Title

Outcomes of community-based suicide prevention approaches that involve reducing access to pesticides: A systematic literature review

Short title

Community approaches to prevent pesticide suicide

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Abstract

Objective

Pesticide ingestion is among the most commonly utilised means of suicide worldwide. Restricting access to pesticides at a local level is one strategy to address this major public health problem, but little is known about its effectiveness. We therefore conducted a systematic literature review to identify effective community-based suicide prevention approaches that involve restricting access to pesticides.

Method

We searched Embase, Scopus, PsycINFO, Cochrane Library, CINAHL and PubMed for well-designed studies that reported on suicide-related outcomes (i.e., attempted or completed suicide).

Results

We identified only five studies that met our eligibility criteria (two randomised controlled trials, two studies with quasi-experimental designs, and one study with a before-and-after design). These studies tested different interventions: the introduction of non-pesticide agricultural management, providing central storage facilities for pesticides, distributing locked storage containers to households, and local insecticide bans. The only sufficiently powered study produced no evidence of the effectiveness of providing household storage containers. Three interventions showed some promise in reducing pesticide suicides or attempts, with certain caveats.

Conclusions

Our review identified three community interventions that show some promise for reducing pesticide suicides by restricting access to means, which will require replication in large, well designed trials before they can be recommended.

Key words

Pesticides; suicide prevention; suicide means; restricting access to means; systematic review

Introduction

Ingestion of pesticides is one of the most frequently utilised suicide methods worldwide (Bertolote et al., 2006; Gunnell et al., 2007). Self-poisoning with pesticides has been estimated to account for at least 110,000 annual deaths globally, or one in seven of all suicides, and is more prevalent in countries with significant rural populations throughout Asia, Africa, Latin America and the Pacific Islands (Mew et al., 2017). The high incidence of pesticide suicides has been understood as being associated with the relative ease of access to pesticides in many rural farming communities, coupled with the high toxicity of many pesticides and the often impulsive nature of self-poisoning attempts. Limiting access to means of suicide has been recommended by the World Health Organization (World Health Organization, 2014) as an effective method of preventing suicide. Therefore, one could assume that strategies which reduce access to pesticides may be an effective means of reducing suicide mortality (Hvistendahl, 2013; Mishara, 2007).

Research has demonstrated that efforts which limit the availability or ease of access to means of suicide (e.g., reductions in the availability of domestic gas, packaging analgesics such as paracetamol in smaller quantities, installation of barriers on bridges and cliffs) are effective in reducing method-specific suicide rates and, in some cases, the overall suicide rate (Sarchiapone et al., 2011). It makes sense that restricting access to pesticides might achieve both outcomes, given the high proportion of global suicides accounted for by ingestion of agricultural chemicals.

Various means restriction strategies have been suggested as ways of addressing pesticide suicides. Some involve policy changes at national or international levels and can involve the efforts of policy-makers, legislators and pesticide manufacturers and distributors (Gunnell et al., 2017). These 'top-down' approaches include national bans on particularly toxic substances, restriction of sales to licensed purchasers, use of warning labels on pesticide containers, reductions in the toxicity of particular pesticides, and the addition of emetics or stanching agents to pesticides. Other strategies are more community-based and are typically driven by partnerships between local community members and other key stakeholders (World Health Organization, 2006). These ‘bottom-up’ approaches involve educating the public about proper handling, storage and use of pesticides, appointing designated individuals in the community to store and distribute pesticides, and limiting access to pesticide through central communal storage facilities or household lockable storage boxes (Vijayakumar et al., 2005; Konradsen et al., 2003).

Our focus in this paper is on community strategies. These have been shown to be acceptable and feasible (Mohamed et al., 2009; Mohanraj et al., 2014; Hawton et al., 2009). We thought that it was timely to synthesise the research evidence, so we conducted a systematic review of well-designed studies that include a control group or were time series to determine which community strategies to restrict access to pesticides are effective in preventing suicides and attempted suicides.

