

**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 – 30th September 2020

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

**Final report of the 2nd extension
(1st January 2020 – 30th September 2020)**

31st August 2020

Principal Investigator: Dr Shu-Sen Chang

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A. Summary

Suicide by pesticide poisoning is a leading method 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 – September 2020) is aimed to collect and analyse data for people who attempted or died by suicide using pesticides in Taiwan to inform future global and local suicide prevention strategies. Specifically, it is aimed to i) collect and analyse death registry and hospital record data of pesticide self-poisoning; ii) interviews suicide attempters who ingested pesticides; iii) assess the early impact of Taiwan's paraquat ban on pesticide suicide; and iv) 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 January 2020 and August 2020, as follows:

- i) We completed hospital record data extraction for 1,633 patients who self-poisoned using pesticides and were treated in eight study hospitals in Taiwan (2000-2019) as of 30th June 2020. Of them, data for 154 patients were collected during the second extension period of the project (January–June 2020). During this period, data collection was affected and interrupted by the COVID-9 pandemic. However, in addition to the eight study hospitals, we obtained ethical approvals from two additional hospitals in East Taiwan, a mostly rural area with high suicide rates of pesticide poisoning.
- ii) We interviewed ten patients who self-poisoned using pesticides as of 30th June 2020. Due to the COVID-19 pandemic, the study hospitals suspended the recruitment of research participants during March-June 2020, and we did not recruit any new patients during January-June 2020.
- iii) We assessed the early impact of the first-stage paraquat ban (i.e. ban on import and production) by conducting preliminary data analysis of a total of 304 patients who ingested pesticides and were treated at one major regional hospital in Middle Taiwan between 2009 and 2018, including 286 patients before the first-phase ban starting from 1st February 2018 and 18 patients after the ban. The results indicated a fall in overall fatality of pesticide self-poisoning from 28% to 17% ($p=0.42$). The proportion of paraquat ingestion decreased from 29.7% to 11.1% after the paraquat ban ($p=0.09$), whilst that of glufosinate-ammonium (an alternative herbicide) and organophosphates (mainly insecticides) ingestion increased from 4.5% to 22.2% ($p=0.002$) and from 13.6% to 33.3% ($p=0.02$), respectively.
- iv) The PI was involved in the following activities that raised the awareness of and supported the pesticide regulation policies, between January and June 2020 – i) publishing one article supporting the paraquat ban policy in national newspapers in February 2020, with the Chinese version published in Apply Daily (Appendix 1) and the English version published in

Taipei Times (Appendix 2); ii) recording a video to provide education about suicide prevention to pesticide vendors, invited by Taiwan Council of Agriculture (Appendix 3); and iii) organising a symposium of four presentations about pesticide poisoning with a focus on paraquat poisoning in Taiwan and Malaysia to be presented at the International Association for Suicide Prevention (IASP) Asia Pacific Conference in Taipei, Taiwan, 23rd – 24th November 2020 (Appendix 4). The PI was also invited to give a plenary talk “Banning high lethality pesticides for suicide prevention: evidence from Taiwan and South Korea” in the conference (Appendix 5).

- v) The PI was recently awarded a research grant entitled “Suicide by paraquat poisoning in Taiwan and potential prevention strategies” (US\$99,921 in two years from October 2020 - September 2022) by the American Foundation for Suicide Prevention, a major charity and leading private funder for suicide research (see Appendix 6 for the project abstract). Prof Michael Eddleston, director of the Pesticide Suicide Prevention Centre, is a co-investigator of the new project. The new project aims to investigate the effectiveness and cost-effectiveness of the paraquat ban on reducing pesticide suicide in Taiwan, based on the solid foundation of collaboration network and data collection structure developed with the support of this pilot project.

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 banned paraquat in two stages - the ban on import and production became effective from 1st February 2018 and the ban on sale and use from 1st February 2020. The ban is expected to be followed by a marked reduction in the number of deaths caused by pesticide self-poisoning. The overall suicide rates may also decrease in some rural areas. Our preliminary analysis of data from one hospital indicated a 10% decrease in the overall fatality of pesticide self-poisoning in the year following the initiation of the first stage ban.

This pilot project demonstrated that it is feasible to collect detailed, systematic, and comprehensive information of pesticide self-poisoning from hospital and death registry data. The project also contributed to the success of the new research grant application.

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, accounting 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 causing most deaths (around 150-200 deaths per year) (Chang and Gunnell, 2019; Lin et al., 2010). Previous studies 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 (the first stage ban) and planned to completely ban the sale and use of paraquat from 1st February 2019 (the second stage ban). However, the second stage ban was later postponed to 1st February 2020; the government cited the reason for the delay as a substantial amount of paraquat stored at farming households and pesticide vendors. On 1st February 2020, the complete ban on paraquat, including its import, production, sale, and use, became effective as scheduled.

