From pesticides to medicinal drugs: time series analyses of methods of self-harm in Sri Lanka
Varuni A de Silva, SM Senanayake, P Dias & R Hanwella

**Objective** To explore if recent changes in methods of self-harm in Sri Lanka could explain the decline in the incidence of suicide.

**Methods** Time series analyses of suicide rates and hospitalization due to different types of poisoning were carried out.

**Findings** Between 1996 and 2008 the annual incidence of hospital admission resulting from poisoning by medicinal or biological substances increased exponentially, from 48.2 to 115.4 admissions per 100 000 population. Over the same period, annual admissions resulting from poisoning with pesticides decreased from 105.1 to 88.9 per 100 000. The annual incidence of suicide decreased exponentially, from a peak of 47.0 per 100 000 in 1995 to 19.6 per 100 000 in 2009. Poisoning accounted for 37.4 suicides per 100 000 population in 1995 but only 11.2 suicides per 100 000 in 2009. The case fatality rate for pesticide poisoning decreased linearly, from 11.0 deaths per 100 cases admitted to hospital in 1997 to 5.1 per 100 in 2008.

**Conclusion** Since the mid 1990s, a trend away from the misuse of pesticides (despite no reduction in pesticide availability) and towards increased use of medicinal and other substances has been seen in Sri Lanka among those seeking self-harm. These trends and a reduction in mortality among those suffering pesticide poisoning have resulted in an overall reduction in the national incidence of accomplished suicide.

**Introduction**

Although adoption of new modes of self-harm by a population does not occur often, when it does happen it can have an impact on the incidence of suicide in that population (in this article we use the word suicide only to mean death by self-harm, excluding failed attempts at fatal self-harm). Many such changes result from reduced access to a means of suicide. In the United Kingdom of Great Britain and Northern Ireland, for example, the removal of carbon monoxide from the gas supply was associated with a reduction in the overall suicide rate. Introduction of catalytic converters, which reduced the amount of carbon monoxide emitted by car exhausts, was also associated with a fall in the overall incidence of suicide.

Sri Lanka is a developing country that once recorded very high suicide rates. During the period from 1985 to 1989, for example, the national suicide rate for males was the second highest in the world. Before 1960, hanging was the commonest method of suicide in Sri Lanka. In the 1960s, 75% of all suicides by poisoning were caused by ingestion of acetic acid, which was used in rubber processing. The national incidence of suicide rose rapidly between 1970 and 1995 and peaked at 47.0 suicides per 100 000 population in 1995. This increase, which was mainly attributable to pesticide-related deaths, coincided with the increasing pesticide imports that followed the adoption of open economic policies in 1977.

Since 1995 the incidence of suicide has gradually declined in Sri Lanka, although this encouraging trend has gone almost unnoticed. Globally, most suicides in low- and middle-income countries are caused by pesticide poisoning. It is estimated that 300 000 people die annually in Asia from pesticide ingestion. The general means of self-poisoning is very different in high-income countries, where analgesics, tranquillizers and other medicinal drugs are commonly used in overdose. Compared with pesticides, many such drugs are relatively non-toxic. The much higher case fatality rate (CFR) from pesticide poisoning (compared with that of medicinal drug overdose) is a major contributor to deaths from suicide in developing countries.

In the absence of any restriction on the availability of the methods previously used, method substitution in self-harm (i.e. the abandonment of one common method of self-harm and its substitution with another method) has not been widely reported. Although, as in many developing countries, pesticide poisoning is a major cause of death in Sri Lanka, medicinal drugs were found to be the commonest substances used by the self-poisoning patients investigated at a tertiary care hospital in the city of Colombo in 2007. We set out to investigate recent changes in the methods of self-harm in Sri Lanka – particularly the changes in the methods employed by people attempting suicide – and to explore if such changes could explain the substantial decline in suicide rates.

