Acute Pesticide Poisoning in Asia: A Four-Country Review

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Executive Summary

i. Purpose of review

This review aims to improve people's understanding of how often unintentional acute pesticide poisoning (UAPP) occurs, primarily amongst farmers and farmworkers in Vietnam, Laos, Bangladesh, and India; whether the incidences are increasing or decreasing; and the pesticides that are likely causing UAPP under the conditions in which pesticides are used in these countries.

ii. Brief comment on methodology

To arrive at new estimates of the prevalence of UAPP, this review uses multiple studies and data sources. As a starting point, this review references the studies used for the global estimation of UAPP by Boedeker et al (2020), which used data from 2006 to 2018,[1] and incorporates data from more recent published studies and community monitoring studies, referencing data from 2010 to 2022. By analysing these studies and other relevant information, including data from confirmed poisoning incidents, we can identify and prioritise the pesticides that are likely responsible for causing UAPP. We also analysed these studies to gather information about the conditions in which the pesticides are being used in each country.

iii. Key findings

The prevalence of UAPP continues to rise in Vietnam, Laos, Bangladesh, and India.

Incidence of non-fatal UAPP

Country	UAPP (Boedeker et al)	UAPP (this review)	Estimated number of cases (this review)
Vietnam	57.35%	59.20%	12,127,549
Laos	39.00%	72.63%	1,672,600
Bangladesh	55.64%	66.14%	17,537,023
India	62.00%	83.88%	172,482,713

New in this review is information on child poisoning, with data pertaining to rural children in Vietnam who are exposed via direct contact and drift, and data pertaining to the situation in India where deaths are reported, often caused by inadvertent ingestion of pesticide stored in the house.

Non-fatal and fatal UAPP in children

Country	Population type	Year	Population size	Fatal	Non-fatal (estimated)	Incidence
Vietnam	children (rural)	2019	14,332,803	?	9,144,328	63.80%
India	children	2019	363,716,740	155	?	?

One hundred and two (102) pesticides were identified as likely to be causing the poisoning incidents in one or more of the four countries (see Table 8.2). This list is based on known poisoning cases, pesticides banned by the European Union (EU) due to acute toxicity, pesticides with high inhalation toxicity, and

1. Boedeker W, Watts M, Clausing P, Marquez E. 2020. The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. *BMC Public Health* 20:1875. https://doi.org/10.1186/s12889-020-09939-0

pesticides with an LD_{50}[2] of less than 2,000, which are classified by the World Health Organization (WHO)[3] as "Ia: Extremely hazardous", "Ib: Highly hazardous", or "Class II: Moderately hazardous." None of these should be used without Personal Protective Equipment (PPE), which is generally not worn to the appropriate level in any of the four countries.

A priority list of 40 pesticides was developed for immediate ban in countries where they are still registered. These include all the pesticides known to have caused poisoning and those with an LD_{50} < 100 mg/kg.

Pesticides for immediate ban in the four countries

Pesticide	Vietnam	Laos	Bangladesh	India	LD_{50}
abamectin/avermectin	x	x	x		8.70
acephate			x	**X**	945.00
aldicarb				x	0.93
aluminium phosphide			**X**	**X**	8.70
bromadiolone	x				0.56
carbofuran		x	x	**X**	7.00
carbosulfan	x		x	x	101.00
chlorfenapyr	x				45.00
chlorpyrifos	x	x	**X**	**X**	66.00
cypermethrin	x	x	**X**	**X**	287.00
cypermethrin – alpha	x			**X**	40.00
cypermethrin – beta	x				93.00
DDT				**X**	113.00
deltamethrin	x				87.00
diafenthiuron	x			**X**	2,068.00
diazinon	x		**X**		1,139.00
dichlorvos			**X**	x	80.00
dimethoate	x		**X**	**X**	245.00
emamectin benzoate	x		x	x	81.50
endosulfan	x			x	38.00
fenitrothion	x		**X**		330.00
fenthion			**X**	x	250.00
fipronil	x		x	**X**	92.00
hexaconazole	**X**				2,189.00
imidacloprid	x	x	x	**X**	131.00
lambda-cyhalothrin	x		x	**X**	56.00
lindane				**X**	163.00
malathion			**X**	**X**	1,778.00
monocrotophos			**X**	**X**	14.00
nereistoxin	x				92.60
paraquat	x	x	**X**	**X**	110.00
parathion-methyl				x	3.00
phorate				**X**	2.00
profenofos	x			**X**	358.00
propiconazole	x		**X**		550.00
quinalphos	x		**X**	x	71.00

