

**Suicide by pesticide poisoning in Taiwan, the impact of bans on toxic pesticides,
and potential prevention strategies: a pilot study**

Project term: 1st April 2018 – 31st March 2019,
with the 1st extension from 1st April 2019 – 31st December 2019

Funded by Centre for Pesticide Suicide Prevention (CPSP), University of Edinburgh

Final report

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A. Summary

Suicide by pesticide poisoning is amongst the leading methods of suicide globally and in Taiwan. Banning highly hazardous pesticides (HHPs) has the potential to save hundreds of thousands of lives. This project (April 2018 – December 2019) is aimed to collect and analyse data for people who died by or attempted suicide using pesticides in Taiwan to inform future global and local suicide prevention strategies. Specifically, it is aimed to collect and analyse i) national mortality data for suicide, ii) hospital records of pesticide self-poisoning, and iii) data from interviews with suicide attempters. In the project we also aim to raise awareness and promote policy making in support for bans on HHPs to prevent pesticide suicides in activities such as publishing opinion pieces in newspapers or online platforms or giving talks in conferences, workshops, or round tables.

In this final report, we summarised the progress and major achievements between April 2018 and December 2019, as follows:

- i) We completed data analysis of 8,713 pesticide suicides using Taiwan's cause-of-death data files for 1987, 1992, 1997, and 2002-2012 during the first year of the project April 2018 – March 2019.
- ii) We completed hospital record data extraction for 1,479 patients as of 31st December 2019 (504 patients in the first year of the project April 2018 – March 2019 and 975 patients in the extension period April – December 2019). Data were extracted for patients who self-poisoned using pesticides and were treated in eight study hospitals in North, Middle, South, and East Taiwan in 2000-2019.
- iii) We interviewed ten patients who self-poisoned using pesticides.
- iv) The PI was involved in following activities that contributed to raising awareness of and supporting the pesticide regulation policies – published three articles in support of the paraquat ban policy in national newspapers in Taiwan in March and June 2019 and February 2020 (Appendices 1,2 and 4); published an editorial in support of the paraquat ban in *Taiwanese Journal of Psychiatry* (Appendix 3), the official journal of the Taiwanese Society of Psychiatry; gave a talk on banning HHPs to prevent suicide at an international conference in Tainan, Taiwan, in April 2019, attended by nearly 50 mental health professionals from nine Southeast/South Asian and Oceanic countries (Appendix 4), and another talk on the same topic at Hospital Bahagia, Ipoh, Malaysia, on 23rd July 2019 (Appendix 6); attended meetings with Malaysian research collaborators to discuss potential projects of pesticide suicide surveillance and prevention in Ipoh, Malaysia, in July 2019 (Appendix 6); and supervised a research assistant to give a presentation based on findings from this project at the annual conference of Taiwanese Society of Psychiatry in Taipei, Taiwan, in November 2019 (Appendix 7).

Data collected in this project showed that paraquat was the leading pesticide used in both fatal and non-fatal pesticide self-poisonings in Taiwan. Paraquat poisoning accounted for at least 4% of total suicides in the country and as high as 14% in some rural counties. 32% of all hospital presentations of pesticide self-poisoning and 77% of deaths in our hospital sample were due to paraquat poisoning, with a high case fatality ratio of 60%, compared to 9% for all other non-paraquat pesticides combined. The characteristics of paraquat self-poisonings and non-paraquat pesticide self-poisonings, either fatal or non-fatal, were similar in sex and seasonal patterns, whilst those using paraquat were younger than those using other pesticides. Interviews with ten patients indicated impulsivity in the majority of the patients - 50% of them spent less than 10 minutes between suicidal ideation and attempt.

The Taiwanese government implemented a complete ban on paraquat from February 2020; it is expected to be followed by a marked reduction in the number of deaths caused by pesticide self-poisoning based on findings from this project. The overall suicide rates may also decrease in some rural areas. However, it is important to continue to monitor the trends and characteristics of pesticide self-poisonings and the type of pesticides involved, using data from national mortality data files and hospital presentations. This project demonstrated that it is feasible to collect detailed, systematic, and comprehensive information of pesticide self-poisoning from these data sources. Such information can provide the much needed evidence to inform local and global suicide prevention strategies and clinical practices to avoid many tragic deaths. Future research is needed to continue such endeavours.

B. Project description

Suicide by pesticide ingestion is a leading method of suicide globally. It is estimated that it causes 110,000-170,000 deaths annually, which accounts for 14%-20% of global suicides (Mew et al., 2017). Banning highly hazardous pesticides (HHP) may save hundreds of thousands of lives (Gunnell et al., 2017).

Over the past 15 years, pesticide ingestion is the third most common method of suicide in Taiwan, taking 450-500 lives per year (Chang et al., 2012). Paraquat is believed to be the pesticide that causes most deaths (around 150-200 deaths per year) (Chang and Gunnell, 2019; Lin et al., 2010). Studies from other countries showed that a ban on paraquat was followed by a decrease in pesticide poisoning related suicide rates and overall suicide rates in South Korea (Cha et al., 2016) and Sri Lanka (Knipe et al., 2017).

At the start of the project in April 2018, the Taiwanese government already banned the import and production of paraquat from 1st February 2018 and planned to completely ban the sale and use of paraquat from 1st February 2019. However, on 30th January 2019, the government announced to delay the complete ban for one year and the revised date to implement the ban was postponed to 1st February 2020. The reason given for the delay was a substantial amount of paraquat stored at farming households and pesticide vendors. It was estimated that it would take one more year for the paraquat stored to be used up. On 1st February 2020, the complete ban on paraquat, including its import, production, sale, and use, finally became effective as scheduled in Taiwan.