**Methods**

Data were collected for the period from 1995 to 2009. Data from the records of the Sri Lanka police force were used to calculate annual incidence rates of suicide. As a coroner’s inquest is conducted into every unnatural death in Sri Lanka, the police records on suicides were viewed as comprehensive. The data collected were for suicide by any method, suicide by poisoning and suicide by any method other than poisoning. Until the year 2002, when a new coding category was introduced, the cause of large numbers of unnatural deaths was simply classified as “other means”. Since the results of previous studies indicate that most such deaths by “other means” were the result of poisoning, they were all attributed to poisoning in the present analysis. Annual health statistics from the national ministry of health were used as the source of data...
on poisoning-related hospital admissions. Estimated mid-year populations for Sri Lanka were used to convert the collected data to annual incidence rates, which throughout this paper are given as the numbers of suicides or admissions for poisonings per 100 000 population.

The records of the Ministry of Health include data on the substances used in each case of poisoning. Since 1997, the Ministry of Health has classified each such poisoning according to the 10th revision of the International Classification of Diseases (ICD-10). For the present study, self-poisonings were separated into three categories: the toxic effects of pesticides (T60.0, T60.1 and T60.9); poisoning by drugs, medicaments and biological substances (T36–T50); and the toxic effects of other, “chiefly non-medicinal” substances, including solvents, halogen derivatives, corrosives, metals, gases and food (T51–T59, T61, T62 and T63.1–T65).

Statistical analysis

Trends in the incidence rates of suicide and self-poisonings were investigated using univariate time series analysis, with the recorded data fitted to linear, quadratic and exponential growth models using Minitab statistical software version 14.0 (Minitab Ltd, Coventry, England). Model adequacy was tested using the mean absolute percentage error (MAPE), a measure of how much a dependent series varies from its model-predicted level. As MAPE is independent of the units used, it can validly be used to compare series with different units.

Results

Trends in suicide

The annual incidence rates of suicide between 1995 and 2009 are shown in Fig. 1, the plotted lines indicating the overall trend and trends for suicides by poisoning or other methods. From a peak of 47.0 suicides per 100 000 in 1995, the overall rate had fallen by more than half, to 20.5 suicides per 100 000 in 2007. The incidence of hospital admission for any type of poisoning showed exponential growth (Y = 210.28 × 1.02^t), having increased from 204.8 admissions per 100 000 population in 1995 to a peak of 321.2 per 100 000 in 2007. The incidence of hospitalization for poisoning with medicinal and biological substances also showed exponential growth (Y = 30.43 × 1.11^t), from 48.17 admissions per 100 000 in 1996 to 115.39 per 100 000 in 2008. Similarly, hospital admissions due to the toxic effects of other, chiefly non-medicinal substances also showed an exponential increase, from 72.11 per 100 000 population in 1996 to 110.68 per 100 000 in 2008 (Y = 74.55 × 1.02^t). In contrast, the annual incidence of hospitalization for pesticide poisoning over the same period decreased in a linear fashion (Y = 106.58 – 1.32t), from 105.14 admissions per 100 000 in 1996 to 88.85 per 100 000 in 2008.

Trends in poisoning

The trends in hospital admissions due to poisoning, as recorded by the Ministry of Health, are shown in Fig. 2. Over the study period, the annual incidence of hospital admission for any type of poisoning showed exponential growth (Y = 210.28 × 1.02^t), having increased from 204.8 admissions per 100 000 population in 1995 to a peak of 321.2 per 100 000 in 2007. The incidence of hospitalization for poisoning with medicinal and biological substances also showed exponential growth (Y = 30.43 × 1.11^t), from 48.17 admissions per 100 000 in 1996 to 115.39 per 100 000 in 2008. Similarly, hospital admissions due to the toxic effects of other, chiefly non-medicinal substances also showed an exponential increase, from 72.11 per 100 000 population in 1996 to 110.68 per 100 000 in 2008 (Y = 74.55 × 1.02^t). In contrast, the annual incidence of hospitalization for pesticide poisoning over the same period decreased in a linear fashion (Y = 106.58 – 1.32t), from 105.14 admissions per 100 000 in 1996 to 88.85 per 100 000 in 2008.