2. LD stands for "Lethal Dose". LD_{50} is the amount of a material, given all at once, which causes the death of 50% (one half) of a group of test animals.
3. WHO. 2019. The WHO Recommended Classification of Pesticides by Hazard and guidelines to classification. World Health Organization, Geneva. https://www.who.int/publications/i/item/9789240005662

thiodicarb				x	50.00
triazaphos				x	66.00
warfarin	x				10.40
zinc phosphide	x		**X**	**X**	12.00

X = indicates use of pesticides that are likely implicated in UAPP; **X** = indicates known poisoning cases

iv. Main conclusions

- UAPP is unacceptably high in all four countries, and urgent action is needed to safeguard the lives and livelihoods of rural people.
- None of the countries have implemented Article 3.6 of the International Code of Conduct on Pesticide Management, which states:

  Pesticides whose handling and application require the use of personal protective equipment that is uncomfortable, expensive, or not readily available should be avoided, especially in the case of small-scale users and farm workers in hot climates.
- Farmers and farmworkers generally do not wear PPE, and in instances where some of them do, it is not according to the standards that are necessary to adequately protect them. The climactic and socioeconomic conditions in these countries make it difficult for people to wear PPE to a level adequate to protect against even moderately toxic pesticides. The fault lies not with the farmers but with those that make the pesticides available to them, such as manufacturers, government regulators, and the international community that fails to enact strict global regulation of pesticides and those countries that stand in the way of regulation.
- Children continue to be poisoned, particularly in India, because they work illegally in floriculture and because highly toxic pesticides are stored in their homes. Children in Vietnam also are poisoned because they are subjected to drifting pesticides. The situation of children in Laos and Bangladesh are not known.
- Laos suffers from a high percentage of illegally imported pesticides, particularly from China and Thailand, and the country needs help to solve this problem.

v. Recommendations

1. Implement Article 3.6 of the International Code of Conduct on Pesticide Management, which prohibits the manufacture, import, or use of any pesticides that require applicators to wear PPE.
2. Immediately ban all pesticides on the Priority List (Table 8.3), including any formulations containing the combination of chlorpyrifos and cypermethrin, which are emerging in a number of countries as being responsible for a number of poisonings and even deaths.
3. Phase out all pesticides on each country's Short List.
4. Cease the import of pesticides banned by the EU.
5. Cease the import of pesticides banned in their country of origin.
6. Cease the export of pesticides banned for use within the country.
7. Governments should work together, with other countries in the region, and with international organisations, to prevent illegal trade in pesticides, particularly within Laos.
8. Develop a national policy on replacing these pesticides with agroecological practices, scale up national and international assistance, and train farmers on how to implement these, so as to remove farmers' perceived need for toxic pesticides.
9. Develop a regional initiative to tackle transboundary movement of illegal pesticides. Laos suffers from a high percentage of illegally imported pesticides, particularly from China and Thailand, and the country needs help to solve this problem.
10. Segregate data pertaining to all cases of hospitalisation based on occupational and accidental causation, and record the pesticides involved.
11. Intensify the monitoring of cases involving non-hospitalised occupational poisoning to more accurately identify the scale of the problem and to identify the pesticides causing the harm.

1. Introduction

Unintentional acute pesticide poisoning (UAPP) is the occupational poisoning of farmworkers, farmers, and other individuals, and the accidental poisoning of children, such as by the accidental ingestion of pesticide stored in the kitchen. It does not include cases involving suicide or homicide in which pesticides are directly ingested by a person.

UAPP has been recently brought into sharp focus by the publication of the paper by Boedeker et al in 2020.[4] That paper updated the 1990 figures published by the World Health Organization (WHO), which were essentially the first of such data to be published,[5] and which estimated 22,000 deaths and 25 million non-fatal occupational pesticide poisonings. Despite numerous small surveys carried out since 1990, no global estimates were again published until Boedeker et al (2020), which concluded that an estimated 385 million cases of UAPP were occurring globally each year, involving about 44% of the worldwide farming population.

