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Pesticide poisonings at a tertiary children's hospital in South Africa: an increasing problem

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Context. Exposure of children to pesticides and overt poisoning are an increasingly important problem in South Africa. *Objective.* This study describes the profile of acute paediatric pesticide exposures and poisonings presenting to Red Cross War Memorial Children's Hospital (RCWMCH) in Cape Town South Africa from 2003 to 2008, identifies those poisonings due to illicit pesticides sold on the streets (''street pesticides'') and assesses the number of incidents in which the statutory requirement of notification to the local health authority is met. *Methods.* Cases were identified by review of the RCWMCH case and notification records and the local health authority notification records. *Results.* There were 306 patients with 311 incidents of acute pesticide exposure or poisoning. This represents 11% of all paediatric exposures and poisonings (N = 2868) seen over the 6-year period. The number of pesticide incidents increased annually. Two hundred seventy-eight (91%) children were under 6 years old and 164 (54%) were males. Two hundred seventeen (70%) patients came from six socio economically diverse suburbs in the Cape Town Metropole, each of which ranges from informal settlements with extreme poverty to formal housing with lower to middle class populations. There was a summer predominance of acute pesticide exposures and poisonings. The commonest group of pesticides were 203 cholinergics (includes organophosphates and carbamates), 35 anticoagulants and 45 unknowns. One hundred incidents were classified as exposures as they were asymptomatic. Two hundred eleven symptomatic incidents, termed pesticide poisonings, required admission; 121 to High Care or Intensive Care Unit (ICU). The median length of stay in hospital was 3 days (range 0–52). There were 6 (2%) deaths. The large group of cholinergic exposures and poisonings (203) required 195 (96%) admissions; 120 (59%) to High Care or ICU. Of the 44 ''street pesticide'' exposures and poisonings, 33 were cholinergic poisonings and 21 required High Care or ICU. Eighty-seven (41%) of 211 poisonings requiring notification were recorded at the local health authority; all were instances of cholinergic poisoning. *Conclusion.* The increasing number and the morbidity and mortality of acute paediatric pesticide exposure and poisoning is of great concern. Furthermore, the magnitude of the problem is masked by inadequate notification with the relevant health authorities.

Keywords Pesticide poisoning; Paediatric poisoning; Street pesticides; Organophosphate poisoning; Carbamate poisoning; Notification

Introduction

Poisoning accounts for 4% of injury-related child fatality and 11% of injury-related child morbidity.[1] Pesticide poisoning is an important component of this burden, especially in developing countries with large agricultural communities. Children, especially those below the age of 6 years, are all-too-often victims of unintentional exposure,[2,3]

whereas in adults, occupational exposure and self-harm are the main modes of pesticide poisoning.[4] The World Health Organisation (WHO) estimates worldwide acute pesticide poisonings to be between one and five million cases annually.[5,6] In specific hospital studies, paediatric pesticide poisoning admissions were 14% of total poisoning admissions in Sri Lanka,[7] 12% in Turkey,[8] 19% in North India,[9] 15% in Brazil[2] and 14% in South Africa.[10] However, the assumption is that the actual number of incidents far exceeds the number of presentations to hospital.[6,11]

The use of pesticides in South Africa is increasing,[12,13] but this is not limited to registered agricultural use. Poor social circumstances such as lack of housing, overcrowding and poor hygiene result in pest proliferation, leading already-impoverished residents to seek cheap and easy solutions.[14] The sale of illegal ''street pesticides'', often

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made from registered agricultural pesticides such as carbamates, has resulted in an epidemic of severe poisonings, reported internationally in Zimbabwe, New York and Rio de Janeiro, to name a few.[15–18] In South Africa, despite strict laws controlling pesticide trade, the illegal distribution and selling of these extremely toxic compounds has increasingly been observed.[14,19]

The surveillance of pesticide poisoning is a critical tool enabling governments to assess pesticide control and the efficacy of policies. Clinicians play their role in surveillance by notification of all acute pesticide poisoning cases. In South Africa, notification of all poisonings by agricultural or stock remedies is a legal requirement in terms of the National Health Act 61 of 2003. It requires completion of a standardised Department of Health form, which is sent to the local health authority. However, notification rates are poor. Estimates are that between 10% and 20% of hospitalised cases and 5% of mortuary cases are notified.[12] One study reported a 10-fold increase in notification rates during an intervention period.[12]

This study describes the profile of children admitted to Red Cross War Memorial Children's Hospital (RCWMCH) in Cape Town, South Africa with a history of exposure to a pesticide or symptoms of pesticide poisoning between 2003 and 2008, identifies those cases due to ''street pesticides'' and reports the number of cases in the local health authority notification record.

