpful pointers to preventive strategies needed. While education is clearly a critical strategy required for prevention, as an isolated solution it does not address the full range of contributory factors, both social and behavioural, that result in pesticide-related morbidity and mortality.

Moreover, suicide with pesticides in the context of agricultural work may be considered an occupational event. For example, Schilling and Anderson\textsuperscript{41} have framed occupational disease in terms of a spectrum of work-relatedness, including conditions for which the workplace is responsible for increased access to workplace hazards. In this formulation, suicide amongst farm workers using pesticides would qualify clearly as an occupational disease.

The other critical policy implication to emerge from the data is that, rather than being a situation where two-thirds of pesticide poisoning cases involve men, the reverse may possibly hold true (Table 3). The impression that women are at lower risk of exposure, as is typically claimed in many areas of occupational epidemiology,\textsuperscript{42} may be erroneous. The involvement of women in piece-work\textsuperscript{43,44} and as seasonal labourers,\textsuperscript{45} and the unfavourable conditions of employment associated with such work\textsuperscript{43,44} (e.g. less training and protective equipment) increases their risk of exposure. Increasing concern about an association between pesticide exposure and impacts on reproductive health not only of the mother\textsuperscript{46–49} but in transgenerational effects on the offspring\textsuperscript{50,51} adds to the significance of pesticide poisoning in women. The cumulative impacts of long-term low-dose exposure are liable to even greater underestimation\textsuperscript{4} than is evident from this review.

Moreover, in settings where developing countries believe that their agricultural sector is critical to national development, economic objectives may place greater priority on expansion of agricultural production than on the social and health costs of pesticide usage.\textsuperscript{7} Policies relating to pesticides usually externalise these costs when weighing up the different control options.\textsuperscript{9,52,53} The absence of a coherent and accurate surveillance system for monitoring adverse health consequences of uncontrolled pesticide usage may therefore contribute to this externalization of cost, and facilitate policies that are both hazardous to human health as well as unsustainable in an ecological framework.

Inspectorates have tended to develop a culture in which the process of investigation and report writing becomes an end in itself. This may undermine attention to intervention in public health practice where surveillance is used to inform risk reduction strategies. The inadequacy of this focus on process rather than outcome is illustrated in cases 10 and 11 in this study, where one farm in the study had two notifications 6 weeks apart despite an inspection, recommendation and completion (and submission) of a toxicology report after the first event. A genuinely effective surveillance system should be able to support a culture of intervention rather than a culture of report writing.

Conclusion

This review shows that, on a number of criteria\textsuperscript{13,14} surveillance for pesticide poisoning in South Africa is highly ineffective and may contribute to misinformed policy choices regarding pesticide use. These problems are fairly typical of surveillance in developing countries.\textsuperscript{4,6,7}

Data collected for surveillance need to be pertinent and action-driven.\textsuperscript{54} Categories used in South Africa such as ‘ignorance’, ‘carelessness’ and ‘negligence’ are of little use for public health control. Surveillance data should provide a better understanding of the circumstances in which poisoning events occur to inform appropriate risk reduction strategies. For example, evidence in the intervention study that spray drift may be responsible for mass poisonings should be followed up by the introduction of specific legislation aimed at addressing re-entry exposures by restricting worker access to sprayed areas, That these regulations need to be formulated and implemented by a department (Labour) different to that which identifies the problem through surveillance (Health), illustrates the critical value of inter-sector collaboration in the Primary Health Care approach needed for pesticide safety.

The plethora of reporting systems across different government departments with little co-ordination or integration (Figure 1) appears to serve as an obstacle rather than facilitating effective surveillance. Departmental co-operation at local level is critically needed for the control of pesticide hazards, rather than reliance solely on a national non-statutory co-ordinating committee.\textsuperscript{5} Rationalization or, at the very least, sharing of inspection and monitoring functions across inspectorates can make a major contribution to improving surveillance and developing healthy and sustainable public policy with regard to pesticides in countries where the adverse impacts of pesticides are greatest.

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