Method

Our systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009; Liberati et al., 2009).

Search strategy

We searched six major international databases from their dates of inception to 4 July 2017 for articles describing studies evaluating community suicide prevention initiatives involving the restriction of access to pesticides. The six databases were Embase, Scopus, PsycINFO, Cochrane Library, CINAHL and PubMed. BM, MP, LV and JP devised the search strategy and LD conducted the search.

We used combinations of key search terms relating to four primary concepts – (a) suicide, (b) pesticide ingestion, (c) community context and (d) means restriction. Our overarching search strategy was further customised to capitalise on the functionality of some databases (e.g., combining key search terms with standard MeSH terms from the PubMed and Cochrane databases, and using PsycINFO index terms). We truncated relevant search terms to ensure the inclusion of singular and plural forms, and relevant derivatives of these search terms. The search terms and syntax used with Embase are shown in Box 1, with the syntax for all other database searches available upon request.

Insert Box 1 about here

Inclusion and exclusion criteria

We included studies that evaluated the effectiveness of means restriction activities delivered as preventive interventions in communities. To be eligible, these studies had to employ robust designs; at a minimum, they had to use before-and-after designs, but desirably they might have involved time-series analyses, quasi-experimental studies or randomised controlled trials. They also had to report on suicide-related behavioural outcomes (i.e., attempted or completed suicide). We did not place any language restrictions or time limitations.

We excluded studies of interventions that were unrelated to pesticide restriction, that involved postvention activities only, or were not based in communities (e.g., studies in hospitals). We also excluded studies with weaker designs (e.g., studies that collected post-intervention data only and included no baseline or comparison information). In addition, we excluded studies that did not assess suicide-related behavioural outcomes (e.g., studies that examined attitudes towards suicide, suicidal ideation).

Study selection and evaluation

LD reviewed the titles and abstracts of retrieved records for potentially relevant articles, and JP reviewed the full text of these articles to determine whether they met our inclusion criteria. Any uncertainty was resolved by recourse to BM, LV and MP who discussed the article and reached a consensus-based decision on its inclusion/exclusion. LR then extracted relevant data from each of the studies and synthesized their findings. Data were extracted on the study design, the nature of the intervention, the sample and setting, the outcomes measured, and the results.

Results

Figure 1 shows the PRISMA flow diagram of the study selection process. We identified 4,030 records in total and, after removing duplicates, screened the titles and abstracts of 3,065. Of these, 3,059 were excluded on the grounds that they did not meet our inclusion criteria. We retrieved and assessed full text articles for the remaining six records and screened these for eligibility, and excluded one additional record. This left us with five eligible studies for inclusion in the review. Table 1 provides an overview of these five studies (Vijayakumar and Satheesh-Babu, 2009; Vijayakumar et al., 2013; Eddleston et al., 2012; Pearson et al., 2017; Nandi et al., 1979).

Insert Figure 1 about here

Insert Table 1 about here

Study settings

The five studies were conducted in Southern Asia, three in India (Vijayakumar et al., 2013; Vijayakumar and Satheesh-Babu, 2009; Nandi et al., 1979) and two in Sri Lanka (Eddleston et al., 2012; Pearson et al., 2017). All five took place in communities defined by districts or villages with a heavy dependence on agriculture that had sizeable numbers of community residents (ranging from 5,500 to 1,000,000).