It is important to collect data regarding suicide by pesticide poisoning before and after the paraquat ban to evaluate its effectiveness; the results will inform suicide prevention strategies in Taiwan and 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 (i.e. death registry), ii) hospital records, and iii) data from interviews with suicide attempters. The PI is also involved in activities to raise awareness and support policy making around banning highly hazardous pesticides.

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. With the support from the new research grant awarded by the American Foundation for Suicide Prevention, we will start a project with wider stakeholders and partner base, collecting data from additional hospitals and comprehensively evaluating the effectiveness on reducing pesticide suicide of Taiwan's paraquat ban fully implemented since February 2020.

C. Expenditure and financial report

Table 1 shows a summary of the income and expenditure, expected as of September 2020.

Table 1. Income and expenditure (April 2018 – September 2020).

Item	Amount (USD)	Note
Income (expected)	55,000 (100%)	
	= 10,000 (1st installment) + 10,000 (2nd installment) + 2,000 (3rd installment) + 8,250 (4th installment) + 8,250 (5th installment) + 8,250 (6th installment) + 8,250 (7th installment)	<p>The 1st 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 2nd installment of the grant (USD 10,000) arrived on 3rd December 2018.</p> <p>The 3rd installment of the grant (USD 2,000) arrived on 22th April 2019.</p> <p>The 4th installment (USD 8,250) arrived on 21th May 2019.</p> <p>The 5th installment (USD 8,250) arrived on 4th September 2019.</p> <p>The 6th installment (USD 8,250) arrived on 17th February 2020.</p> <p>The 7th installment (USD 8,250) is expected to be received in September 2020.</p>
Expenditure (expected)	55,000 (100%)	
Research assistant salary	44,960	<p>Ms Chiyuan Chen (USD 16,720; full-time during August 2018- June 2019)</p> <p>Ms Yun-Jen Chang (USD 27,663; full-time during January, February, and July to December 2019, and March to September 2020)</p> <p>Dr Hwei Yuen Chang (USD 577; part-time in October 2018)</p>

General expenses	10,040	Ms Chien-Yu Lin (USD 336; fee for data analysis) Ethical review fees (USD 341; Saint Mary's Hospital Luodong, E-Da Hospital, National Cheng Kung University Hospital, and Mennonite Christian Hospital) Training fee for ethical review (USD 25) One desktop computer and one laptop computer for data analysis and collection (USD 1,852) Overhead for National Taiwan University (USD 5,500) Travel to study hospitals (USD 1,538) Participant fee (USD 85) Consumables such as stationeries (USD 363)
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Balance (expected)	0 (0%)
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The total income during April 2018-September 2020 will be USD 55,000, in seven installments. By September 2020, the total expense will be USD 55,000 and the balance is expected to be 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, and January to August 2020. Ms Chang has a background in psychiatric nursing. She travelled to six hospitals in North and South Taiwan extracting data for pesticide self-poisoning hospital presentations.

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. She will present the findings again in a symposium at the International Association for Suicide Prevention Asia Pacific Conference in Taipei, Taiwan on 23rd November, 2020 (see the abstract in

Appendix 4).

Ms Chien-Yu Lin was paid to analyse the data during the second extension period (January – June 2020).

D. Results

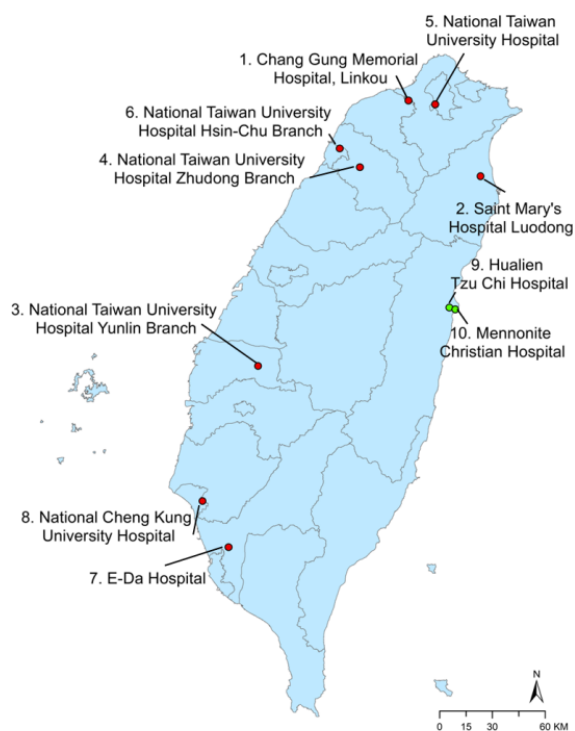
With support from the grant from the Centre for Pesticide Suicide Prevention (CPSP), University of Edinburgh, we successfully completed the works below, as summarised into three studies.