UAPP occurs when people are exposed to pesticides, resulting in symptoms such as headaches, nausea, vomiting, loss of appetite, skin irritations, eye irritations and damage (including permanent blindness), excessive salivation, excessive sweating, fatigue, dizziness, slowed heartbeat, respiratory symptoms, spasms, convulsions, or death.[6]

Addressing unintentional non-fatal pesticide poisoning is critical for a number of reasons:

- Poisoning causes unacceptable suffering to the people and communities involved.
- There is an economic impact on low-income farming families caused by the loss of productivity and cost of medical treatment.
- Repeated exposure to pesticides that may cause only seemingly unimportant transitory poisoning symptoms can also result in chronic health impacts and even intergenerational impacts.[7, 8]
- Pesticides that are toxic to people are usually also toxic to the environment, resulting in decreased biodiversity and in particular soil microorganisms essential to plant nutrition and preventing climate-changing emissions from the soil.[9, 10] Pesticides decrease agri-biodiversity, in turn reducing the ability of the agroecosystem to balance the pests with beneficial insects/ biological controls. Hence, this stimulates greater use of pesticides – the treadmill effect.

Although there was an attempt to address the problem of child poisoning in Boedeker et al (2020), very little published peer-reviewed information was found. However, there is a certain amount of information available in media reports, especially for India, and community monitoring studies that are included here.

4. Boedeker W, Watts M, Clausing P, Marquez E. 2020. The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. *BMC Public Health* (2020) 20:1875. https://doi.org/10.1186/s12889-020-09939-0
5. WHO, UNEP. 1990. Public health impact of pesticides used in agriculture. Geneva: World Health Organization, Geneva. p. 128. https://apps.who.int/iris/handle/10665/39772
6. Boedeker W, Watts M, Clausing P, Marquez E. 2020. The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. *BMC Public Health* 20:1875. https://doi.org/10.1186/s12889-020-09939-0
7. Boedeker W, Watts M, Clausing P, Marquez E. 2020. The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. *BMC Public Health* 20:1875. https://doi.org/10.1186/s12889-020-09939-0
8. Nicolella H, Assis S. 2022. Epigenetic inheritance: intergenerational effects of pesticides and other endocrine disruptors on cancer development. *Int J Mol Sci* 23:4671.
9. Das S, Ang W, Reeves S, Dalal R, Dang Y, Gonzalez A, Kopittke P. 2022. Non-target impacts of pesticides on soil N transformations, abundances of nitrifying and denitrifying genes, and nitrous oxide emissions. *Sci Total Environ* 844:157043.
10. Rahman M, Khanom A, Biswas S. 2021. Effect of pesticides and chemical fertilizers on the nitrogen cycle and functional microbial communities in paddy soils: Bangladesh perspective. *Bull Environ Contam Toxicol* 106(2):243-249.

Child poisoning, particularly in Asia, is often the result of storing pesticides in the home – a practice that contravenes the requirements of the FAO/WHO International Code of Conduct on Pesticide Management (the Code)[11] – as well as children's occupational and bystander exposure.[12] The Code is the only international instrument that addresses issues of pesticide management, such as registration of pesticides, storage, advertising, labelling, distribution, , and primarily addresses the responsibilities of governments and the pesticide industry. However, it is voluntary and not well implemented by governments and the industry. Occupational UAPP is usually the result of the failure of governments and the industry to adequately implement the Code. Hence, this publication will also look at where this implementation is failing and make recommendations for change. The Code is crucial to international pesticides management, given that the only two other operative United Nations (UN) mechanisms for pesticides are: 1) the Stockholm Convention on Persistent Organic Pollutants,[13] which has globally banned a few current use pesticides, such as endosulfan, lindane, and dicofol; and 2) the Rotterdam Convention on Prior Informed Consent,[14] which requires exporters of listed pesticides[15] to seek the permission of the importing country's government before pesticides are dispatched. Together, both conventions are estimated to cover less than 4% of pesticides in use.[16]

The other potential UN mechanism is the voluntary Strategic Approach to International Chemicals Management,[17] but despite recognising Highly Hazardous Pesticides (HHPs) as an 'issue of concern',[18] so far, it has failed to come up with a plan of action to address them or even create a global platform for stakeholders to work together on the issue. Whilst the Code is also voluntary, it is currently the only operative UN mechanism for managing pesticides and should, therefore, be respected and implemented by everyone involved.