Methods

Permission to perform this study was granted by the Faculty of Health Sciences Human Research Ethics Committee and by the School of Child and Adolescent Health Research Committee, University of Cape Town.

A retrospective review of children presenting to RCWMCH with pesticide exposure or poisoning between January 2003 and December 2008 inclusive was performed. RCWMCH is a 288-bed state teaching hospital with tertiary and regional functions, serving children mostly under the age of 13 years. It is a referral hospital with 24-hour trauma and emergency units, both of which have overnight inpatient beds. Referrals are from clinics and day hospitals in the Cape Town Metropole (paediatric population 0–14 years, 901,385)[20] and regional hospitals in the Western Cape Province (paediatric population 0–14 years, 1,387,800).[20]

The Poisons Information Centre at RCWMCH records information on all children who present to RCWMCH with suspected or confirmed exposure to a toxin or poisoning. Cases are identified on a weekly basis by examining the attendance registers of the Outpatients Department and the admission and nursing registers of all the wards in the hospital for incidents that could be due to an exposure or poisoning. The case notes are reviewed and if confirmed as an incident, recorded in a Clinical Poisonings Database. For the purposes of this study, possible cases of pesticide exposure and poisoning were extracted from this database.

The term pesticide included insecticides, rodenticides, fungicides, moth repellents, fumigants, herbicides, compounds associated with pesticides (e.g. naphthenes, benzoates, organophosphates, glyphosates, captans) and any substance that may serve a pesticidal function. The RCWMCH and Cape Town District Health Office (from here on referred to as City Health) records of notified cases were joined with the cases retrieved from the database to create a list of patient hospital folder numbers and names. The information in the Clinical Poisonings Database and the hospital records of each of these children was then reviewed (by KB) to verify that the child was a case of pesticide exposure or poisoning, identified by a history of exposure, clinical signs or positive laboratory toxicology, and a final list compiled.

Information extracted included age, gender, address, season of presentation, route of exposure, length of stay in hospital, clinical details, severity of presentation, toxicology results, pesticide identification and record of notification. Causative agents were identified either by the actual name of a product or by clinical and toxicological confirmation.

The assessment of clinical severity was according to a predefined classification, based on the level of care required. It can be applied to the Poisoning Severity Score (PSS)[21]: 1 – asymptomatic and discharged immediately (PSS 0); 2 – admitted for observation, remained asymptomatic and discharged (PSS 0); 3 – admitted symptomatic (PSS 1–2); 4 – severely symptomatic defined as requiring High Care or Intensive Care Unit (ICU) admission or needing mechanical ventilation (PSS 3); 5 – death (PSS 4). The term High Care refers to those children requiring complex medical and nursing care, but not needing mechanical ventilation. Intensive Care Unit admissions required mechanical ventilation additionally.

In many instances, the distinction between organophosphate and carbamate poisoning is blurred. For the purposes of this article, the term cholinergic pesticides is used to include all cases of exposure or poisoning by known organophosphates or carbamates and those patients with clinical or toxicological features suggestive of poisoning by an organophosphate or carbamate or both. In these children, toxicological confirmation was by serum pseudocholinesterase levels.

''Street pesticide'' was defined as any substance obtained from an unlicensed outlet; known not to have been in manufacturer's packaging; described as a variety of formulations, such as black granules, white liquid or yellow powder; or prescribed as traditional medicines, which proved to have known pesticidal activity.

Results

Three hundred six patients with 311 incidents of acute pesticide exposure or poisoning were identified. These included 306 incidents captured on the Clinical Poisonings Database, four in the hospital notification record and one in the City Health notification record. Twenty-one names were not included in the study: 14 with no record of hospital

attendance and therefore no patient notes (two in the hospital notification list and 12 in the City Health list); three duplications in the City Health notification list; and four where the initial notification as an organophosphate poisoning was disproved during the clinical course at RCWMCH (one patient in the hospital list and three in the City Health list).