It is important to collect data regarding suicide by pesticide poisoning before and after the paraquat ban and evaluate the effect of Taiwan's new regulation on paraquat implemented in 2020; the data will inform suicide prevention strategies not only in Taiwan and but also globally.

This project is important for improving regulations and policies related to highly hazardous pesticides, such as paraquat. It is aimed to collect and analyse i) national mortality data, ii) hospital records, and iii) data from interviews with suicide attempters. The study will provide important insight into the burden, distribution, and characteristics of suicide by pesticide self-poisoning and the impact of HHP bans in Taiwan to inform local and global prevention strategies to reduce pesticide suicides.

In this pilot project the Centre for Pesticide Suicide Prevention (CPSP), University of Edinburgh, provided funds to support data collection and analysis in hospitals where the ethics approvals have been obtained. In the next stage, depending on the approval by Taiwanese or international funding agencies, a project with wider stakeholders and partner base will be started, and data will be collected from additional hospitals and other institutions.

C. Expenditure and financial report

Table 1 shows a summary of the income and expenditure.

Table 1. Income and expenditure (April 2018 – December 2019).

Item	Amount (USD)	Note
Income	38,500 (100%) = 10,000 (1st installment) + 10,000 (2nd installment) + 2,000 (3rd installment) + 8,250 (4th installment) + 8,250 (5th installment)	<p>The first installment of the grant (USD 10,000) was transferred to the account of College of Public Health and became available for use on 12th July 2018.</p> <p>The second installment of the grant (USD 10,000) was transferred to the account of College of Public Health and became available for use on 3rd December 2018.</p> <p>The third installment of the grant (USD 2,000) was transferred to the account of College of Public Health and became available for use on 22th April 2019.</p> <p>The fourth installment (USD 8,250) was transferred to the account of College of Public Health and became available for use on 21th May 2019.</p> <p>The fifth installment (USD 8,250) was transferred to the account of College of Public Health and became available for use on 4th September 2019.</p>
Expenditure	38,500 (100%)	
Research assistant salary	31,517	<p>Ms Chiyuan Chen (USD 16,720; full-time during August 2018- June 2019)</p> <p>Ms Yun-Jen Chang (USD 1,4220; full-time during January, February, and July to December</p>

		2019)
General expenses	6,983	Dr Hwei Yuen Chang (USD 577; part-time in October 2018) Ethical review fees (USD 171; Saint Mary's Hospital Luodong and E-Da Hospital) One desktop computer and one laptop computer for data analysis and collection (USD 1,852) Overhead for National Taiwan University (USD 3,850) Travel to study hospitals (USD 830) Participant fee (USD 30) Consumables such as stationeries (USD 250)
Balance	0 (0%)	

The total income during April 2018-December 2019 is USD 38,500, in five installments. By December 2019, the total expense is USD 38,500 and the balance is USD 0.

Ms Chiyuan Chen was employed full-time to the project during August 2018-June 2019. Ms Chen has a background in psychiatric nursing. She travelled to three hospitals in North, East, and South Taiwan extracting data for pesticide self-poisoning hospital presentations.

Ms Yun-Jen Chang was employed full-time to the project during January, February, and July to December 2019. Ms Chang has a background in psychiatric nursing. She will continue to extract data from study hospitals.

Dr Hwei Yuen Chang was employed part-time to the project during October 2018. She helped with data analysis and writing up a manuscript of the nationwide pesticide and paraquat suicide study in preparation for submission to academic journals. She presented the findings at the 58th Annual Conference of the Taiwanese Society of Psychiatry in Taipei, Taiwan on 2nd November, 2019 (see the abstract in Appendix 7).

D. Results

With support from the grant from the Centre for Pesticide Suicide Prevention (CPSP), University of Edinburgh, we successfully completed the works below, which were summarised into three studies.

1. Activities to raise awareness and promote policy making in support for bans on HHPs to prevent pesticide suicides.

- i. At the start of the project in April 2018, the Taiwanese government already banned the import and production of paraquat from 1st February 2018 and planned to completely ban the sale and use of paraquat from 1st February 2019. However, on 30th January 2019, the government announced to postpone the complete ban for one year and the start date of the complete ban was changed to 1st February 2020. The reason given for the delay was a substantial amount of paraquat stored at farming households and pesticide vendors. It was estimated that it would take one more year for the paraquat stored to be used up. The government also stated that its policy of banning the herbicide would remain unchanged despite the delay. The PI, with co-author Prof Ying-Yeh Chen, published an article in a national newspaper entitled “Paraquat ban must be implemented”, commenting on the delay in banning paraquat and arguing that the ban must be implemented in 2020 as scheduled to save lives (Appendix 1) (Chang et al., 2019-3-6).
- ii. In June 2019, two potential presidential candidates from the opposition party criticised the paraquat ban saying that it will substantially increase farmers’ cost and arguing for careful management rather than a ban of paraquat. The Council of Agriculture responded that the scheduled ban will remain unchanged as paraquat is highly toxic and alternative, lower toxicity herbicides and chemicals are now available for the purposes of weed killing and harvest aid. The debate attracted substantial media attention and commentaries against or for the paraquat ban policy. To contribute to the debate, the PI, with co-author Prof Ying-Yeh Chen, published an article in support of the paraquat ban in a national newspaper (Appendix 2) (Chang and Chen, 2019-6-19).
- iii. Due to the media attention on the debate of paraquat ban policy, the PI was invited by the Taiwanese Journal of Psychiatry, the official journal published by the Taiwanese Society of Psychiatry, to write an editorial commenting on the paraquat ban. The editorial, entitled “Banning Paraquat Would Prevent Nearly 200 Deaths from Suicide per Year in Taiwan”, by the PI and co-author Prof David Gunnell, appeared in the September issue of the Journal (Appendix 3) (Chang and Gunnell,