Taken together – if we assume that, over the study period, cases of self-harm represented a large and fairly stable proportion of the people hospitalized for other, chiefly non-medicinal substances also declined over the study period but this trend was linear (Y = 2.71 – 0.13t). The corresponding incidences of fatal self-poisoning using drugs, medicaments and biological substances did not show a clear trend over time but ranged between 0.26 and 1.92 cases per 100 000.

Fig. 1. Trends in the annual incidence of completed suicides, Sri Lanka, 1995–2009

![Graph showing trends in the annual incidence of completed suicides, Sri Lanka, 1995–2009.](chart.png)
poisoning – these data suggest that the exponential increase seen in Sri Lanka in the incidence of self-harm by poisoning since the mid 1990s is mainly attributable to increased use for such poisoning of medicinal and biological substances and substances classified as “chiefly non-medicinal”, while self-harm due to pesticide poisoning has decreased.

**Case fatality rates**

Case fatality rates, expressed throughout this paper as deaths per 100 admitted cases, were calculated for each study year and each of the three main categories of substances used in self-poisonings (Fig. 3). Over the study period, the CFR for all types of poisoning showed a decreasing linear trend, with a drop from 6.13 deaths per 100 cases of poisoning in 1995 to 2.01 deaths per 100 in 2008. This trend could be described as \( Y_t = 6.97 - 0.35t \), where here \( Y_t \) is the CFR (in deaths per 100 cases) and \( t \) is, again, the number of years elapsed. The CFR for pesticide poisoning also showed a decreasing linear trend \( (Y_t = 11.18 - 0.37t) \); it peaked at 11.0 deaths per 100 admitted cases in 1997 and then gradually declined to 5.07 deaths per 100 in 2008. The CFR for poisoning by medicinal drugs and biological substances showed an exponential decline \( (Y_t = 2.95 \times 0.89^t) \), from 1.81 deaths per 100 cases in 1995 to just 0.51 deaths per 100 in 2008. Similarly, the corresponding CFR for poisoning by other, chiefly non-medicinal substances also showed an exponential decline over the study period (\( Y_t = 3.6 \times 0.91^t \)).

**Discussion**

**Main findings**

Sri Lanka is one of the few countries in the developing world to report a steady decline in suicide rates in the recent past. Our findings indicate that the exponential decrease seen in suicide rates in Sri Lanka since the mid 1990s is largely attributable to a decline in fatal self-poisonings, the incidence of suicides by non-poisoning methods having remained almost the same. Over the same period, the annual number of people hospitalized after pesticide poisoning has also declined, which suggests that the ingestion of pesticide as a method of self-harm has become rarer. The probability that a person admitted to hospital because of pesticide ingestion will survive the toxic effects has also increased. Nonetheless, self-poisoning has become more common overall, despite the reduction in pesticide ingestion, because medicinal drug overdose and poisoning by other substances classified as “chiefly non-medicinal” have become ever more frequently used for self-harm.

**Changing patterns of self-harm and suicide**

Several explanations for the decline in pesticide-related suicides must be considered. In 1990, the Food and Agriculture Organization recommended the safe storage of all pesticides and a ban on the use of highly toxic pesticides. The data collected in two previous studies indicate that in Sri Lanka the banning of pesticides in the Class I toxicity category of the World Health Organization (WHO) (in 1995) and of endosulfan (in 1998) could explain the decline in the CFR for pesticide poisonings and the decline in the incidence of suicide. However, since the CFR for non-pesticide poisonings has also been declining in Sri Lanka, it can be assumed that a general improvement in the medical management of poisoning has also contributed to the decline in the pesticide-related CFR. Since the 1990s, efforts have been made to develop and disseminate guidelines for the management of poisoning in Sri Lanka and to improve the training of clinicians in...
such management. Other factors that have certainly contributed to improving the survival of poisoning cases in Sri Lanka are the increased availability of antidotes in hospitals, improvements in the management of intensive care units and improvements in the road network and transport facilities (enabling quicker access to hospital).

