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| **Institution:** University of Edinburgh | | |
| **Unit of Assessment:** 1 | | |
| **Title of case study:** K: Demonstration of the ineffectiveness of 'safe storage' in preventing pesticide self-poisoning changes WHO policy and results in national bans on pesticides in rural Asia | | |
| **Period when the underpinning research was undertaken:** 2002 – 2019 | | |
| **Details of staff conducting the underpinning research from the submitting unit:** | | |
| **Name(s):** | **Role(s) (e.g. job title):** | **Period(s) employed by submitting HEI:** |
| Michael Eddleston | Personal Chair of Clinical Toxicology | 2005 – present |
| **Period when the claimed impact occurred:** 2017 – 2020 | | |
| **Is this case study continued from a case study submitted in 2014?** N, but case study REF2014/1/D covered earlier research on pesticide self-poisoning in rural Asia that led to a ban on the use of 3 pesticides in Sri Lanka. The impact described here results from new research proving that safe storage is ineffective at preventing pesticide suicides. | | |

## 1. Summary of the impact

**Underpinning Research:** Having built up a strong evidence base showing that regulation and banning of highly hazardous pesticides (HHPs) is the most effective way to prevent pesticide suicides in rural Asia, University of Edinburgh (UoE) researchers proved definitively that the industry-preferred method of 'safer storage' was ineffective at preventing pesticide suicides.

**Significance and Reach of Impact:** Since 2019, the World Health Organization (WHO) and the United Nations' Food and Agriculture Organization (FAO) have recommended pesticide regulation (bans) as a highly cost-effective approach to suicide prevention. In November 2020, the World Health Assembly accepted this recommendation, and it now forms an integral part of the WHO Menu of Cost-Effective Interventions for Mental Health.

As a result of UoE research, India, in 2018, and Nepal, in 2019, banned several HHPs. These bans will prevent an estimated 20,000 suicides per year when fully implemented, particularly in poor rural farming communities. Global removal of HHPs from agricultural practice following the new WHO and FAO advice, based on the Sri Lankan experience, has the potential to save 75,000 lives per year.

## 2. Underpinning research

**The Challenge: Pesticide self-poisoning kills approximately 150,000 people every year**
Pesticide self-poisoning is one of the most common means of suicide globally, killing approximately 150,000 people every year. Preventing pesticide suicides is important for achieving the suicide reduction targets included in the United Nations Sustainable Development Goals.

Most pesticide suicides occur in small-scale farming communities in low-and-middle-income countries, because farmers can purchase HHPs over the counter without controls and store them at home. This means that HHPs are easily available for people experiencing transient suicidal impulses during moments of crisis. Restricting access to HHPs would necessitate individuals choosing other forms of self-harm, typically with less lethal poisons and consequently a much higher chance of survival. There are two approaches to restricting access: 1) 'safer storage', which is preferred by the pesticide industry, but places the onus on the farming households to prevent suicides and 2) simply banning acutely toxic HHPs, which places the onus on governments to ensure lethal substances are not stored in homes. UoE research has examined the efficacy of both methods at preventing pesticide suicides in rural communities.

**Pesticide regulation plays a key role in suicide prevention in rural communities**
In 2002, Eddleston and colleagues established the first prospective cohort of patients with acute pesticide self-poisoning anywhere in the world, building up a strong body of evidence on the key

role of pesticides in suicide in rural Asia and effectiveness of available treatments. This led to the Sri Lankan Government banning the HHPs fenthion, dimethoate and paraquat in 2008–11 (reported in REF2014/1/D).

Since REF2014, Eddleston, in collaboration with Professor Gunnell (University of Bristol), has focused on the effectiveness of government action to regulate the availability of HHPs as a method to prevent pesticide self-poisoning. This work has shown that the bans of 3 HHPs in Sri Lanka led to dramatic reductions in overall (all method) suicide rates in Sri Lanka [3.1], and that pesticide bans in Bangladesh and South Korea have markedly reduced pesticide suicides. Between 1995 and 2015, Sri Lankan pesticide regulation was responsible for a >70% reduction in total suicides, saving an estimated 93,000 lives at a cost of USD1.3 per disability-adjusted life year [3.2]. Importantly, these pesticide bans had no apparent effect on the cost of agricultural inputs or outputs [3.3]. In 2017, Eddleston and Gunnell led a systematic review of the global literature, which confirmed the effectiveness of pesticide regulation for suicide prevention [3.4].

**Definitive clinical trial in 53,000 households showed 'safe storage' to be ineffective at preventing pesticide self-poisoning**

Despite these demonstrations that pesticide regulation was an effective method to prevent pesticide suicides, 'safe use and storage' of HHPs by farming communities remained the dominant approach to pesticide suicide prevention, promoted in particular by the pesticide industry, which did not want any of its products banned.