In 2006, the FAO Council recommended the phase out of "particularly toxic pesticides", and in 2007, the FAO/WHO Joint Meeting on Pesticides Management (JMPM) established criteria for identifying HHPs to assist in implementing this recommendation. Most of these criteria can be easily referred to as they are based on published information. These criteria include acute toxicity, carcinogenicity, mutagenicity, reproductive toxicity, and whether the pesticide has been listed under a relevant UN Convention/Protocol.[19] However, Criterion 8 requires action at the national level and remains largely unused.

The definition of Criterion 8 is "Pesticide active ingredients and formulations that have shown a high incidence of severe or irreversible adverse effects on human health or the environment." It is easy to identify pesticides that are causing death via suicide as meeting Criterion 8 – there is nothing more irreversible than death. However, it is more difficult to identify those that are responsible for the unacceptable high level of non-fatal UAPP, partly because of the lack of monitoring in most countries, and partly because farmers are using so many different pesticides that it can be difficult to identify which one is the cause of particular incidents. This report considers a range of evidence to identify those pesticides that are responsible for the poisoning plague and which of these should be a priority for phase-out.

The World Health Organization (WHO) has recently stated that, "Nobody should be exposed to unsafe amounts of pesticide" and that it has an objective "to ban pesticides that are most toxic to people."[20] Therefore, the need to identify and address the pesticides causing the poisoning problems in Asia is paramount.

11. FAO, WHO. 2014. The International Code of Conduct on Pesticide Management: Guidelines on highly hazardous pesticides. Rome: Food and Agriculture Organization of the United Nations. https://www.fao.org/3/I3604E/i3604e.pdf
12. CGFED, SRD, PANAP. 2020. School Children's Exposure to Pesticides in Vietnam: A Study in Three Districts. PAN Asia Pacific, Penang.
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19. See https://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/code/hhp/en/ for HHP criteria.
20. WHO. 2022. Pesticide residues in food. Sept 2022. https://www.who.int/news-room/fact-sheets/detail/pesticide-residues-in-food

2. Overview of UAPP in South and South-East Asia

To better understand the gravity of the situation in South and South-East Asia, information has been extracted from the systematic review of UAPP by Boedeker et al (2020)[21] and reproduced in Tables 2.1 and 2.2. From this global overview, it becomes immediately apparent that East, South-East, and South Asia (and northern Africa) are the regions where pesticide poisoning, both fatal and non-fatal, are worst, with South Asia having the greatest number of poisoning cases by far.

Table 2.1 shows how the fatalities reported for the population covered by the papers included in the Boedeker review were extrapolated to provide an estimate for the global population. The country-specific case numbers were summed by sub-region and the respective sums multiplied by the share of these country's populations to the overall population in the sub-regions for the reference year of 2016. The national estimates summed to an overall fatal UAPP of 7609, which Boedeker et al's extrapolation procedure resulted in about 11,000 fatalities worldwide, although this number was regarded by the authors as likely to be an underestimate.

Table 2.1: Estimated worldwide annual fatal UAPP by region

Region	Subregion	Population in region	Population in review [1]	Number of countries[1]	Sum fatalities	Estimated fatalities
AFRICA	East	405,425,679	42,752,218	3	8.50	81
	Middle-Southern	217,729,520	53,771,984	1	16.60	67
	Northern	228,846,848	133,894,911	3	90.30	154
	Western	362,197,544	539,560	1	0	0
AMERICA	Caribbean	43,278,165	31,557,456	19	6.10	8
	Central	174,988,756	167,463,654	8	283.40	296
	North	359,792,066	353,535,331	3	5.40	6
	South	420,434,194	395,970,288	12	215.20	229
ASIA	**Central**	**70,118,950**	**61,486,031**	**4**	**3.50**	**4**
	Eastern	**1,616,177,218**	**1,532,006,035**	**5**	**320.20**	**338**
	South-Eastern	**641,760,625**	**195,058,336**	**5**	**48.40**	**159**
	Southern	**1,846,671,142**	**1,284,597,898**	**3**	**6,539.30**	**9,401**
	Western Asia	**262,879,373**	**160,485,199**	**12**	**23.60**	**39**
EUROPE	Eastern	293,011,923	94,597,984	7	24.20	75
	Northern	96,464,409	94,640,537	8	1.20	1
	Southern	160,067,370	154,290,938	13	13.70	14
	Western	195,338,358	191,762,460	7	6.60	7
OCEANIA	AUS, NZ, Mel-Mic-Polynesia	40,153,128	28,353,352	3	2.40	3
All	**All**	**7,435,335,268**	**4,976,764,172**	**117**	**7,609**	**10,881**