- 2019).
- iv. The ban on paraquat was eventually implemented as scheduled in Taiwan, effective from 1st February 2020. Taiwan government announced that use or sale of the banned paraquat products will lead to a maximum fine of New Taiwan Dollar 150k (around USD 5000), and sale could lead to a maximum fine of New Taiwan Dollar 5m (around USD 167k) and imprisonment of maximum five years. Taiwan government suggested alternative pesticides and chemicals for the purpose of weed killing or harvest aid, and subsidized one chemical (nonanoic acid) as a desiccant to aid the harvest of Adzuki bean.
 - v. The PI, with co-author Prof Ying-Yeh Chen, published an article in a national newspaper entitled “What the government needs to do after banning paraquat”, commenting on paraquat ban and suggesting measures that local governments can take to enhance the suicide prevention effect (Appendix 4) (Chang and Chen, 2020-2-2). In the article we shared evidence for initial possible effect of the paraquat ban – in 2018, when the first stage of the ban on paraquat import and production became effective from 1st February, this was followed by an initial increase but a later marked drop in paraquat sale. In keeping with the decrease in sale amount of paraquat, the number of deaths from paraquat poisoning dropped to 185 in the same year (2018), compared to an average of 221 per year in 2015-2017.
 - vi. The PI was invited to give a talk entitled “Monitoring suicide trends to inform suicide prevention strategies, with a focus on preventing pesticide suicide”, at the 1st Research and Education Center of Bridging Asian Mental Health and Psychiatry (REBAMP) conference at National Cheng-Kung University, Tainan, Taiwan on 27th April, 2019 (Appendix 5). The conference was funded by Taiwan’s Ministry of Health and Welfare to promote exchanges in research and education between mental health and psychiatric researchers and practitioners from Taiwan and Southeast / South Asian and Oceanic countries. The conference participants are nearly 50 mental health researchers / professionals from nine Southeast/South Asian and Oceanic countries (Australia, Thailand, Malaysia, Cambodia, Indonesia, the Philippines, Vietnam, Bangladesh, and India). The PI’s talk contributed to the dissemination of evidence in support of bans on HHPs to prevent suicide to international audience from countries where pesticide self-poisoning is a major public health issue.
 - vii. In a research trip to Malaysia in July 2019, the PI met up with Malaysian collaborators Dr Lai Fong Chan (associate professor at Department of Psychiatry, National University of Malaysia, Dr Ying Pin Ng (psychiatrist in private practice), and Dr (Vicky) Tsui Huei Loo (consultant psychiatrist at Ipoh Hospital). In the trip the PI discussed potential research collaborations with Malaysian colleagues to develop a pesticide suicide surveillance project similar to this project, using hospital data from

Ipoh Hospital and death registries from forensic services in the Perak State. The PI joined research meetings attended by physicians and forensic specialists at Ipoh Hospital. Accompanied by Malaysian psychiatrist colleagues, the PI also visited staff at Pesticide Action Network Asia and the Pacific (<http://pan-international.org/asiapacific/>) and shared perspectives and experiences on pesticide regulations. The PI gave an invited talk entitled “Monitoring suicide trends to inform suicide prevention strategies, with a focus on pesticide suicide” at Hospital Bahagia, the largest psychiatric hospital in Malaysia, to share evidence and experiences on preventing pesticide suicide with staffs at Hospital Bahagia. These activities were summarised in Appendix 6.

- viii. Ms Hwei Yuen Chang, a former research assistant of this project, gave a presentation entitled “The epidemiology of suicide by pesticide poisoning, with a focus on paraquat poisoning, in Taiwan (1987-2012): trends, geographic variations, and characteristics”, at the 58th Annual Conference of the Taiwanese Society of Psychiatry at National Taiwan University, Taipei, Taiwan on 2nd November, 2019 (Appendix 7) (Chang et al., 2019). Ms Chang presented findings from this project regarding trends, geographic variations and characteristics of suicide by pesticide and paraquat poisoning in Taiwan.

E. Conclusions

1. Paraquat was the leading pesticide used in both fatal and non-fatal pesticide self-poisonings in Taiwan. The characteristics of paraquat self-poisonings and non-paraquat pesticide self-poisonings, either fatal or non-fatal, were similar in sex and seasonal patterns, whilst those using paraquat were younger than those using other pesticides.
2. Based on data for 1,479 patients who ingested pesticide and were treated in eight hospitals across Taiwan (2000-2019), paraquat was the leading pesticide amongst both fatal and non-fatal pesticide self-poisonings. The case fatality ratio of paraquat self-poisoning was the highest (60.3%; 284/471) in all pesticides, compared to 8.6% for all other non-paraquat pesticides combined. Other pesticides commonly used in self-poisoning included glyphosate (glyphosate, glyphosate IPA, and glyphosate ammonium combined; n=182; 12.3%), chlorpyrifos (n=79; 5.3%), and permethrin (n=75; 5.1%); their case fatality was much lower than that of paraquat (7.7%, 10.1%, and 2.7%, respectively).
3. Compared with patients who ingested other non-paraquat pesticides, those who ingested paraquat were younger; more likely to be unmarried or divorced, have higher educational level, be active in the labour force, smoke, drink, chew areca nut, have lower risk of having chronic illness or cancer than those using other pesticides, ingest only one type of pesticide, ingest fewer amount of pesticide, and have depressive or adjustment disorders.
4. The numbers of both fatal and non-fatal self-poisonings using paraquat in Taiwan are expected to fall substantially after the ban on the sale and use of paraquat effective from February 2020. This will also lead to a substantial fall in overall case fatality of pesticide self-poisonings and the number of deaths resulted from pesticide poisoning, particularly in some rural areas where paraquat accounted for as many as 14% of total suicide deaths.
5. The project demonstrated that it is feasible to collect detailed, systematic, and comprehensive information of pesticide self-poisoning based on hospital presentation data and death registry. Such information can provide the much needed evidence to inform local and global suicide prevention strategies and clinical practices to avoid many tragic deaths from pesticide ingestion, a leading method for suicide worldwide.