To establish definitively the real-word effectiveness of this 'safe use/storage' approach, Eddleston, in collaboration with Professor Konradsen (University of Copenhagen), was awarded a GBP1,000,000 Wellcome Trust grant to conduct a major community-based clinical trial comparing self-poisoning outcomes between 91 rural villages randomised to a "lockable household container" intervention group and a 91-village no-intervention control group. Over 6 years, 53,000 households in Sri Lanka (including 223,000 people) were recruited to this cluster randomised controlled trial. The results definitively proved the 'safe storage' approach to be ineffective, with no effect on the incidence of pesticide self-poisoning (rate ratio [RR] 0·93, 95%CI 0·80–1·08; p=0·33) [3.5]. There was no evidence of switching from pesticide self-poisoning to other forms of self-harm, and no difference in the number of suicides (RR 1·22, 0·88–1·68) or all suicide attempts (RR 0·97, 0·86–1·08).

In addition, during the clinical trial [3.5], UoE researchers noted that the pesticides carbosulfan and profenofos were responsible for more than 50% of pesticide suicides in rural Sri Lanka during 2014–16 and should now be the key target of regulation efforts [3.6].

**3. References to the research**

[3.1] Gunnell D, Fernando R, Hewagama M, Priyangika WDD, Konradsen F, Eddleston M. The impact of pesticide regulations on suicide in Sri Lanka. International Journal of Epidemiology 2007, 36: 1235-1242. doi:10.1093/ije/dym164

[3.2] Knipe D, Gunnell D, Eddleston M. Preventing deaths from pesticide self-poisoning - learning from Sri Lanka's success. Lancet Global Health 2017; 5: e651-e652 doi: 10.1016/S2214-109X(17)30208-5

[3.3] Manuweera G, Eddleston M, Egodage S, Buckley NA. Do targeted bans of insecticides to prevent deaths from self-poisoning result in reduced agricultural output? Environmental Health Perspectives 2008; 116: 492-95. doi: 10.1289/ehp.11029.

[3.4] Gunnell D, Knipe D, Chang SS, Pearson M, Konradsen F, Lee WJ, Eddleston M. Prevention of suicide with regulations aimed at restricting access to highly hazardous pesticides: a systematic review of the international evidence. Lancet Global Health 2017; 5: e1026-e1037. doi: 10.1016/S2214-109X(17)30299-1

[3.5] Pearson M, Metcalfe C, Jayamanne S, Gunnell D, Weerasinghe M, Pieris R, Priyadarshana C, Knipe DW, Hawton K, Dawson AH, Bandara P, de Silva D, Gawarammana I, Eddleston M, Konradsen F. Effectiveness of household lockable pesticide storage to reduce pesticide self-

poisoning in rural Asia: a community-based, cluster-randomised controlled trial. Lancet 2017; 390: 1863-1872. doi: 10.1016/S0140-6736(17)31961-X
[3.6] Weerasinghe M, Pearson M, Konradsen F, Agampodi S, Sumith JA, Jayamanne S, Senanayake SMHMK, Rajapaksha S, Eddleston M. Emerging pesticides responsible for suicide in rural Sri Lanka following the 2008-2014 pesticide bans. BMC Public Health 2020, 20:780. doi: 10.1186/s12889-020-08871-7

**Selected grant:**
[3.7] A community trial to determine whether 'Safe Storage' reduces pesticide self-poisoning in rural Asia 2010–16 (PI: Prof Eddleston) by Wellcome Trust (ref. 090958); GBP1,021,368.

## 4. Details of the impact

### Pathway to impact

In 2017, Eddleston established the Centre for Pesticide Suicide Prevention (CPSP; www.centrepsp.org) at UoE with a USD1,300,000 (GBP947,210; 01-21) Incubator Grant from the Open Philanthropy Project Fund. The CPSP uses the research in rural Asia to influence global pesticide policy and promote pesticide regulation for suicide prevention. Its initial work has focused on global policy with the WHO and FAO, and on national projects in Nepal, India, and Sri Lanka, leading to significant international and national policy and practice change.

### Impact on policy and guidelines

In 2016, the 3rd edition of Disease Control Priorities (DCP-3), published by the University of Washington, identified pesticide regulation as a probable highly effective approach to reduce non-communicable diseases, based on UoE research (see panel 2, p.1680, [5.1]). However, at this point, 'safe storage and use' of pesticides, based on industry-funded work and pilot studies, continued to also be encouraged as a life-saving alternative to pesticide bans [5.2].