There were five patients who presented with two separate incidents, too far apart for the second to be regarded as a relapse or readmission. In four of the five children, the same pesticide was involved on both occasions.

The number of all paediatric exposures and poisonings over the 6-year period was 2868. Pesticide exposures and poisonings accounted for 11%. While the annual number of all incidents remained stable, there was an increase in the annual number of incidents due to pesticides (Fig. 1).

Most children, 278 (91%), were under 6 years, with 57 (18%) between 13 and 18 months. Approximately half, 164 (54%), were males. Two hundred seventeen (70%) patients came from six socioeconomically diverse peri-urban sub-urbs in the Cape Town Metropole (Table 1). Each ranges from informal settlements with extreme poverty to formal housing with lower to middle-class populations. One hundred three (33%) incidents occurred in summer, from December to February, and between 67 and 70 (22%) for each of autumn, winter and spring. Eighty-four (27%) incidents presented directly to RCWMCH and 227 (73%) were referred.

The route of exposure was by oral ingestion in 75% of incidents, unknown in 20% and from home pesticide spraying in 5%. There were three (1%) cases of intentional ingestion: in two, the mothers gave it to their children as
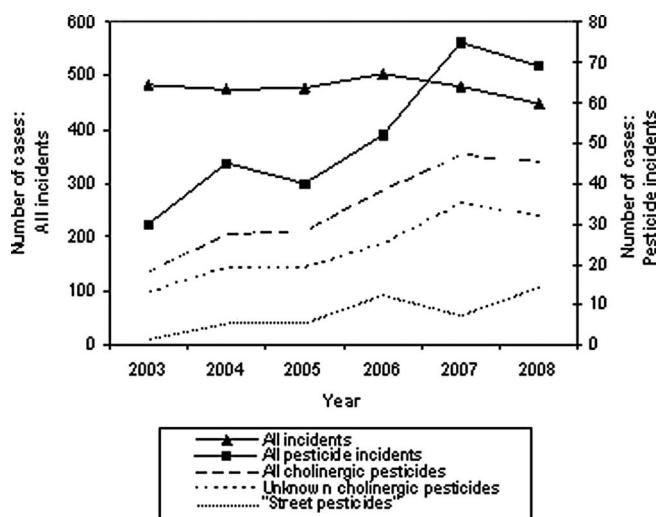
well as themselves in suicide attempts, and in the third, the child ingested it as a means to stay home from school.

In 93 (30%) incidents, the actual name of the pesticide, usually the trade name, was known. In 136 (44%) incidents, the name of the pesticide was not known, but the substance was intended for use as a pesticide. The remaining 83 incidents (26%) were diagnosed on clinical or toxicological grounds alone, the majority of which were cholinergic pesticide poisonings. There were 203 (65%) incidents due to cholinergic pesticides, 35 (11%) due to anticoagulant pesticides (coumar-ins and indanediones), 11 (4%) incidents each to naphthalene and benzoate pesticides and 45 (14%) exposures to unknown pesticides (Table 2). Only one child ingested two poisons simultaneously; both were known pesticides.

In 100 (32%) of the total incidents, children were asymp-tomatic pesticide exposures and either discharged immediately or admitted for overnight observation (Table 3). In 211 (68%) incidents, children were symptomatic pesticide poisonings, requiring admission. One hundred twenty-one incidents, 39% of incidents and 57% of admissions, required high care or ICU admission, all but one having clinical features of cholinergic pesticide poisoning. The median length of stay in hospital for all symptomatic incidents was 3 days (range 0.5–52, 90th centile 7). There were six deaths; a case fatality rate of 2%. One death was due to Phostoxin (a mixture of aluminium phosphide and ammonium carbamate); three were from known choliner-

Fig. 1. The annual figures for all paediatric exposures and poisonings (incidents) and paediatric pesticide exposures and poisonings (incidents) seen at RCWMCH 2003–2008. Note: The y-axis labelled ''Number of cases: All incidents'' represents the values for all paediatric exposures and poisonings. The y-axis labelled ''Number of cases: Pesticide incidents'' represents the values for paediatric pesticide exposures and poisonings and its subgroups (all cholinergic pesticides, unknown cholinergic pesticides and ''street pesticides'').

Table 1. Number of paediatric pesticide exposures and poisonings seen at RCWMCH 2003–2008 by suburb.