The impact that the changing pattern of self-harm has had on the overall suicide rate in Sri Lanka has not been reported previously, perhaps because this has only become apparent in the past 8 years. Since 2003 there has been a decline in hospital admissions because of pesticide ingestion and an almost parallel increase in admissions because of medicinal drug overdose. Since 2005, the incidence of hospital admissions for drug overdose, like that for poisoning with other, chiefly non-medicinal substances, has been higher than for pesticide ingestion. Of the total admissions due to poisoning in 2008, for example, 36.64% were due to ingestion of "medicaments and biological substances", 35.15% to ingestion of "other, chiefly non-medicinal substances" and only 28.21% to pesticide ingestion. Thus, we see a gradual change in methods of self-harm in Sri Lanka with the increasing use of medicinal drugs, a pattern found primarily in developed societies.

How and why this change occurred needs to be explored. Social acceptability and availability have been cited as the main factors affecting the choice of method in self-harm. Easy availability may be particularly important in unplanned, impulsive attempts; of the 82 patients investigated in a recent study, all of whom had attempted suicide, almost 50% reported an interval of no more than 10 minutes between their first thought of suicide and their actual attempt. In Sri Lanka, no apparent restriction has been imposed on the general availability of pesticides over the period when suicide incidence has been declining. Between 1995 and 2000, pesticide consumption in Sri Lanka remained almost the same. The import of pesticide formulations has, in fact, increased, with approximately 3460 and 6210 tonnes imported in 2001 and 2005, respectively. Therefore, in Sri Lanka the change in the predominant substances used for self-poisoning, from those with high lethality (pesticides) to others with, in general, relatively low lethality, has occurred even in the absence of any apparent restriction on the general availability of pesticides.

In the past, most suicides in Sri Lanka were thought to result from impulsive attempts in people with low suicidal intent who, often unknowingly, used highly lethal methods. It is possible that, after widespread use of pesticide self-poisoning (as a suicide or parasuicide method) over several decades, the fact that pesticides are highly lethal is now general knowledge and therefore people with low suicidal intent choose other substances, such as medicinal drugs, for poisoning themselves. It is perhaps noteworthy that reduction in the use of pesticides for self-harm has not led to a corresponding increase in other, generally lethal methods, such as hanging.

Use of paracetamol and other medicinal drugs in overdose cases has mainly been reported from developed nations, such as Australia, European countries and the United States of America. In most developing countries, overdoses with such medicines are mainly reported in cities. Since the 1990s, however, the Hong Kong Special Administrative Region (SAR) in China and several Asian countries, such as Malaysia, Singapore and Viet Nam, have reported the increasing use of medicinal drugs in self-poisoning and this is now the most common mode of self-harm in urban areas of Malaysia and Viet Nam. There are, however, no corresponding reports of medicinal drugs replacing pesticides as the preferred method of self-harm. The rapid and extensive spread of a novel method of suicide in China (including the Hong Kong Special Administrative Region SAR and Taiwan, China) – the burning of charcoal to produce fatal amounts of carbon monoxide – has been attributed to extensive media coverage. On the other hand, in Sri Lanka the use of overdoses of paracetamol and other pharmaceutical agents for self-harm has not received much media coverage and the influence of the media on method substitution is therefore probably minimal.

The reason for the change in the main mode of self-harm in Sri Lanka, from pesticides to other substances, is still unclear. As discussed above, common reasons for a change in method of self-harm, such as restriction of method availability or extensive media attention, are unlikely to have played a major role. Qualitative research methods could be used to understand this change and future research could also look at geographical variation within the country in the choice of methods used, which might also help answer the above question. It would also be interesting to see if the incidence and methods of suicide have changed in other developing countries as they have in Sri Lanka. Identification of the factors that have contributed to the reduced use of pesticides as a method of self-harm in Sri Lanka would be beneficial in the development of suicide prevention programmes.

The findings of this study have several public health implications. Because of the reduction in the national incidence of suicide, the health authorities and policy-makers of Sri Lanka may slacken their efforts to implement interventions to prevent self-harm. Our analyses indicate that, although the annual numbers of deaths from poisoning have fallen since the mid 1990s, the incidence of self-harm has increased alarmingly. There is a need to identify and deal with the factors that lead to self-harm. The number of people who die from pesticide poisoning is still substantial, and efforts to prevent such poisoning and further reduce the related CFR need to continue. In addition, the health personnel of Sri Lanka need training in the effective management of medicinal drug overdose.