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G. Appendix

Appendix 1. An article by Dr Shu-Sen Chang and Prof Ying-Yeh Chen commenting on Taiwanese government's policy to ban paraquat, published in Taipei Times on 6th March 2019 (Chang et al., 2019-3-6).

Paraquat ban must be implemented

<http://www.taipeitimes.com/News/editorials/archives/2019/03/06/2003710926/1>

By Chang Shu-Sen and Chen Ying-Yeh

The Council of Agriculture had scheduled a full ban on the use of paraquat that was to take effect on Feb. 1, but in a last-minute announcement, it postponed the ban for a year, saying that its policy of eliminating the highly toxic herbicide remains unchanged.

Banning paraquat would protect human lives and reduce the number of suicides, but there is concern that if the ban keeps getting pushed back, it will continue to cause more than 200 deaths per year, bringing everlasting grief to families and causing great losses to farming villages and society at large.

Hopefully, the council will ban paraquat as scheduled next year and suggest complementary measures, including the promotion of alternative pesticides and helping farmers recycle paraquat.

From 2003 to 2017, more than 2,600 people in Taiwan — one every two days — died of paraquat poisoning. The number peaked in 2017 with 227 deaths. Had paraquat been banned earlier, many innocent lives could have been saved.

It is not the only defoliant, and many alternative pesticides are much safer. The council is developing an alternative way to defoliate red bean plants before harvesting, which farmers would receive a subsidy for using.

It is easy to see how the ban would reduce suicides: Paraquat is far more toxic than other herbicides and ingesting even a small amount could cause a painful death. Other pesticides have lower toxicity and people who ingest them could be cured after receiving medical treatment.

Some people think that the government should tighten regulations on paraquat to license its use rather than banning it, but this will not prevent people from using it to commit suicide. Of the people who attempted to end their lives by ingesting paraquat, 60 percent used what was stored in their home. Only an outright ban could prevent the use of paraquat as a suicide method.

A tragic lesson can be learned from Malaysia, where the government prohibited the use of

paraquat in 2005 and 2006, but then lifted the ban on limited use, allowing farmers to continue to stock the herbicide.

The number of people who died from paraquat poisoning soared from 34 in 2006 to 187 in 2015, Malaysian National Poison Center data showed.

From 2013 to 2017, Changhua County had the highest number of deaths by paraquat at 126, followed by 89 in Yunlin and Pingtung counties. The highest proportion of paraquat deaths in relation to all suicides was recorded in Taitung and Hualien counties, where it was the cause of one in five to six suicides. High proportions were also found in Yilan, Changhua, Yunlin and Chiayi, where it accounted for one in seven to eight suicides.

A ban on paraquat is expected to have the most positive effect in these counties. The sooner paraquat is recalled, the quicker the nation will see a reduction in suicides.

Local health and agricultural bureaus should collaborate to intensify the promotion of the ban and help farmers return paraquat to vendors or to local farmers' associations for handling. They could also cooperate with local environmental protection bureaus to provide farmers with incentives to encourage them to return paraquat containers.

For example, the Yilan County Environmental Protection Bureau holds an annual competition for pesticide bottle returns and offers prize money to encourage farmers, farmers' associations and vendors to join the effort. Environmental protection bureaus could also provide bottle cleaning guidance and publicize information about recycling sites.

The central government should work to improve the Methods and Facilities Standards for the Storage, Clearance and Disposal of Waste Containers (廢容器回收貯存清除處理方法及設施標準), which only stipulates the methods for recycling waste pesticide containers, but not pesticides.

To achieve its promise of halving pesticide use by 2027, the council could consider working with the Environmental Protection Administration to establish a mechanism for managing pesticide recycling. Local environmental protection bureaus could coordinate with pesticide businesses and farmers' associations to recycle bottles and their contents at the same time.

About 400 to 500 people die from pesticide poisoning every year, of whom 40 percent used paraquat. To create a safer and healthier living environment in disadvantaged farming villages, people should show concern for the issue and monitor the timely implementation of the government's ban and subsidies.

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Appendix 2. An article (originally in Chinese) by Dr Shu-Sen Chang and Prof Ying-Yeh Chen supporting Taiwanese government's policy to ban paraquat, published in Liberty Times on 19th June 2019 (Chang and Chen, 2019-6-19).

The most lethal pesticide

<https://talk.ltn.com.tw/article/paper/1297012>

By Chang, Shu-Sen and Chen, Ying-Yeh

Recently, Terry Gou and Han Kuo-yu (two potential presidential candidates) criticized the government's policy to ban paraquat in their campaigns. The Taiwanese government has banned several highly toxic pesticides over the last two decades, and the policy to ban paraquat is a continuation of such endeavour aimed to protect the safety of farmers, their families, and the community particularly in the rural areas. It is a vital policy that needs to be implemented immediately. In the "Suicide Prevention Act" passed by the Legislative Yuan in May earlier this year, it was stated more clearly that "the authorities at all levels should establish mechanisms to reduce the chances that people obtain and use high-fatality means for suicide."