Area	Total pesticides (%)	Cholinergic pesticides (%)	''Street pesticides'' (%)
Khayelitsha	91 (29)	64 (32)	17 (39)
Nyanga	24 (8)	16 (8)	4 (9)
Gugulethu	21 (7)	18 (9)	7 (16)
Langa	19 (6)	12 (6)	4 (9)
Philippi	31 (10)	24 (12)	7 (16)
Mitchell's plain	31 (10)	17 (8)	0
All areas	311	203	44

Table 2. Number of paediatric pesticide exposures and poisonings seen at RCWMCH 2003–2008 by agent.

Causative agent	Total pesticides (%)	''Street pesticides'' (%)
Cholinergics	203 (65)	33 (75)
Anticoagulants	35 (11)	–
Naphthenes	11 (4)	–
Benzoates	11 (4)	–
Phosphide	1 (0.3)	–
Pyrethroids	2 (0.6)	–
Metaldehydes	1 (0.3)	–
Boron and borates	1 (0.3)	–
Formamidine	2 (0.6)	–
Unknown pesticides	45 (14)	11 (25)

Table 3. Number of paediatric pesticide exposures and poisonings seen at RCWMCH 2003–2008: age, clinical severity and length of hospital stay.

	Total pesticides (%)	Cholinergic pesticides (%)	''Street pesticides'' (%)
Total	311	203	44
Age (months)			
Median	26	26	23
Range	0–155	0–155	0–137
90th centile	79	84	105
Clinical severity (PSS)			
Asymptomatic, discharged immediately (0)	40 (13)	1 (0.5)	1 (2)
Admitted for observation, remained asymptomatic (0)	60 (19)	7 (3)	8 (18)
Admitted, symptomatic (1–2)	90 (29)	75 (37)	14 (32)
Severe symptoms, requiring High Care or ICU admission (3)	115 (37)	115 (56)	21 (48)
Death (4)	6 (2)	5 (2.4)	0
Hospital stay (days)			
Median	3	3	3
Range	0.5–52	0.5–52	0.5–25
90th centile	7	7.6	6.6

PSS, Poisoning Severity Score.

gic pesticides; and two had no history of ingestion, but presented clinically with cholinergic pesticide poisoning. One of the cholinergic pesticide deaths was a second incident. Chlorpyrifos had been identified as the poison in the first incident and discarded. The name of the cholinergic pesticide involved in the second incident is unknown and a medicolegal investigation is underway. Another cholinergic death was a child with no history of ingestion, but considerable co-morbidity. She was HIV positive, marasmic and had tuberculosis.

Of the 203 cholinergic pesticide exposures and poisonings, 157 (74%) incidents came from the six peri-urban suburbs previously mentioned (Table 1). Their seasonal occurrence reflects a similar pattern to the total number of pesticide incidents. There were 27 incidents where the actual name of the substance was known and 33 incidents of ''street pesticides''. In a further 69 incidents, the intended use of the substance was recorded as a pesticide. They included 30 cockroach killer baits and 11 rodenticides. Of the remaining 74 incidents, 60 had no history of exposure to any substance. One hundred ninety-five (96%) cholinergic poisoning incidents were symptomatic with 120 (62%) requiring High Care or ICU (Table 3). The median length of stay in hospital was 3 days (range 0.5–52, 90th centile 7.6). One hundred ninety-four incidents had serum pseudocholinesterase levels measured (median 499, range 174–12105, 90th centile 2067, laboratory normal reference range 3000–9300 units per litre). Fifteen incidents (7%) had normal to high serum pseudo-cholinesterase levels with a clinical toxidrome of cholinergic poisoning or an identified cholinergic pesticide or both. One hundred seventy-nine (88%) incidents had reduced serum pseudocholinesterase levels.

Forty-four (14%) of the total pesticide incidents were due to ''street pesticides''. Most, 36 (82%), were under 6 years of age, and there were 26 (59%) males. The majority of patients (89%) came from five of the six peri-urban suburbs previously mentioned (Table 1). Thirty-three (75%) incidents were cholinergic poisonings, on clinical or toxicological grounds. A further 11 (25%) incidents were due to unknown pesticides, identified by their intended pesticide use only (Table 2). Nine of the 11 were asymptomatic exposures. Of the 35 (80%) symptomatic poisonings, 21 (48%) required High Care or ICU admission. The median length of stay in hospital was 3 days (range 0.5–25, 90th centile 6.6). There were no deaths (Table 3). Nine (20%) of 44 ''street pesticides'' were prescribed by traditional healers for medicinal purposes. All but one of these cases required high care or ICU admission and all were cholinergic pesticide poisonings.