The UoE-led randomised controlled trial [3.5], which definitively showed a lack of effect from 'safe storage', led to a major switch in WHO focus, from 'safe storage' to pesticide regulation. In 2019, the WHO Mental Health Unit collaborated with the FAO to publish a guideline for pesticide registrars and regulators on how they could prevent suicides through effective regulation [5.3]. The Head of the WHO Unit states: "*Research work led by Professors Eddleston (Edinburgh) and Gunnell (Bristol) has been seminal in helping WHO formulate its strategy to attain the suicide reduction target within the United Nations Sustainable Development Goals (UN SDGs). Their empirical findings and systematic review concerning the effectiveness of national pesticide regulations in preventing suicide, and the relative ineffectiveness of lockable storage devices in pesticide suicide prevention, informed us to produce the booklet "WHO/FAO Preventing suicide: a resource for pesticide registrars and regulators (Geneva 2019)*". This booklet concludes, citing paper [3.1]: *"For suicides by pesticide poisoning, regulations to ban the most toxic products are the most effective approach to reducing deaths"* [p. 20; 5.3].

### Impact on WHO's Menu of Cost-Effective Interventions for Mental Health

Building on this work, in 2019, the WHO assessed the cost-effectiveness of bans of several HHPs as a means of suicide prevention in 14 countries. Eddleston contributed technical expertise and data to this modelling exercise [5.4a] and was a co-author on the report [5.5]. The assessment found that banning HHPs could result in up to 28,000 fewer suicide deaths each year across the 14 countries at an annual cost of USD0.007 per capita. The report concluded that national bans are cost-effective in countries where pesticide self-poisoning accounts for a high proportion of suicides, and are among the most cost-effective mental health interventions evaluated [5.4a; 5.5].

The Head of the WHO Mental Health Unit confirms [5.4a] that this cost-effectiveness analysis informed the WHO's first draft of the Menu of Cost-Effective Interventions for Mental Health [5.4b], such that regulatory bans on the use of HHPs were included as one of 3 population-wide interventions that could contribute to preventing suicides. The draft Menu was approved by the WHO Executive Board in December 2019 [5.4c], and subsequently formally accepted at the World

Health Assembly in November 2020 [5.4a]. Thus, directly informed by UoE research, pesticide regulation now forms an integral part of the WHO's plan to reduce suicides worldwide.

Of note, bans of HHPs do not mean that farmers cannot use any pesticides: Eddleston's earlier proposal for a minimum pesticides list (Eddleston *et al* 2002 Lancet 360: 1163–67) has directly informed an influential analysis, funded by agricultural non-governmental organisations, the US Department of Agriculture, the US Agency for International Development, and the FAO (amongst others). Published in 2020, this proposes, for the first time, a systematic method to implement a minimum pesticide list and outlines lower-risk candidate compounds that could be used instead of HHPs to protect crops while reducing risks to human bystanders, aquatic and terrestrial wildlife and pollinators [5.6].

**Impact on practice: national bans in Nepal, India and Sri Lanka**

In Nepal, discussion with the CPSP and provision of clinical data from UoE on HHPs being used for suicides in Nepal resulted in bans of 5 organophosphorus and carbamate pesticides in 2019. The Chief of the Plant Quarantine and Pesticide Management Centre (Nepalese Ministry of Agriculture and Livestock Development) testified: "*In part due to these conversations, the Pesticide board took the decision in February 2019 to ban 5 highly hazardous pesticides, including dichlorvos, from agricultural use. These represent all the WHO Class I pesticides that were still being use [sic] in Nepal. We believe that these bans will reduce suicides and episodes of severe occupational poisoning in the country*." [5.7].

They further state: "*Further discussions with the Centre for Pesticide Suicide Prevention informed us that a marked reduction in suicides from aluminium phosphide had occurred in India after the standard 56% pure 3g tablets were banned and replaced by a lower concentration powder. After review of data […] a decision was made to ban these 3g tablets in Nepal. Again, we believe that we will see a marked reduction in suicides as a result of this decision"* [5.7].

In April 2018, the Indian Supreme Court instructed the Department of Agriculture to decide whether to ban 18 HHPs following public interest litigation put forward by the Indian non-governmental organisation Alliance for Sustainable & Holistic Agriculture. CPSP was then invited by the Alliance to prepare a submission to the Department of Agriculture on the benefits of such bans for suicide prevention [5.8a]. In August 2018, the Department of Agriculture banned 12 HHPs with immediate effect and a further 6 with effect in 2020 [5.8b]. Several of these pesticides had been shown by UoE research to be extremely toxic and key for pesticide suicides in India and responsible for hundreds of thousands of deaths in the country (paragraphs 26–43 of [5.8a]).

A report to the Sri Lankan government of the 2 key pesticides responsible for suicide in rural areas (carbosulfan and profenofos, as identified in [3.6]) resulted in a request from the Ministry of Defence to the Department of Agriculture to ban these pesticides [5.9a]. Such as ban was also supported by the Sri Lanka Medical Association Expert Committee on Suicide Prevention, which in December 2019 published a policy document recommending bans for carbosufan and profenofos, citing papers [3.2] and [3.4], the WHO/FAO guideline [5.3] and data provided by Eddleston as a special adviser [5.9b].