1. The retrospective study of pesticide self-poisoning based on hospital records

i. Data collection

- As shown in Figure 1, we obtained ethical approval to access data from nine hospitals in North (hospital 1, 4, 5, and 6), East (hospital 2 and 9), Middle (hospital 3), and South (hospital 7 and 8) Taiwan. Three hospitals (hospital 3, 4, and 6) are branch hospitals of National Taiwan University Hospital (hospital 5).
- We obtained ethical approval from Hospital 9 (Hualien Tzu Chi Hospital) on 22nd May 2020 and started the application for data collection. Hualien Tzu Chi Hospital is a medical centre and major referral centre for pesticide poisoning in the region. The ethical approval from Hospital 10 (Mennonite Christian Hospital) is currently under review and expected to be granted soon. Mennonite Christian Hospital is a major regional referral centre for pesticide poisoning in the region.
- We expect that the inclusion of the hospital 9 and 10 (labelled in green colour) will contribute significantly to the new project.

Figure 1. Map of locations of study hospitals



- Table 2 summarises the number of cases for which data extraction was completed as of 30th June 2020. In total, we completed data extraction for 1,633 cases from eight study hospitals.
- During the first year of the project (April 2018 – March 2019), we completed data collection for 504 patients from seven hospitals. During the first project extension period of the project (April 2019 – December 2019) we completed data collection for 975 more patients and included one additional study hospital. During the second project extension period (January – June 2020) we completed data collection for 154 more patients and included two additional study hospitals; during this period data collection was affected by the COVID-19 pandemic, when study hospitals suspended our research activities in the hospital in March - June.

Table 2. Distribution of number of cases for which data extraction was completed in eight study hospitals by year (N=1633).

	1. Chang Gung Memorial Hospital, Linkou	2. Saint Mary's Hospital, Luodong	3. National Taiwan University Hospital Yunlin Branch	4. National Taiwan University Hospital Zhudong Branch	5. National Taiwan University Hospital	6. National Taiwan University Hospital Hsin-Chu Branch	7. E-Da Hospital	8. National Cheng Kung University Hospital
	n	n	n	n	n	n	n	n
2000	0	2	0	0	0	0	0	0
2001	0	5	0	0	0	0	0	0
2002	31	13	0	0	3	0	0	0
2003	40	8	0	0	8	0	0	0
2004	35	6	0	2	4	0	0	0
2005	21	7	0	1	2	0	0	0
2006	28	11	0	0	3	0	1	0
2007	85	4	0	1	3	0	0	0
2008	66	10	0	4	6	0	0	0
2009	63	16	25	2	3	0	0	0
2010	59	10	32	1	3	0	1	0
2011	40	17	37	0	1	0	1	0
2012	55	9	46	4	8	0	20	9
2013	31	9	31	0	5	0	25	13
2014	39	14	39	2	4	1	31	12
2015	46	7	50	2	2	2	24	14
2016	63	9	22	5	0	3	37	9
2017	40	8	28	3	1	0	32	7
2018	23	4	22	1	0	1	28	10
2019	1	0	0	1	0	0	0	0
Sum	766	169	332	29	56	7	200	74

- Data extraction was comprehensive, covering the areas such as basic demographics, lifestyle, use of alcohol, baseline chronic medical illness, time

and date of self-poisoning, pesticide agents and amount ingested, combined use of alcohol or drug, interval between self-poisoning and hospital presentation, the sources of obtaining the pesticide ingested, triggering events, mental status and suicidal ideation and plan, past history of self-harm, family history of self-harm, past history of psychiatric illness, present psychiatric diagnosis given by consultant psychiatrists, clinical parameters, laboratory data, treatments, and clinical outcomes (e.g. death

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

- i. In February 2020, the PI, with co-author Prof Ying-Yeh Chen, published an article in national newspapers entitled “Follow paraquat ban with action”, with the Chinese version published in Apply Daily (Appendix 1) and English version published in Taipei Times (Appendix 2), commenting on the paraquat ban and highlighting that the critical measure to obtain the greatest benefit from banning is to efficiently remove paraquat stored in households. In the article we shared evidence for the areas where paraquat accounted for more than one-eighth of all suicides would benefit the most from the ban.
- ii. In May 2020, the PI was invited to record a 30-min video talk entitled “Pesticide management and suicide prevention” to providing distance education about suicide prevention to pesticide vendors. The video was available on YouTube from 28th May, 2020 (<https://www.youtube.com/watch?v=PTi98UFM5OY>; Appendix 3). The video is part of a training programme concerning agricultural and pesticide management, launched by the Bureau of Animal and Plant Health Inspection and Quarantine, Council of Agriculture, Executive Yuan, Taiwan.
- iii. The PI organised a symposium entitled “Pesticide suicide surveillance and prevention” of four presentations in relation to pesticide poisoning, with a focus on paraquat poisoning in Taiwan and Malaysia to be presented at the International Association for Suicide Prevention Asia Pacific Conference, 23rd – 24th Nov 2020 (Appendix 4). The symposium will contribute to the dissemination of initial impact of bans on HHPs to prevent suicide to international audience from countries where pesticide self-poisoning is a major public health issue.
- iv. The PI was invited to give a plenary talk at the International Association for Suicide Prevention (IASP) Asia Pacific Conference: Taipei, Taiwan on 23rd – 24th November 2020. The topic of the talk is “Banning high lethality pesticides for suicide prevention: evidence from Taiwan and South Korea” (Appendix 5). Preliminary findings from this pilot project will be presented in this talk.