Limitations of this study

Questionable data accuracy is the main limitation of this study. Suicides are under-reported in many developing countries. The quality of data from Sri Lanka is classified as level 3 (i.e. only poor to fair) by the WHO. Ministry of Health data do not allow the relatively small numbers of admissions resulting from criminal poisoning or unintentional self-poisoning to be distinguished from admissions for intentional self-poisoning and these data include admissions to only government hospitals. Although the number of admissions to private hospitals for self-poisoning is likely to be small, these numbers were not included in the present analysis. Data for the north and the east of Sri Lanka are likely to be incomplete because of armed conflict in these areas during the study period. Many deaths from pesticides are misclassified as accidental or as deaths of undetermined cause. Despite these limitations, the suicide trends are clear.
This study has looked only at changes in methods of self-harm in Sri Lanka used; it has not looked at factors that may influence such behaviour, such as alcohol use or economic status.

**Competing interests:** None declared.

---

**Statistical Methods**

The study has looked at changes in self-harm and suicide and the methods used; it has not looked at factors that may influence such behaviour, such as alcohol use or economic status.

**Competing interests:** None declared.

---

**Statistical Methods**

The study has looked at changes in self-harm and suicide and the methods used; it has not looked at factors that may influence such behaviour, such as alcohol use or economic status.

**Competing interests:** None declared.

---

**Statistical Methods**

The study has looked at changes in self-harm and suicide and the methods used; it has not looked at factors that may influence such behaviour, such as alcohol use or economic status.

**Competing interests:** None declared.

---

**Statistical Methods**

The study has looked at changes in self-harm and suicide and the methods used; it has not looked at factors that may influence such behaviour, such as alcohol use or economic status.

**Competing interests:** None declared.

---

**Statistical Methods**

The study has looked at changes in self-harm and suicide and the methods used; it has not looked at factors that may influence such behaviour, such as alcohol use or economic status.

**Competing interests:** None declared.
Резюме

От пестицидов к лекарственным средствам: исследование методов самоповреждения в Шри-Ланке с помощью анализа временных рядов

Цель
Исследовать, можно ли объяснить снижение распространенности самоубийств в Шри-Ланке недавними изменениями методов самоповреждения.

Методы
Был проведен анализ временных рядов по показателям количества самоубийств и случаев госпитализации по поводу различных видов отравления.

Результаты
За период с 1996 по 2008 год ежегодная встречаемость случаев поступления в больницу по поводу отравления лекарственными средствами или биологическими веществами экспоненциально возросла, с 48,2 до 115,4 случая на 100 тыс. человек населения. За тот же период ежегодное количество случаев поступления в больницу по поводу отравления пестицидами снизилось со 105,1 до 88,9 случая на 100 тыс. человек. Произошло экспоненциальное снижение ежегодной встречаемости самоубийств, с пика в 47,0 случаев на 100 тыс. человек в 1995 году до 19,6 случая на 100 тыс. человек в 2009 году. На долю отравлений в 1995 году приходилось 37,4% самоубийств на 100 тыс. человек населения, а в 2009 году – только 11,2% самоубийств. Произошло линейное снижение коэффициента смертности от отравления пестицидами с 11,0 смертных случаев на 100 пациентов, поступивших в больницу, в 1997 году до 5,1 смертного случая на 100 пациентов в 2008 году.

Вывод
С середины 1990-х годов в Шри-Ланке среди лиц, стремящихся к самоповреждению, наблюдается тенденция к снижению злоупотребления пестицидами (несмотря на то, что доступность пестицидов не уменьшилась) и к росту использования лекарственных препаратов и других веществ. Эти тенденции и снижение смертности среди пострадавших от отравления пестицидами привели к общему уменьшению встречаемости случаев совершения акта самоубийства.

References


Varuni A de Silva et al.