Interventions

The five studies tested four different interventions. The first evaluated the introduction of non-pesticide based pest management (NPM), which is based on the principles of crop diversity, understanding the life cycle of insects and pest management via locally available natural materials. NPM practices include the use of deep summer ploughing, light traps, bonfires, sticky boards, pheromone traps, natural extracts and trap crops to control pests (Vijayakumar and Satheesh-Babu, 2009). The second study examined the introduction of central, lockable pesticide storage boxes that were located inside a central storage facility. Storage facilities were managed by two designated managers who were identified by the local community, trained in safe pesticide storage and disposal, and orientated to the purpose of the facility. Central storage facilities were accessible to key-holding farmers in participating intervention villages between the hours of 7am and 7pm (Vijayakumar et al., 2013). The third study examined the effectiveness of household-based lockable pesticide storage containers, which were typically installed within the home compound, partially buried within the ground, and locked by household members (Pearson et al., 2017). The fourth study piloted a selective ban of two insecticides classified as Class II – or 'moderately hazardous' – by the World Health Organization (Eddleston et al., 2012), while the fifth study piloted a selective ban of one highly toxic insecticide (Nandi et al., 1979). For further detail on these interventions readers are referred to the original studies.

Study designs and outcomes assessed

Two studies involved cluster randomised controlled trials (Vijayakumar et al., 2013; Pearson et al., 2017), two studies employed quasi-experimental designs (Eddleston et al., 2012; Vijayakumar and Satheesh-Babu, 2009) and one study involved a before-and-after design (Nandi et al., 1979). In each case, the intervention was delivered in certain villages or districts, and comparisons were made with control districts or villages that were randomly or purposively selected, except for one study, which involved pre-post comparisons within the same sub-district, without a control group (Nandi et al., 1979).

One cluster randomised controlled trial examined changes in the rates of suicides and attempted suicides (gleaned from official records and pre-/post- household surveys) in intervention and control villages following the establishment of the central storage facilities in each of the intervention villages (Vijayakumar et al., 2013). The other cluster randomised controlled trial examined differences in the incidence of self-poisoning by pesticides and all substances (gleaned from hospital records, pre-post household surveys, and official records) between intervention and control villages following the installation of household-based storage containers (Pearson et al., 2017). One quasi-experimental study compared changes in the number of suicides (ascertained from official records and interviews with community members) between intervention and control villages after the introduction of non-pesticide management in the intervention villages (Vijayakumar and Satheesh-Babu, 2009). The other quasi-experimental study tracked admissions to hospital and deaths associated with self-poisoning by pesticides in a district that was subject to a pesticide ban and in a control district (Eddleston et al., 2012). The fifth study involving the before-and-after design examined changes in the rates of suicide and pesticide suicide (gleaned from official police records of two police stations) within a subdistrict that was subject to a selective pesticide ban (Nandi et al., 1979).

Study findings

The cluster randomised controlled trial of household-based lockable storage containers, which presents the most robust evidence to date, produced no evidence for the effectiveness of these devices in reducing the incidence of self-poisoning by pesticide (or all substances) over the study period. The incidence of pesticide self-poisoning for those aged ≥14 years was 293 per 100,000 person years in intervention and 318 per 100,000 person years in control villages, (rate ratio 0.93, 95%CI 0.80, 1.08; p=0.33); while the incidence of self-poisoning due to all substances was 554 per 100,000 person years in intervention and 582 per 100,000 person years in control villages (rate ratio 0.97, 95%CI 0.86, 1.08, p=0.55) (Pearson et al., 2017).

The four remaining studies, which were not randomised and/or only insufficiently powered, produced promising findings, with certain caveats. The cluster randomised controlled trial of the centralised pesticide storage facility found that suicide events (suicides and attempted suicides) decreased significantly more in intervention villages than in control villages over the study period (by 295 per 100,000 person years for pesticide suicides, (95%CI: 155, 435, p<.001) and by 339 per 100,000 person years for suicides by any method, (95%CI: 165, 513, $p<.001$)). However, there were several methodological issues, such as the intervention scope being limited to only two villages, and baseline imbalances and differential loss to follow up between intervention and control villages (Vijayakumar et al., 2013).

In the quasi-experimental study of the effectiveness of non-pesticide management there was evidence of a greater reduction in suicides (the majority of which were pesticide suicides) in the intervention villages (from 14 to 3) than in the control villages (from 15 to 8). However, the study was insufficiently powered for this difference to be statistically significant (Vijayakumar and Satheesh-Babu, 2009).