E. Conclusions

1. Paraquat was the leading pesticide used in both fatal and non-fatal pesticide self-poisonings in Taiwan before the paraquat ban. 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 1,633 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 (60.1%; 324/539) in all pesticides, compared to 9.0% for all other non-paraquat pesticides combined. Other pesticides commonly used in self-poisoning included glyphosate (glyphosate, glyphosate IPA, and glyphosate ammonium combined; n=201; 12.3%), chlorpyrifos (n=90; 5.5%), and permethrin (n=85; 5.2%); their case fatality was much lower than that of paraquat (9.0%, 10.0%, and 3.5%, respectively).
3. Compared with patients who ingested other non-paraquat pesticides, those who ingested paraquat were younger, had higher educational level, and more likely to be unmarried or divorced, be active in the labour force, smoke, drink, chew areca nut, ingest only one type of pesticide, and have depressive or adjustment disorders; they also had lower risk of chronic illness or cancer and ingested fewer amount of pesticide.
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.

F. References

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G. Appendix

Appendix 1. An article (in Chinese) by the PI Dr Shu-Sen Chang and Prof Ying-Yeh Chen commenting on Taiwanese government's policy to ban paraquat, published in Apply Daily on 2nd February 2020.

Follow paraquat ban with action

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

By Chang Shu-Sen and Chen Ying-Yeh

張書森、陳映燁：巴拉刈終退場 政府接著要做的事

9小時前



台灣終於在昨天（2月1日）全面禁用巴拉刈。圖為彰化縣農藥店販售架已不賣巴拉刈。資料照片

張書森／台灣大學公衛學院副教授

陳映燁／台北市立聯合醫院松德院區社區精神科主任、陽明大學兼任教授

農委會日前宣告，如期於昨天（2月1日）全面禁用巴拉刈，終於讓這個每年造成台灣200人死亡的劇毒農藥退場，走入歷史。世界上越來越多國家禁用巴拉刈，包括鄰近台灣的韓國、中國、越南、泰國與馬來西亞，如今台灣終於加入這個行列，為保護農民與農家的生命與健康跨出重要一步，不但可預防巴拉刈急性中毒導致痛苦死亡的悲劇，也減少長期使用可能增加巴金森氏症的風險。

Appendix 2. An article by the PI Dr Shu-Sen Chang and Prof Ying-Yeh Chen commenting on Taiwanese government's policy to ban paraquat, published in Taipei Times on 22nd February 2020.

Follow paraquat ban with action

<http://www.taipeitimes.com/News/editorials/archives/2020/02/22/2003731406>

By Chang Shu-Sen and Chen Ying-Yeh

The Council of Agriculture has announced that paraquat would be banned as scheduled from the beginning of this month. This highly lethal herbicide, which leads to approximately 200 deaths per year in the nation, is finally being phased out.

A growing number of countries have banned paraquat, including South Korea, China, Vietnam, Thailand and Malaysia. Taiwan finally joins them in removing the chemical, which is an important step toward protecting the lives and health of farmers and their families.

The ban would not only prevent painful deaths from paraquat poisoning, but also reduce the potential risk of developing Parkinson's disease from long-term use of the herbicide.

In June last year, Taiwan passed and implemented the Suicide Prevention Act (自殺防治法), which requires authorities to reduce access to highly lethal means of suicide. The policy to ban paraquat is not only consistent with the council's long-term goal to reduce the use of pesticides in farming, but also complies with the law.

This suicide prevention strategy is supported by scientific evidence, which shows that banning highly hazardous pesticides is the only effective approach in reducing this kind of suicide, while other strategies, such as restricting sales of the chemical to licensed users, have shown limited success.

The WHO recommends restricting lethal means of suicide, such as firearms or highly hazardous pesticides, as one of the multilevel strategies for countries to prevent suicide. The ban on paraquat is the realization of those recommendations.

Taiwan's phased ban on paraquat is showing some initial effects in reducing suicide. When the government announced the two-stage ban on paraquat in October 2017, sales of paraquat went up substantially for a brief period, indicating that users were stocking up on the herbicide.