Paraquat self-poisoning leads to more than 200 deaths per year in Taiwan. Over the past 15 years, more than 2,600 people died from paraquat poisoning, and an estimated 10,000 or more family members and friends were affected. It is the single pesticide that causes the most deaths in Taiwan. Paraquat has high toxicity to human, and there is no antidote for paraquat poisoning. A mouthful of paraquat can cause respiratory failure and painful death. Moreover, long-term exposure to paraquat may lead to neurotoxicity and Parkinson's disease. A ban on paraquat and shift to low-toxicity alternative pesticides can prevent tragic deaths and protect health.

Second, pesticide self-poisoning is usually impulsive. If the pesticide used for ingestion happens to be paraquat, the person who self-poisons is unlikely to get a chance.

Third, paraquat is neither the only available nor the best-selling herbicide in Taiwan. Namely, there are alternative herbicides available. Meanwhile, paraquat may need to be applied several times to kill the weed; it may not be that economically efficient as felt.

Last but not least, more and more countries have banned paraquat. To be more specific, more than 50 countries have already banned paraquat worldwide. Taiwan's neighbouring countries that have banned or announced to ban paraquat include South Korea (since 2012), Vietnam (since 2017), Malaysia (from 2020), China (paraquat solution banned since 2017; water-soluble paraquat gel to be banned from 2020, without banning production and exportation). If Taiwan continues to allow the use of paraquat, it will be ridiculous that the paraquat products banned to be used but produced in China continue to be exported to and lead to tragic self-poisoning deaths in Taiwan.

To implement policies that prioritize the safety of people's lives and well-being is the responsibility of the government. We hope that policymakers from all political parties can unite to support the ban on paraquat and help farmers to adopt alternative pesticides. We also hope that the public can be together to support and ensure the scheduled ban.

Chang Shu-Sen is an associate professor at the College of Public Health at National Taiwan University. Chen Ying-Yeh is director of psychiatry at Taipei City Hospital's Songde Branch and an adjunct professor at National Yang-Ming University.

Appendix 3. An editorial by Dr Shu-Sen Chang and Prof David Gunnell in support of Taiwan government's policy to ban paraquat, published in Taiwanese Journal of Psychiatry (Taipei) in September 2019 (Chang and Gunnell, 2019). The Centre of Pesticide Suicide Prevention was acknowledged in the editorial – “The pilot hospital-based study of suicide by pesticide poisoning in Taiwan was funded by Centre for Pesticide Suicide Prevention (CPSP), University of Edinburgh, UK (principal investigator, SSC, the first author)”

[Downloaded free from <http://www.e-tjp.org> on Tuesday, October 8, 2019, IP: 10.232.74.22]

Editorial

Banning Paraquat Would Prevent Nearly 200 Deaths from Suicide per Year in Taiwan

In early 2007, a 45-year-old male patient was admitted to an emergency department in Taipei; he had swallowed a mouthful of paraquat after an argument with his wife. He anxiously asked the nurse whether he would die and said that he greatly regretted ingesting the pesticide. He died from respiratory failure three days later [1]. Tragedies like this are all too common in Taiwan. Self-poisoning is the most commonly used method in suicide attempts in Taiwan. In a study based on mortality data in 2006–2008, self-poisoning with paraquat caused at least 160 deaths a year, accounting for approximately half of all self-poisoning deaths using pesticides where the name of the product was recorded [2]. Recent estimates suggest that there are around 200 paraquat self-poisoning deaths per year (Ministry of Health and Welfare, personal communication). Ingestion of as little as a tablespoonful of paraquat can be fatal, and there is no effective antidote. The fatality of paraquat poisoning is around 66%–92% in Taiwan [3], much higher than that of almost all other pesticides [4].

We support a ban on paraquat and argue that it is an important, lifesaving policy that may prevent 200 deaths a year in Taiwan. There is strong evidence that restriction of access to commonly used and highly lethal methods of suicide leads to falls in method-specific and overall suicide rates [5, 6]. In this editorial, we summarize the evidence in support of the paraquat ban.

Paraquat and the Arguments for Its Ban

Paraquat was licensed as a herbicide (i.e., weed killer) for farming in Taiwan in 1969. It was listed as a highly hazardous pesticide (HHP) in 1983 [7], and regulations required stenching agents and dyes to be added to the formulations to deter people from ingesting it from then. In 1997, it was required that emetics should also be added to the formulations of paraquat. The Agro-pesticides Management Act (2007) requires that HHPs are stored in a locked cabinet in shops, and the vendors should keep a record of the purchasers' personal information including name [8]. However, these measures do not appear to have prevented the many paraquat poisonings and deaths that occur every year.

In Taiwan, paraquat is widely used as a weed killer and is commonly stored in farming households. Indeed, licensed indications for its use were widened in 2011, permitting its use as a desiccant to assist harvesting adzuki bean. On several occasions, the Ministry of Health and Welfare has suggested a ban of paraquat because of its toxicity to humans. However, this has been contested, and those against the ban argue that paraquat is a cheap, effective, and environmentally friendly herbicide and there are no effective substitutes for its use as a desiccant. In October 2017, the Council of Agriculture,

Taiwan's pesticide regulator, finally announced a plan to ban the two remaining pesticide products that contain paraquat. The ban will be in two phases – the ban on the import and production came to effect in February 2018, and the ban on the sale and use would become effective in February 2019. However, the second phase of ban was later postponed to February 2020; the reason cited by the Council for the delay is that unusually high amounts of paraquat-containing pesticides were sold in 2017–2018, and the Council estimated that one additional year was needed for the purchased paraquat products to be used up by farmers.

In June 2019, two potential presidential candidates from the opposition party criticized the paraquat ban saying that it will substantially increase farmers' costs and arguing for careful management rather than a ban of paraquat. The Council responded that the scheduled ban will remain unchanged as paraquat is highly toxic, and alternative, lower toxicity herbicides and chemicals are now available for the purposes of weed-killing and harvesting aid.