The quasi-experimental study that considered the district-level ban on Class II insecticides showed that this intervention was associated with a reduction in hospital admissions for suicide attempts by these specific agents (admissions fell by 43% in the intervention district and rose by 23% in the control district). However, this did not translate into a sustained reduction in pesticide-related deaths, despite the promising short-term effects. There was a 5.4% reduction in case fatality for all pesticides in the intervention district (odds ratio 0.59, 95%CI 0.41, 0.84) and only a 0.7% reduction in the control district (odds ratio 0.93, 95%CI 0.70, 1.25), but this was explained by a contemporaneous reduction in case fatality rates for herbicides and other pesticides that were not targeted, and was not sustained (Eddleston et al., 2012).

The before-and-after study examining the impact of a selective ban of one highly toxic insecticide in an Indian subdistrict reported respective reductions in the rate of insecticide suicide by 17% (from 34-25) for one police station, and by 13% (4-3) for the other police station (Nandi et al., 1979). However, this study was insufficiently powered for these differences to be statistically significant. Moreover, since decreases in the rate of insecticide suicide were accompanied by equivalent corresponding increases (of 17% and 13% respectively) in the use of other suicide methods, the overall rate of suicide remained constant.

Discussion

Our review identified only five studies with relatively strong designs that examined the effectiveness of community-based means restriction interventions in reducing suicidal behaviours. Some might argue that the small number of eligible studies makes it premature to synthesise their results. However, we contend that it is important to present and discuss these studies because of the pressing need to implement effective intervention to prevent pesticide suicides worldwide. The five studies we identified indicate that it is possible to undertake fairly rigorous evaluations of community interventions to prevent pesticide suicides. They also provide some preliminary evidence that certain ways of reducing the availability of pesticides may lead to decreases in suicide attempts and suicides.

Our review identified four studies with positive findings (Vijayakumar and Satheesh-Babu, 2009; Vijayakumar et al., 2013; Eddleston et al., 2012; Nandi et al., 1979), although each had limitations which imply that the findings should be interpreted with caution (e.g., small numbers, confounders, lack of a sustained effect). Nonetheless, these studies suggest that the introduction of non-pesticide management, storing pesticides in central storage facilities, and local bans of specific insecticides show promise. Each of the interventions may be worth exploring further in the appropriate context, particularly if additional evaluation efforts are initiated. It may be useful to conduct research to compare these approaches and to evaluate combinations of the three, because it is not yet clear that one is better than the others. Decisions about which of these approaches (or combinations of approaches) is most appropriate to test, and under what circumstances, should be guided by local community members, working in partnership with other key stakeholders.

Our review also identified one study that yielded null findings (Pearson et al., 2017). This study was the largest and most methodologically robust of the five, and it found no evidence for the effectiveness of household-based storage containers in reducing the incidence of self-poisoning by pesticides. There is a question as to whether there is value in exploring the usefulness of this intervention further, or whether it should now be ‘put to bed’ as one that is not worth pursuing. In this context, it is possible that the centralised community-managed storage facility model may have added advantages over the use of household-based locked boxes in that it can provide additional safeguards to pesticide access and reduce the domestic risk of impulsive self-poisoning (Konradsen et al., 2007; WHO, 2016). The fact that less than one quarter of households in intervention villages had utilised central storage facilities also highlights the need to carefully consider storage facility locations to improve equitable and convenient community access in future. Moreover, interventions that are effective may be specific to the cultural context, so interventions that are not effective in one culture may be effective in another, and interventions that are proven to reduce suicidal behaviours in one culture will need to be validated when transposed to another cultural context.

It is perhaps not surprising that these interventions show promise, given that restricting access to other means has been shown to be one of the few suicide prevention methods that has been confirmed by many research studies as an effective suicide prevention strategy (Zalsman et al., 2016). Controlling access to means is thought to work because it stops or delays the suicidal process, giving the person time to reconsider and take an alternative course of action or, at the very least, choose a less lethal suicide means (Hawton, 2007; Yip et al., 2012). They also ‘buy time’ for a third party to intervene (Hawton, 2007; Yip et al., 2012).