Subsequently, sales fell markedly from July 2018, and deaths from paraquat poisoning declined that year — from 2015 to 2017, the average annual number of deaths from paraquat poisoning was 221, while in 2018 it dropped to 185.

Sales of paraquat further decreased last year, and mortality rates are expected to fall as well. After the ban, people attempting suicide by ingesting other pesticides would have a higher chance of survival compared with using paraquat.

This means that survivors would have a chance to receive the treatment and support they need, and the risk of death from a repeat suicide attempt is relatively low, research shows.

The following counties would benefit the most from the ban: Taitung, Hualien, Yilan, Changhua, Yunlin and Chiayi. Paraquat accounted for more than one-eighth of all suicides in those counties.

One critical step to obtaining the greatest benefit from banning it is to remove paraquat stored in households as soon as possible.

One survey showed that 60 percent of people who attempted suicide by ingesting paraquat already had it in their home and few purchased it solely for suicide. Health and agricultural departments at local governments should work together to educate farmers about the ban and encourage them to turn over their remaining supply of the herbicide to vendors or authorities.

Local governments should also survey farmers and vendors for any remaining paraquat and encourage them to use alternative herbicides or other weed-control measures that would not involve the use of pesticides.

The council should also request manufacturers and vendors to recall and destroy paraquat in line with Article 19 of the Agro-pesticides Management Act (農藥管理法).

The sooner we reduce the stock of paraquat, the more lives we save and the more we avoid losses to families and communities.

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

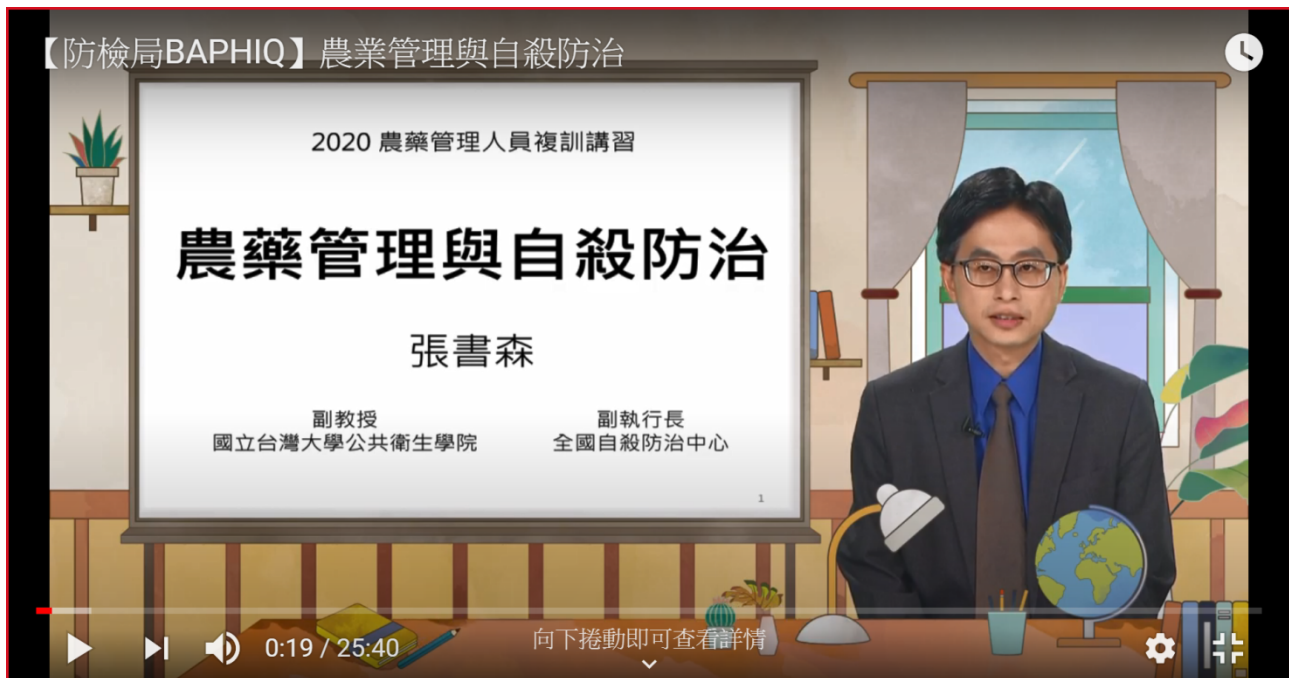
Appendix 3. The PI, Dr Shu-Sen Chang, was invited by Taiwan Council of Agriculture to record a lecture entitled “Pesticide management and suicide prevention” (in Chinese) as part of the training course for pesticide vendors, on 28th May, 2020.