Most suicidal behaviors are impulsive. Research shows that 24%–74% of suicide attempters act within 30 min of the first thinking about suicide [9]. Their choice of poison determines whether they survive or die as a result of their suicide attempt. The late toxicologist Ja-Liang Lin and his colleagues based at the Chang Gung Memorial Hospital reported that repeated pulse therapy of cyclophosphamide and steroids would reduce the fatality of paraquat poisoning from 92% to 66% [3], which is still far higher than the 7% [10] and 6% [11] fatality ratio of alternative herbicides glyphosate and glufosinate, respectively, based on reports from Taiwan National Poison Control Center. However, a more recent randomized controlled trial from Sri Lanka showed no evidence of the effectiveness of high-dose immunosuppression on improving the survival in paraquat-poisoned patients [12].

The majority of people who attempt suicide and survive do not make repeated attempts. In Taiwan, research suggests that only 6%–10% of attempters re-attempted suicide [13–15] and only 1%–2% died by suicide [16, 17] within one year. In contrast, in view of paraquat's high case fatality, most people who ingest it do not get a second chance, and eliminating paraquat would save many lives.

Our previous studies showed that Taiwan's earlier bans on pesticides do not appear to lead to a reduction in the rates of suicide by pesticide poisoning [18]. This is most likely to be because these bans do not include paraquat, which was the main pesticide involved in fatal self-poisonings [2]. Our previous studies also showed that pesticide ingestion is the third most common method for suicide in Taiwan and

contributes to the higher overall suicide rates in rural areas than urban areas [19].

The Burden of Paraquat Self-poisoning

In 2013–2018, a total of 1,253 people died by paraquat self-poisoning in Taiwan – approximately 200 deaths/year or more than one death every two days. These deaths accounted for 41% of 2,716 suicides by pesticide poisoning and 5% of 22,283 overall suicides in the same period. Paraquat accounted for the highest proportion of total suicides in rural counties. In 2013–2018, the percentages of suicides due to paraquat self-poisoning were 17.6%, 15.3%, 12.2%, 12.1%, 12.0%, and 12.0% in Taitung, Hualien, Chiayi, Changhua, Yunlin, and Yilan counties, respectively. We anticipate that a ban on paraquat would be followed by the greatest reduction in suicide rates in these areas. Some may be concerned about the substitution by other methods or poisons. However, because of the high lethality of paraquat, if people used other methods or poisons, they would have a considerably lower risk of death; for example, the fatality of self-poisonings using drugs and other nonpesticide chemicals is less than 5% [20].

Hospital-based data also show the very high burden of mortality of self-poisonings using paraquat. In our ongoing pilot study based on hospital records collected from five hospitals in different parts of Taiwan, data from a sample of 504 patients who self-poisoned using pesticides showed that paraquat poisoning accounts for 33% of these self-poisonings and 78% of in-hospital deaths (Chang SS, et al., unpublished observations).

Evidence for the Effectiveness of Paraquat Ban and Alternative Approaches

Previous studies strongly indicated that a ban of HHPs would decrease suicide rates from pesticide poisoning and in some circumstances, overall suicide rates. The impact of pesticide bans has been studied in six countries; in five countries the bans are followed by falls in pesticide suicides and in three these falls resulted in reductions in total suicides [21]. In South Korea, the rate of suicide by pesticide ingestion is dropped 37% compared to the expected rate in the year after paraquat was completely banned (2013); this impacted on overall suicide rates, which fell by 13% in 2011–2013 [22]. In Sri Lanka, the ban of paraquat and two organophosphates is followed by a 50% and 21% reduction of pesticide and overall suicide rates, respectively, in the five years after the ban [23].

Short of bans, a number of other approaches to reducing the death toll from pesticide poisoning has been suggested. These include sales restrictions, reduced concentration of product, new formulations, and lockable storage boxes. Evidence indicates that the impact of these approaches on suicide is limited.

Compared to bans, restricting the use and sale of HHPs appears to have less of an effect on reducing suicide [21]. In the 1960s and 1970s, to tackle the rising death rates from paraquat poisoning, Ireland implemented measures including restricting its sale to licensed dealers and agriculture-related

occupations, reducing the number of retail outlets, educating farmers, and safety labeling; however, they were ineffective in reducing the number of paraquat suicides, and paraquat was later banned throughout European Union countries in 2007. From 1999, South Korea implemented measures such as setting standards for handling, compulsory education in pesticide use for farmers and sellers, and enforcement of labeling, but the number of suicides involving paraquat did not decrease significantly until the recent ban in 2011–2012 [24].

None of the restrictions implemented in other countries, except bans, would prevent household storage of paraquat; such storage remains common in agricultural areas of Taiwan. Even a small amount of paraquat ingested impulsively can be fatal and thus, these restrictive measures are unlikely to be effective. A survey by the Taiwan Suicide Prevention Center indicated that 60% of people who ingested paraquat use paraquat stored in households. It is only an outright ban that can completely remove paraquat and prevent related harms and deaths.

In Malaysia, a ban on the use of paraquat was implemented in 2005–2006 but was later lifted and changed to limited use, and thus farmers can continue to stock the herbicide in households. The number of people who died from paraquat poisoning was increased markedly from 34 in 2006 to 187 in 2015, according to data from the Malaysia National Poison Centre [25].

Japan used the approach of reducing the concentration of paraquat solution from 24% to 5% from 1986; however, case fatality following paraquat poisoning remained high (80%) [26].