Two hundred eleven (68%) of the 311 incidents were symptomatic and therefore required notification. Of the 211, 84 (40%) were cited in the RCWMCH notification record and 87 (41%) in City Health's. There were only 60 (28%), which appeared in both. In 19 (9%) of the 211 incidents, the hospital record reflected the doctor's intention to notify, but the incidents were not found in the RCWMCH or City Health notification records. All notified cases were instances of cholinergic pesticide poisoning. Of the six deaths, two were found in the hospital's notification record, and one of these incidents was also found in the City Health record. Of the 35 ''street pesticide'' poisonings requiring notification, 13 (34%) were found in the hospital's notification record and 12 in City Health's. Seven incidents were found in both records and in six, the doctor had written their intention to notify, but the incidents were not found in either notification record.

Discussion

This study has found that although overall paediatric exposure and poisoning figures from RCWMCH remain

stable, pesticide incidents are increasing. The majority are cholinergic poisonings requiring advanced medical care and come from six socioeconomically diverse peri-urban communities. The study also shows that ''street pesticides'' are an emerging problem. These results may reflect the behaviour of a growing socioeconomically deprived population living in overcrowded and unhygienic conditions, but there is no direct evidence in this study to support such a conclusion.

Comparison of this study's results with other published data is limited. The true incidence of acute pesticide poisoning is uncertain globally[5,6] and data on childhood poisoning from all substances in developing countries are poorly documented.[1] However, age and gender figures do reflect similar patterns of under-5-year old and male predominance when compared with international reports[2,7–10] on specific hospital admissions for all childhood poisonings. The seasonal variation also reflects a summer peak in all pesticide incidents and the cholinergic subgroup, which is similar to a South African study on paediatric organophosphate poisoning.[22]

International pesticide poisoning figures are collated from a variety of sources including hospital admissions, Poisons Call Centres, surveys and government health and agriculture departments. These sources rely on initial recognition of a possible pesticide poisoning so that they may be recorded as such. This usually depends on a history of pesticide exposure or in the case of no known exposure, a clinical symptom complex which is typical of a particular pesticide or a toxicological test, e.g. cholinergics. This means that there is a diagnostic bias, where cases with mild or non-specific symptoms may not be recognised as acute pesticide poisonings and therefore not reported.

Underestimation of acute pesticide poisoning incidence is compounded by problems in the system of notification, a basic technique for pesticide poisoning surveillance. The South African National Department of Health figures from 2003 to 2008, report the total number of pesticide poisonings for the Western Cape Province at 341 cases.[23] However, as RCWMCH alone had 211 pesticide poisonings, it would be extraordinary if the figure of 341 is not an underestimate of the true incidence. Other provinces failed to supply figures or were recorded as ''no notified cases'' for certain years. The South African Department of Health requires that medical staff notify all poisonings with agricultural or stock remedies. These agents include pesticides, moth repellents, herbicides, fungicides and rodenticides. The policy at RCWMCH has been to notify all clinically symptomatic cases of pesticide poisoning. This approach prevents flooding of the Department of Health with information on asymptomatic cases of exposure. However, it has the disadvantage that there may be underreporting. Although the proportion of poisonings from RCWMCH found in the local health authority notification record was 41%, which is better than other reported studies, it is still inadequate. Even more concerning, is that only one of six deaths appeared on the City Health notification list.

The efficiency of the current South African notification system is of concern. At RCWMCH, patient and notification records are tracked by a hospital folder number system, but may also be found through patient names. The City Health notification systems, however, are based on notification by name only. This creates instances where misspelt names lead to untraceable hospital cases, fostering poor correlation between hospital and City Health figures. Throughout South Africa, collation of all the notification records requires considerable inter- and intra-departmental collaboration between the Departments of Health at national, provincial and local government levels, Home Affairs, Labour and Agriculture and Environmental Affairs, and cases are often lost.[12] Lack of recognition of pesticide exposures and poisonings, underreporting and inefficiency of the current notification system are problematic and efforts to strengthen these are required.