Pesticide management and suicide prevention

<https://www.youtube.com/watch?v=PTi98UFM5OY>

Presenter: Chang Shu-Sen

- A screenshot of the recorded lecture



Appendix 4. The PI, Dr Shu-Sen Chang, organized a symposium of four presentations about pesticide poisoning with a focus on paraquat poisoning in Taiwan and Malaysia, to be presented at the International Association for Suicide Prevention (IASP) Asia Pacific Conference, Taipei, Taiwan on 23rd - 24th November, 2020

IASP Taipei 2020 conference

Symposium: “Pesticide suicide surveillance and prevention”

1. ‘The Epidemiology of Suicide by Pesticide poisoning, with a Focus on Paraquat Poisoning, in Taiwan (1987-2012): Trends, Geographic Variations, and Characteristics’

i. to be presented by Dr Hwei Yuen Chang

ii. Coauthors: Hwei Yuen Chang, Shu-Sen Chang, Chien-Yu Lin, Chia-Yueh Hsu, Tzung-Hai Yen, Chia-Ming Chang, David Gunnell, Michael Eddleston

- 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.

2. 'Assessing the initial impact of paraquat ban on pesticide suicide: a retrospective study based on data from one hospital in Middle Taiwan'
 - i. to be presented by Dr Chao-Ying Tu
 - ii. Coauthors: Chao-Ying Tu, Shu-Sen Chang

- The abstract of the presentation

Objectives. Paraquat poisoning accounted for approximately half of all pesticide suicides in Taiwan. Taiwanese government banned paraquat in two stages - the ban on import and production became effective from 1st February 2018 and the ban on sale and use from 1st February 2020. We aimed to investigate i) the change in pesticides ingested and clinical outcomes of pesticide self-poisonings after the first stage of paraquat ban; and ii) the association between ingested pesticides and clinical outcomes.

Material and Methods. We retrospectively collected data of patients who ingested pesticides and were treated at a major regional hospital in Middle Taiwan between 2009-2018. Data for demographic characteristics, pesticides ingested, triggers of self-poisoning, psychiatric diagnoses, and clinical outcomes were extracted from hospital records. Pesticides were grouped into six categories, namely glufosinate, glyphosate, paraquat, organophosphates, others, and unknown pesticides. Chi-square test was used to compare pesticides ingested and outcomes before and after the paraquat ban. Logistic regression analyses were conducted to investigate the association between pesticides ingested and clinical outcomes (intubation and death).

Results. A total of 322 patients (pre-ban n=302; post-ban n=20) were identified. The proportion of paraquat ingestion decreased from 29.5% to 10.0% after the paraquat ban ($p=0.06$), whilst that of glufosinate and organophosphates ingestion increased from 4.6% to 30.0% ($p<0.001$) and from 13.2% to 30.0% ($p=0.038$), respectively. Overall fatality decreased from 28.8% to 15.0% ($p=0.18$). Among patients who ingested known pesticides (n=292), paraquat poisoning had the highest fatality (75%) and glufosinate poisoning had the highest intubation rate (65%). There was no between-group difference in demographic characteristics, the presence of interpersonal conflict before pesticide ingestion, psychiatric diagnoses, or past history of suicide attempt and psychiatric treatment amongst patients who received psychiatric assessment (n=163). Compared to other four categories of pesticides (unknown category excluded), paraquat was associated with markedly increased mortality risk (adjusted odds ratio [aOR]=388.8, 95% confidence interval [CI] 57.6-2623.6). By contrast, glufosinate and organophosphates were associated with increased risk of intubation (aOR=4.69 [95% CI 1.72-12.80] and 2.30 [95% CI 1.16-4.56], respectively) but not mortality (aOR=0.28 [95% CI 0.06-1.41] and 0.06 [95% CI 0.02-0.19]).

Conclusion. Paraquat ban appeared to show an initial effect of reducing pesticide ingestion fatality in Taiwan. Ban on highly lethal pesticides while providing adequate treatment for adverse outcomes such as respiratory failure associated with alternative pesticides ingested could prevent many pesticide suicides.

3. 'Suicide attempt by paraquat poisoning: after the paraquat ban, is it still happening? A Malaysian perspective'

- i. to be presented by Dr Tsui Huei Loo
- ii. Coauthors: Loo Tsui Huei, Lai Fong Chan, Shu-Sen Chang

- The abstract of the presentation

Introduction. The Malaysian Pesticides Board took the second attempt of banning the import of paraquat which took effect from 1st January 2020 after the initial ban in 2005. And under the Pesticides Act 1974, selling of paraquat in the local market will be considered an offence under the Act. Paraquat is commonly used in weed control in Malaysia. Because of the high level of toxicity, the use of paraquat was banned in 2005; however, paraquat was reintroduced a year later. Pesticide poisoning is the 2nd most common method of suicide in Malaysia. According to the previous study conducted in Ipoh General Hospital (2013-2017), out of 192 cases of pesticide poisoning, 86 (44.8%) presented with paraquat ingestion, with a high fatality ratio (52%; n=45) amongst them. It is critical to evaluate the effect of the paraquat ban on preventing suicide.