Manufacturers of paraquat have used other approaches in an attempt to make their product safer. In Sri Lanka, the introduction of a new formulation of paraquat containing an increased concentration of emetics, a purgative, and an alginate that slows the absorption of paraquat had only a modest impact on case fatality – it fell from 73% to 63% [27], which is still much higher than that of alternative herbicides.

The effectiveness of safe storage of pesticides using locked boxes has been recently investigated in a large randomized trial in Sri Lanka [28]. No difference in the rates of self-poisoning using pesticides has been found in the intervention versus control villages. Critically, only half of the households continued to use and lock the box after three years, indicating that this is not a sustainable approach.

More than 60 countries have already banned paraquat. China banned the sale and use of paraquat solution in 2016 and will further ban water-soluble paraquat gel in 2020. However, China has not banned the production of paraquat for export. It will be very unfortunate if paraquat exported from China continues to contribute to self-poisoning deaths in Taiwan.

Conclusion

The causes of suicide are complex, involving biological, psychological, social, cultural, and environmental factors. Therefore, its prevention requires multifaceted actions. As psychiatrists, we are well-trained to provide support and treatments for people with suicide risk. A ban on paraquat can enhance the chance of survival in patients who have ingested the pesticide, allowing us the opportunity to

provide the professional help needed, for example, treating psychiatric disorders which are common among people who self-poisoned using pesticides [29]. We together could advocate and support the policy to ban paraquat, and other HHPs with alternative pesticides available, to prevent suicides and save many lives.

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Appendix 4. An article (originally in Chinese) by Dr Shu-Sen Chang and Prof Ying-Yeh Chen commenting on Taiwan government's ban on paraquat, published in Apple Daily on 2nd February 2020 (Chang and Chen, 2020-2-2).

What the government needs to do after banning paraquat

<https://tw.news.appledaily.com/forum/20200201/CRH7R65XWAZAYFEOA6P54VQ3TE/>

By Chang Shu-Sen and Chen Ying-Yeh

The Council of Agriculture announced that paraquat will be banned as scheduled, effective from 1st February 2020. Paraquat leads to approximately 200 deaths a year in Taiwan. This highly lethal herbicide is finally phased out in Taiwan. More and more countries are banning paraquat, including Taiwan's neighbouring countries such as South Korea, China, Vietnam, Thailand, and Malaysia. Taiwan finally joins these countries to ban paraquat, and this is an important step towards better protection of the lives and health of farmers and their family. The ban will not only prevent painful deaths as a result of paraquat poisoning but also reduce the potential risk of Parkinson's disease associated with long-term use of paraquat.

Taiwan passed and implemented "Suicide Prevention Law" last June (2019). One article of the law requires that the authorities should reduce the public's access to highly lethal means of suicide or their chance to use high-lethality methods for suicide. The policy to ban paraquat is not only consistent with the Council of Agriculture's long-term goal to reduce the use of pesticides in farming but also complies with Suicide Prevention Law. This suicide prevention strategy is supported by scientific evidence which shows that banning highly hazardous pesticides is the only approach shown to be effective in reducing suicide, whilst other strategies such as restriction of sale to licensed users have showed limited effects. The World Health Organization recommends the restriction of lethal means of suicide such as firearms or highly hazardous pesticides as one of the multilevel strategies for countries to prevent suicide. Now the ban on paraquat is the realization of such recommendations.

Taiwan's phased ban on paraquat is showing some initial effects to reduce suicide. When the Taiwan government announced the two-staged ban on paraquat in October 2017, the sale of paraquat went up substantially for a short period, indicating that the users were stocking up on this herbicide. Subsequently, the sale of paraquat went down markedly from July 2018, and deaths from paraquat poisoning showed a decline in that year – in 2015-2017, the average annual number of deaths from paraquat poisoning was 221, whilst the number reduced to 185 in 2018, in keeping with the reduction in paraquat sale. The sale of paraquat further decreased to a very low level last year (2019), and the mortality is expected to fall as well in that year. After paraquat is banned, suicide attempters who shift to ingest other pesticides would have a much higher chance of survival compared to paraquat ingestion. This means that many will pass their crisis and have a chance to receive the treatments and supports that they need, and the risk of death from repeat

suicide attempt is relatively low according to research.

The following counties will benefit most from the paraquat ban – Taitung, Hualien, Ilan, Changhwa, Yunlin, and Chiayi. Paraquat accounted for more than one eighth of all suicides in these counties. One critical step to obtain the greatest benefit from banning paraquat is to remove paraquat stored in the households as soon as possible. One previous survey indicates that 60% of suicide attempters who ingested paraquat used the chemical stored in the households and only a few purchased paraquat just before the suicide attempt. Departments of Health and Agriculture at local governments can work together to disseminate information about the paraquat ban and encourage the farmers to turn in remaining paraquat to the producers and shops. The local government can also survey the farmers and vendors for any remaining paraquat and encourage the farmers to use alternative herbicides or other weed control measures that would not involve the use of pesticides. The Council of Agriculture can also request the manufacturers and vendors to recall and destroy paraquat, according to Article 19 of the Agro-pesticides Management Act. The sooner we can reduce the stock of paraquat in the community, the more lives we can save, and more loss to the family and society can be avoided.

Appendix 5. The PI, Dr Shu-Sen Chang, gave a talk entitled “Monitoring suicide trends to inform suicide prevention strategies, with a focus on preventing pesticide suicide”, at the 1st Research and Education Center of Bridging Asian Mental Health and Psychiatry (REBAMP) conference at National Cheng-Kung University, Tainan, Taiwan on 27th April, 2019.