''Street pesticides'' are an emerging problem. They are often made from known predominately (SP) agricultural pesticide formulations and sold, unregistered and unlabelled, by unlicensed outlets. The actual incidence in South Africa is unknown. A recent study conducted in peri-urban informal areas of Cape Town, concluded that youth are particularly vulnerable.[14] They are involved in the sale, distribution and use of ''street pesticides'' and are exposed during handling, transportation, spillage and storage with little safety information available.[14] Vendors sell a multitude of concoctions at train stations, taxi ranks and on the street.[14,19] Liquid pesticides are decanted into smaller medicinal, alcohol or juice bottles, and pellets or granules are sold in plastic straws and packets. Laboratory analysis has found aldicarb, chlorpyrifos, chlorpyrifos-methyl, methamidophos and cypermethrin in samples taken off Cape Town's streets.[19] Aldicarb, listed as Extremely Hazardous Class Ia by the WHO Acute Toxicity Classification,[24] is found in a street pesticide with the nickname ''*two step*'', as a rat can only take so many steps before dying.[19]

Similar ''street pesticides'' have been described in other countries. In Zimbabwe, aldicarb-containing sachets are sold on the streets and have contributed to the increase in rodenticide poisoning admissions in recent years. About 60% of the records in a particular study presented with clinical features suggestive of cholinergic pesticide poisoning.[15] A 4-year study on poisoning by *Tres Pasitos* (meaning ''three little steps'') in the Dominican community in New York, showed the agent to be aldicarb, not licensed for rodenticide use in the United States.[16] There were no case fatalities, but almost 25% of the patients required ICU admission. Another retrospective study in the Federal District of Brazil reported 709 pesticide poisonings between 2004 and 2007.[17] The illegal rodenticide, *chumbinho* (meaning ''small shot''), formulated mainly with aldicarb, was the agent involved in 27% of cases. The case fatality rate for these patients was 5.2%. A recent article from Rio de Janeiro (2009) looking at the poisoning profile of children, states that of the 15% of cases due to pesticides, 50% involved *chumbinho*.[2]

The illegal selling of such illegal substances serves to highlight the importance of appropriate pesticide management in the community, to adequately control sales and thereby prevent poisonings. The International Code of Conduct on the Distribution and Use of Pesticides[25] aims to provide a guideline for the safe management of pesticides. It is a voluntary code, stating that the primary responsibility for adequate pesticide control is in the hands of the country's ruling government. A country's ability to adhere to the Code depends on adequate surveillance systems being in place, but unfortunately, in many developing countries, lack of resources and political will lead to ineffectual governance and a breakdown in pesticide management protocols. There have been many studies, from developing countries in particular, looking at techniques to improve pesticide surveillance and prevent unnecessary poisonings. The suggestions are numerous and the evidence supportive: reducing the use and need for pesticides with integrated pest management and plant bio-technology,[26] restricting availability of highly toxic pesticides,[5] a call for a minimum pesticide list[4] and the role of pesticide manufacturers and their responsibility to environmental health.[5]

Limitations of this study include that it is a retrospective study leading to the not unexpected phenomena of misplaced documents, reliance on clinical case notes for patient history and so forth. More specific limitations include a diagnostic bias as previously mentioned. An underestimation of the total number of pesticide exposures and poisonings would result in an overestimate of the proportion of cholinergic pesticide poisonings. Furthermore, the inclusion criteria for ''street pesticides'' relied on a thorough history and documentation by the original admitting clinician. This may also have contributed to an underestimate in the number of incidents due to ''street pesticides''.

Conclusion

This study is dissimilar to others, in that it describes acute pesticide exposures and poisonings at a children's hospital. Furthermore, the majority of the reported incidents are accidental ingestions, where pesticide exposure occurs in the context of poor living conditions and domestic use, rather than under the guise of occupational exposure as described in agricultural communities in the Western Cape.[22]

Although national figures underestimate the true incidence, this study indicates an increase in paediatric acute pesticide exposure and poisoning with certain identifiable points: specific peri-urban communities are at risk; cholinergic pesticides are causing significant morbidity; ''street pesticides'' are not uncommon; a good history is essential in starting the process of adequately defining the pesticide involved; and notification is inadequate. Dealing with these factors will improve quantification of acute pesticide poisonings and contribute to prevention strategies such as pest control, pesticide risk education and local policy.

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