Objective. The aim of this study is to assess the immediate effectiveness of the paraquat ban by monitoring cases who presented to the Ipoh General Hospital, Perak, Malaysia with pesticide related suicide attempts after the ban.

Method. A surveillance form was used to capture the sociodemographic data and clinical factors related to pesticide related suicides. The records of the patients who presented to Emergency Department for pesticides related suicides were reviewed and the surveillance form was filled.

Results. A total of three paraquat related suicides attempts were captured after the ban as of Feb 2020. The first case was a 23-year-old Indian gentleman who presented with suicide attempt after an argument. Father is an estate worker who stored paraquat in his house. The second case was an 81-year-old Chinese lady who presented with paraquat ingestion after suffering from non-relieving stomach pain. Both cases passed away due to complications. The third case was a 45-year-old Indian man presented with history of stimulant induced psychosis. The auditory hallucination commanded him to ingest paraquat which he stored for weed clearing purpose in the house.

Conclusion. Paraquat is still one of the commonest methods used in suicide in our data. The three cases presented indicate that paraquat is easily available and accessible in Malaysia in the short period after the ban. Interventions like awareness and enforcement of the ban are critically needed to prevent suicide, and such efforts and evidence for their effectiveness will help with preventing the reintroduction of paraquat.

4. 'Piloting Pesticide Poisoning Surveillance in a General Hospital in Bintulu, Sarawak, Malaysia'
 - i. to be presented by Dr Ravivarma Rao Panirselvam
 - ii. Coauthors: Ravivarma Rao Panirselvam, Nur Adilah Sulaiman, Tien Yong Chua, Lydia Elyanie Azman, Simon Chen Chao Guo, Mohamad Rashidi Bin Mohammad Rashid, Lai Fong Chan, Shu-Sen Chang

- The abstract of the presentation

Background. One in five of the world's suicides are due to pesticide poisoning. In low and middle income countries, ingestion of highly toxic pesticides is common and fatal. Sarawak is a state in East Malaysia with nearly 25% of Malaysia's crop land and Bintulu is a division in the northern region of Sarawak. In view of the dangers of paraquat, indicated by previous studies, and need for safer agricultural practices, a total ban on paraquat use came to effect on January 1, 2020 in Malaysia. There is need to evaluate the efficacy of the ban and identify gaps of interventions to improve prevention activities.

Methods. An electronic surveillance system was developed to identify and characterise pesticide poisoning including risk factors and outcomes in Hospital Bintulu (HBTU). This system combines the collaborative efforts of the Medical, Psychiatry and Records Departments of HBTU to monitor trends of self-poisoning from 2015 to the present using a standardised proforma designed based on the Pesticide Exposure Record by the World Health Organisation (WHO).

Results. Preliminary data from 1 January 2015 to 31 December 2019 identified 58 cases of pesticide poisoning, which showed an overall decline from 2015. Median age is 35 and admission is 3 days. Poisoning showed a preponderance to males with 70.7% of cases. More than half of the samples were involved in occupations related to agriculture and nearly two-thirds of cases happened in rural population. 43.1% (n=25) of poisoning was paraquat; 81% of the pesticides were stored at home at the time of ingestion. About a quarter of the samples were found to be intoxicated at the time of ingestion and of that population 60% involved alcohol. More than half of the poisonings (56.9%) were intentional. Notably 81% of the samples survived. However, case fatality rate of paraquat was 32% (8/25), significantly higher than 6.1% (2/33) for all other pesticides ($p=0.025$). Furthermore, paraquat poisoning accounted for 80% of all pesticide mortalities.

Discussion. Limiting access to lethal means is recommended by the World Health Organisation (WHO) and the International Association of Suicide Prevention as an evidence based strategy in preventing suicides. The advocacy efforts by the local Department of Agriculture to engage with stakeholders may have contributed to the downward trend in pesticide poisoning in Bintulu. Comprehensive surveillance of pesticide poisoning is important to inform prevention strategies and evaluate any prevention efforts. Future interventions should focus on intersectoral collaboration specifically in the rural farming community and include the regulation of highly hazardous pesticides and safe drinking patterns along with other ongoing suicide prevention efforts.