It is conceivable that two of the interventions we examined, which involved local-level insecticide bans (Eddleston et al., 2012; Nandi et al., 1979) may be operating on the basis of principles similar to those that have been found to be effective in the context of top-down strategies, such as large-scale, national-level bans (Gunnell et al., 2017). In this context, it is noteworthy that the local ban reported by Eddleston et al. (2012), whilst implemented in local communities, was also based on a decision made by the Sri Lankan Department of Agriculture. As such, local-level bans can be seen to straddle the boundary between community-based (bottom-up) and top-down approaches to restricting pesticide access.

Community-based approaches to restricting pesticide access constitute an important complementary strategy to top-down strategies within the broader arsenal of pesticide suicide prevention approaches. The advantages of local-level approaches may lie in the demonstrated acceptability, feasibility of such approaches, the greater chance of local buy-in and support, as well as flexibility in implementing locally relevant solutions (e.g., in situations where large-scale bans may not be appropriate, feasible or easily implemented). However, it is essential that community-based approaches to restricting pesticide access do not divert from existing efforts and responsibilities of policy makers in regard to pesticide regulation, and are also not provided in isolation but rather as part of a comprehensive multi-sectoral approach to preventing pesticide suicides, one that encompasses community engagement and education, implementation and enforcement of regulations, improved access to clinical treatment of pesticide poisoning, training and surveillance (WHO, 2016) and is complemented by the availability of suicide prevention services, such as telephone, text message and internet helplines and gatekeeper training in suicide prevention.

In view of the established effectiveness of regulation-focussed top-down approaches (Gunnell et al., 2017), amassing further evidence of the effectiveness of community-based approaches will be required if these approaches are to be utilised more effectively by local communities as a complementary strategy to address the pressing public health concern of pesticide suicide in future. Because the evidence base is still in its infancy, it is important to ensure that interventions continue to be evaluated, and in the most rigorous way possible.

The five studies cited all used fairly robust designs and all measured 'hard' outcomes, attempted suicides and suicide fatalities. They demonstrate that it is possible to undertake methodologically rigorous studies in this challenging area. Multi-site studies may help strengthen the evidence base. Ideally, these studies should be conducted in communities in regions where the burden of pesticide suicide is particularly high (Gunnell et al., 2007). They should strive to ensure comparability of the intervention and control groups in terms of essential baseline characteristics. Ideally, they should not rely on official records alone (due to the common issue of underreporting of suicide in many countries where pesticide poisoning is a problem), but should draw on multiple relevant information sources in order to corroborate official suicide statistics (London and Bailie, 2001). The protocols used in the five existing studies can inform well-designed and rigorous evaluations in future (Madsen et al., 2015; Pearson et al., 2011).

Our review has certain limitations. Despite our best efforts, our search strategy may have missed some studies. There may also have been some publication bias, whereby studies which found community-based pesticide restriction activities to be effective may be more likely to be published than studies with negative findings. Most of the studies we identified (excepting Pearson et al., 2017) could be regarded as pilot or feasibility studies that were only insufficiently powered to detect meaningful effects. Three studies (except for the two cluster-randomised trials) did not account for possible clustering. Two studies (Vijayakumar and Satheesh-Babu, 2009; Vijayakumar et al., 2013) were limited in their ability to assess suicide method substitution (i.e., shifts from suicides by pesticide ingestion to suicides by other methods). We are also conscious that our strict inclusion criteria relating to study designs and outcomes of interest meant that we excluded some studies that may provide some useful information (e.g., studies that demonstrate the feasibility and acceptability of local pesticide storage facilities (Hawton et al., 2009; Mohanraj et al., 2014; Pieris et al., 2017; Konradsen et al., 2007)). By focussing on the peer-reviewed literature, we may have missed studies that have been published in reports from governments or non-government organisations. For example, recently published WHO case study reports of community-based demonstration projects in China, India and Sri Lanka were not eligible for inclusion in this review but may still provide the reader with valuable lessons for implementing community interventions (WHO, 2016). However, although the studies we excluded may provide useful insights for intervention design and implementation, it is essential to rigorously examine suicide outcomes to determine the effectiveness of different means of controlling access to pesticides as an effective method for preventing suicides.