- The abstract of the presentation



*1st International
Conference of REBAMP*

Monitoring Suicide Trends to Inform Suicide Prevention Strategies, with a Focus on Preventing Pesticide Suicides

Dr Shu-Sen Chang (Taiwan)

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Honorary fellow, Hong Kong Jockey Club Centre for Suicide Research and Prevention, The University of Hong Kong, Hong Kong



Abstract

Suicide is a global public health priority. Approximately 800,000 individuals die by suicide each year worldwide. National suicide mortality rate is one of the indicators (indicator 3.4.2) in the United Nation’s Sustainable Development Goals, with a target of a one-third reduction by 2030. It is therefore important to closely monitor trends in suicide rates to access whether the target could be achieved as well as factors that may influence national suicide trends. Research findings from Taiwan and other Asian countries will be presented regarding the following factors that may impact on suicide trends – changes in the quality of suicide data, macroeconomic factors such as economic recessions, inappropriate and irresponsible media reporting of suicide, and changes in the popularity and accessibility of suicide methods. Findings from investigating the impact of bans of highly hazardous pesticides on suicide rates will be also presented and their implications for national suicide prevention strategies discussed.

- The photo of the audience, who are mental health professionals from nine Southeast/South Asian and Oceanic countries (Australia, Thailand, Malaysia, Cambodia, Indonesia, the Philippines, Vietnam, Bangladesh, and India).



Appendix 6. The PI, Dr Shu-Sen Chang, visited research collaborators in Malaysia in July 2019.

- A visit to Pesticide Action Network Asia and the Pacific (PANAP; <http://pan-international.org/asiapacific/>) in Penang, Malaysia on 22nd July 2019, to share perspectives, experiences and evidence on harms associated with pesticide.

Photo (from left to right): Ms Deeppa Ravindran and Sarojeni V. Rengam (PANAP), Dr Chan Lai Fong (Associate Professor and Consultant Psychiatrist, Department of Psychiatry, UKM Medical Centre, Kuala Lumpur), Dr Ng Yin Ping, Consultant Psychiatrist at Pantai Hospital, Penang, and Dr Shu-Sen Chang (PI of this project)



- A visit to Clinical Research Centre, Ipoh Hospital, Ipoh, on 22nd July 2019, to discuss potential research projects of a surveillance system of fatal and non-fatal pesticide poisoning in Ipoh and Perak State.

Photo (from left to right): Dr Shu-Sen Chang (PI of this project), Dr Chan Lai Fong (Associate Professor and Consultant Psychiatrist, Department of Psychiatry, UKM Medical Centre, Kuala Lumpur), Dr Raja Mangeet Singh (forensic specialist at Clinical Research Centre, Ipoh Hospital), and Dr (Vicky) Tsui Huei Loo (consultant psychiatrist at Department of Psychiatry, Ipoh Hospital).



- A visit to Hospital Bahagia, Ipoh, Malaysia on 23rd July 2019, to give a presentation entitled “Monitoring suicide trends to inform suicide prevention strategies, with a focus on pesticide suicide” that includes experiences and evidence of the effectiveness of bans on highly hazardous pesticides to prevent suicide.



- A visit to Forensic Department at Ipoh Hospital on 24th July 2019 to discuss a potential surveillance system of pesticide suicide in Perak State, Malaysia

Photo (from right to left): Dr Mohammad Shafie bin Othman (Director of Forensic Department, Ipoh Hospital), Dr Shu-Sen Chang (PI of this project), and Dr (Vicky) Tsui Huei Loo (consultant psychiatrist at Department of Psychiatry, Ipoh Hospital).



Appendix 7. Ms Hwei Yuen Chang, research assistant of this project gave a presentation entitled “The Epidemiology of Suicide by Pesticide poisoning, with a Focus on Paraquat Poisoning, in Taiwan (1987-2012): Trends, Geographic Variations, and Characteristics”, at the 58th Annual Conference of the Taiwanese Society of Psychiatry, 2019: Taipei, Taiwan on 2nd November, 2019 (Chang et al., 2019).

- The abstract of the presentation

Aim. Pesticide self-poisoning accounts for 14–20% of the world’s suicides. Paraquat, a herbicide highly lethal to human when ingested, was found to be involved in many suicides in some countries. However, there is no previous study of the epidemiology of suicides by paraquat poisoning in a national sample. We investigated the epidemiology of pesticide and paraquat suicides in Taiwan.

Methods. Suicide data were obtained from Taiwan’s cause-of-death data files for years 1987, 1992, 1997, and 2002-2012. We examined national trends and geographic variations in pesticide and paraquat suicides using graphs and maps. The differences in characteristics between pesticide vs non-pesticide suicides and paraquat vs non-paraquat pesticide suicides were analyzed using logistic regression.

Results. Pesticide ingestion accounted for 8,713 (15.5%) of a total of 56,361 suicides in Taiwan during the study period. Age-standardized pesticide suicide rates decreased 71% from 7.7 to 2.2 per 100,000 in 1987-2012. Paraquat was the leading agent involved, accounting for 63-65% of pesticide suicides with the information of pesticide agents used available on the death certificate. Geographically, the percentage of paraquat suicides in all suicides varied markedly (0.4%-14%) across the 23 cities / counties. Pesticide suicides were more likely to be male and from the elder group and cities / counties with a higher percentage of agricultural workers compared to non-pesticide suicides. By contrast, suicides by paraquat poisoning tended to be younger compared to suicides by poisoning using non-paraquat pesticides.

Conclusions. Paraquat was the leading pesticide among pesticide suicides in Taiwan, accounting for at least 4% of all suicides in the country and as high as 14% in some counties. A ban of paraquat will contribute to a significant reduction in pesticide suicides in Taiwan and overall suicides in some rural areas.

The photo of the presenter Ms Hwei Yuen Chang and the PI Dr Shu-Sen Chang