**Impact on health and welfare**

Limiting easy access to lethal means by banning HHPs means that the self-harm that does occur is much less likely to result in death, allowing people to survive their transient suicidal impulse and obtain the support they need from family, community and mental health services. UoE's body of research since 2002 has proven that banning HHPs and thus restricting access to highly lethal means for suicide prevents suicides. Continued global regulation of pesticides to remove HHPs from poor smallholder farms in low-and-middle-income countries will further and rapidly reduce pesticide suicide and, where pesticide poisoning is common, total suicide rates.

In Sri Lanka, the ban on 3 pesticides in 2008–2011, reported in REF2014, was estimated to save an estimated 900 lives per year by 2015 [5.10]. The Indian and Nepalese bans are only now being

implemented and their effects will start being seen in the next few years. Approximately 1,200 and 72,000 pesticide suicides occur annually in Nepal and India, respectively. These national bans are predicted to reduce pesticide suicide rates by 40% and 25–30%, respectively, conservatively resulting in an overall reduction of approximately 20,000 deaths per year.

Removal of HHPs from agricultural practice following the new WHO and FAO advice, will, based on the Sri Lankan experience [3.2], result in pesticide suicides globally falling by more than two-thirds each year, from 150,000 per year to fewer than 50,000. Over 10 years, this reduction will save an estimated mean of 75,000 lives per year.

**5. Sources to corroborate the impact**

[5.1] Patel V, et al; DCP MNS Author Group. Addressing the burden of mental, neurological, and substance use disorders: key messages from Disease Control Priorities, 3rd edition. Lancet 2016, 387:1672–85. doi: 10.1016/S0140-6736(15)00390-6
[5.2] Evidence that 'safe storage' was previously a widely recommended and adopted approach to prevent pesticide suicide
a. Report on the International Workshop on Secure Access to Pesticides in Conjunction with the Annual Congress of the International Association for Suicide Prevention, Durban, South Africa, September 12, 2005 (sponsored by Syngenta Crop Protection).
b. WHO 2016. Safer access to pesticides for suicide prevention: Experiences from community interventions.
[5.3] WHO/FAO 2019. Preventing suicide: a resource for pesticide registrars and regulators Geneva [citing 13 UoE papers out of 41 references].
[5.4] Pesticide regulation added to WHO Menu of Cost-Effective Interventions for Mental Health
a. Testimonial from the Head of WHO Mental Health Unit, 14 Dec 2020
b. WHO Discussion Paper 1 (Sept 2019). Draft Menu of Cost-Effective Interventions for Mental Health.
c. WHO Executive Board decision to promote the ban on HHPs at the 73rd World Health Assembly
[5.5] Lee YY, Chisholm D, Eddleston M, Gunnell D, Fleischmann A, Konradsen F, Bertram MY, Mihalopoulos C, Brown R, Santomauro DF, Schess J, van Ommeren M. The cost-effectiveness of banning highly hazardous pesticides to prevent suicides due to pesticide self-ingestion across 14 countries: an economic modelling study. Lancet Global Health 2020, doi: 10.1016/S2214-109X(20)30493-9
[5.6] Jepson PC, Murray K, Bach O, Bonilla MA, Neumeister L. Selection of pesticides to reduce human and environmental health risks: a global guideline and minimum pesticides list. Lancet Planet Health 2020; 4: e56–63. doi: 10.1016/S2542-5196(19)30266-9
[5.7] Testimonial from Pesticide Registrar, Nepal
[5.8] Supporting information regarding the Indian Supreme Court submission on pesticide bans
a. Centre for Pesticide Suicide Prevention Expert Submission "Banning highly hazardous pesticides in India will save lives and reduce total suicide numbers" to Ministry of Agriculture & Family Welfare, Government of India (May 2018)
b. The Gazette of India List of Prohibited Pesticides. Ministry of Agriculture & Farmers Welfare Notification (August 2018) [English notification from p.5]
[5.9] a. Letter from the Sri Lankan Ministry of Defence to the Department of Agriculture, requesting a ban of carbosulfan and profenofos. b. Policy document by the Sri Lanka Medical Association Expert Committee on Suicide Prevention, December 2019
[5.10] Knipe DW, Chang SS, Dawson A, Eddleston M, Konradsen F, Metcalfe C, Gunnell D. Suicide prevention through means restriction: impact of the 2008-2011 pesticide restrictions on suicide in Sri Lanka. PLoS One 2017, 12: e0172893. doi: 10.1371/journal.pone.0172893