Appendix 5. The Pl. Dr Shu-Sen Chang, was invited to give a plenary talk at the International Association for Suicide Prevention (IASP) Asia Pacific Conference: Taipei, Taiwan on 23rd - 24th November 2020

Topic: “Banning high lethality pesticides for suicide prevention: evidence from Taiwan and South Korea”

Associate Professor Dr Shu-Sen Chang

Institute of Health Behaviors and Community Sciences and Department of Public Health, College of Public Health, National Taiwan University

Abstract: Pesticide ingestion is a leading method for suicide worldwide. It is estimated that there are 110,000-168,000 pesticide self-poisoning deaths a year, accounting for 14-20% of global suicides. The proportion of suicides from pesticide poisoning varies markedly between regions and is highest (48%) in low- and middle-income countries in the Western Pacific region. It is therefore crucial to identify and implement evidence-based strategies targeted at preventing pesticide suicides to reduce the overall burden of suicide in the region. This plenary will introduce recent research evidence about the association of pesticide suicide with the access to highly hazardous pesticides (HHPs) and its regulation, focusing on paraquat, a commonly used herbicide (weed-killer), based on data from Taiwan and South Korea. Data from Taiwan will be presented regarding the burden, trends, geographic variations, and characteristics of pesticide and paraquat self-poisoning. Experiences will be shared about how such findings have informed Taiwan’s policy to ban paraquat, which was initiated in February 2018 and fully implemented in February 2020. Preliminary data on the impact of Taiwan’s recent ban on paraquat suicide will be presented. Finally, preliminary data will be presented on the longer-term effect of the paraquat ban on reducing suicide in South Korea, where paraquat was banned in 2011-2012. I will conclude by highlighting the importance of pesticide-specific suicide and hospital presentation data to inform targeted pesticide regulations, staged bans and availability of substitute pesticides or alternative management strategies to facilitate the smooth and successful implementation of the bans, and continuous monitoring of the effect of the bans and regulations of HHPs.

Appendix 6. Abstract of research grant project awarded by the American Foundation for Suicide Prevention (USD 99,921; October 2020- September 2022)

Project title: Suicide by paraquat poisoning in Taiwan and potential prevention strategies

Principal Investigator:

Dr Shu-Sen Chang, National Taiwan University

Co-investigators:

Prof Michael Eddleston, University of Edinburgh

Prof David Gunnell, University of Bristol

Prof Wonjin Lee, Korea University

Prof Hsien-Ho Lin, National Taiwan University

Research aims and hypotheses

Pesticide ingestion accounts for one fifth of global suicides and is a major public health problem in low- and middle-income countries. Paraquat, a commonly used weed killer that is highly lethal when ingested in suicide attempt, accounts for around 200 suicides (5% of all suicides) in Taiwan a year. On 5th October 2017, Taiwan introduced new regulations to ban paraquat use from 1st February 2020 onwards. Few studies have prospectively investigated the effectiveness, cost-effectiveness and impact on crop yields of such a ban. We aim to investigate the effectiveness and cost-effectiveness of the ban on paraquat to reduce suicide in Taiwan. We hypothesize that the paraquat ban will be followed by a decrease in paraquat suicide and pesticide suicide in Taiwan, and overall suicide in rural areas where paraquat accounts for a significant proportion of overall suicides (~15%). The intervention will be cost-effective. The overall fatality of pesticide self-poisoning will decrease, and there will be no impact on crop yields. Patients who ingested paraquat are not more likely to have psychiatric disorders than those who ingested other pesticides.

Sample

The evaluation will be based on the whole Taiwanese population (23 million). Data for suicide (2002-2020) and self-harm (2015-2020) by paraquat poisoning will be extracted from national death and self-harm registries. Hospital records of 2,660 patients who ingested pesticides in 2000-2020 will be examined. The hospital record collection will benefit from the collaboration established in a pilot study that has extracted data for 1,035 patients from six hospitals in different regions of Taiwan.

Measures

The main outcomes of the effectiveness analysis include suicide and self-harm rates by paraquat poisoning, pesticide poisoning, and all methods. In the cost-effectiveness analysis, costs involve expenses of enforcing the paraquat ban and subsidising substitute weed-killer products; effects will be assessed by life year and healthy life year gained. Additional benefits include loss of productivity (income) due to premature death and costs of hospital stay from paraquat self-

poisonings averted. Hospital data extraction includes a wide range of variables such as length of hospital stay, psychiatric disorders, pesticides ingested, and outcome at discharge.

Procedures

The effectiveness analysis will examine change in suicide rates by applying rigorous methodology that takes into account suicide trends before the paraquat ban. The cost-effectiveness analysis will report the ratio of US\$ or International dollar per one life year gained from the paraquat ban.

Potential impact

The project has the potential to not only inform strategies for reducing the incidence of pesticide suicide in low-income countries or agricultural regions, but also have relevance to suicide prevention by restricting other methods such as opioid overdose and firearms.

Next steps in this line of proposed research

We intend to investigate the longer-term effect of paraquat ban on reducing suicide in the future. Findings from the current study will be disseminated to policy makers responsible for pesticide regulation and inform suicide prevention strategies in countries where pesticide ingestion accounts for many deaths that are preventable by banning highly lethal pesticides such as paraquat.