Conclusion

Our review identified three promising community-based interventions for reducing pesticide suicides by restricting access to means. Community-based approaches, such as those identified in the review have been found to be both feasible and acceptable. Nevertheless, in view of the established effectiveness of regulation-focussed top-down strategies, further evidence of the effectiveness of community-based strategies will be required, if these complementary strategies are to be utilised more effectively by local communities in future. We need to act now to address the global public health problem of pesticide suicides (World Health Organization, 2006; Gunnell and Eddleston, 2003), which is among the most common suicide methods worldwide, and this review suggests one important way forward.

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Conflict of interest

Lakshmi Vijayakumar and Michael Phillips have received in the past financial support from Syngenta to conduct investigations of pesticide suicide prevention involving restriction of access to means. Jane Pirkis and Brian Mishara have had a part of their travel expenses paid by a grant from Syngenta to attend a meeting where they developed the design of this review.

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TABLE 1. Overview of studies

Authors	Setting / Sample size	Intervention	Study design	Outcomes assessed	Findings
Vijayakumar and Satheesh-Babu, 2009	Selected villages in India 4 Intervention villages (N=2814) 4 Control villages (N=2682)	Non-pesticide based pest management (NPM)	Quasi-experimental design	Number of suicides (from official records and interviews with community members)	Reduction in suicides from 14-3 in intervention villages compared with 15-8 in control villages
Vijayakumar et al., 2013	Selected villages in India 2 Intervention villages (N=4446) 2 Control villages (N=3307)	Central, lockable pesticide storage boxes	Randomised controlled trial	Rates of suicide and attempted suicide (from official records and pre-/post-household surveys)	Suicides and attempted suicides combined decreased more in intervention than control villages, by a difference of 295/100,000 person years for pesticide suicide (95%CI 155, 435, *p*<.001) and 339/100,000 person years for suicides by any method (95%CI 165, 513, *p*<.001).
Pearson et al., 2017	Selected villages in Sri Lanka 90 Intervention villages (N=114168) 90 Control villages (N=109693)	Household-based, lockable pesticide storage containers	Randomised controlled trial	Incidence of self-poisoning by pesticide and all substances (from hospital records, pre-post household surveys, and official records)	No difference in the incidence of pesticide self-poisoning for those aged ≥14 years between intervention (293/100,000 person years) and control villages (318/100,000 person years) (rate ratio 0.93, 95%CI 0.80, 1.08; *p*=0.33); or in the incidence of self-poisoning due to all substances (with 554/100,000 person years in intervention versus 582/100,000 person years in control villages) (rate ratio 0.97, 95%CI 0.86, 1.08, *p*=0.55).

Eddleston et al., 2012	Selected districts in Sri Lanka 1 Intervention district 1 Control district Total study population (N=1.1 million)	Selective ban of two insecticides	Quasi-experimental design	Rates of suicide and attempted suicide (from official records and hospital admissions)	43% reduction in hospital admissions for suicide attempts in intervention district compared with 23% in control district. No sustained reduction in pesticide related deaths.
Nandi et al., 1979	Selected police stations in a district-subdivision of India 2 Intervention sites (N=238251 and N=156851)	Selective ban of one insecticide	Before-and-after design	Rates of suicide and insecticide suicide (from police records)	Reductions in insecticide suicides by 17% (from 34-25) at one police station and by 13% (from 4-3) at the other. Accompanied by respective increases of 17% and 13% in use of other suicide methods. No change in the overall rate of suicide.