[1] Countries with data on fatal UAPP

Source: Boedeker et al (2020), Table 7 modified

For non-fatal UAPP, Boedeker et al based their extrapolations on farming/occupational population "because this population was well covered by studies".

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21. Boedeker W, Watts M, Clausing P, Marquez E. 2020. The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. *BMC Public Health* 20:1875. https://doi.org/10.1186/s12889-020-09939-0

Table 2.2: Estimated worldwide annual non-fatal UAPP by region

Region	Subregion	Population in region	Population in review[1]	Number of countries[1]	Sum of non-fatal cases	Estimated non-fatal cases
AFRICA	East	110,892,829	72,889,835	6	33,480,337	50,936,173
	Middle-Southern	43,418,696	5,519,071	1	2,696,550	21,213,838
	Northern	18,237,245	4,189,286	1	2,216,132	9,647,501
	Western	52,622,701	28,778,253	6	18,502,947	33,833,710
AMERICA	Caribbean	3,602,799	1,271,668	1	203,466	576,445
	Central	11,986,716	259,564	1	83,060	3,835,727
	North	2,931,504	2,294,329	1	1,078	1,377
	South	24,345,793	18,917,959	6	6,165,372	7,934,306
ASIA	**Central**	**6,983,220**	**0**	**0**	**–**	**–**
	Eastern	**152,053,052**	**189,363,417**	**2**	**20,793,763**	**16,696,758**
	South-Eastern	**105,088,068**	**94,439,399**	**6**	**49,645,682**	**55,243,562**
	Southern	**292,859,652**	**282,851,206**	**5**	**174,141,658**	**180,303,510**
	Western Asia	**14,083,454**	**889,267**	**3**	**231,353**	**3,663,972**
EUROPE	Eastern	12,990,116	0	0	–	–
	Northern	919,915	397,175	1	91,350	211,580
	Southern	4,008,995	1,324,195	2	418,900	1,268,217
	Western	1,920,615	797,471	1	57,863	139,357
OCEANIA	AUS, NZ, Mel-Mic-Polynesia	1,620,369	349,697	1	270	1,251
All		**860,565,737**	**704,531,792**	**44**	**308,729,782**	**385,507,286**

[1] Countries with data on non-fatal UAPP

Source: Boedeker et al (2020), Table 8 modified

Looking more closely at South and South-East Asia (see Table 2.3), three things become apparent:

- The countries with the largest known problems with UAPP, including fatalities, were Pakistan, Nepal, Cambodia, and India.
- Only Thailand and Laos had UAPP percentages that were less than the global average of 44%, and the figure for Laos was based on only one study.
- There was no published data for:
  - South Asia – Afghanistan, Bhutan, Iran, Maldives, Sri Lanka.
  - South-East Asia – Malaysia, Myanmar, Singapore.

Table 2.3: Incidence of annual non-fatal UAPP among the occupational/farming population by countries in South and South-East Asia, calculated for the year 2016, based on 2006-2028 data

Region	Subregion	Country	UAPP (%)
Asia	South-East	Cambodia	62.00
		Indonesia	53.83
		Laos	39.00
		Philippines	57.99
		Thailand	36.03
		Vietnam	57.35
		Mean	*51.03*
	South	Bangladesh	55.64
		India	62.00
		Iran	59.35
		Nepal	65.00
		Pakistan	81.75
		Mean	*64.75*

Source: Boedeker et al (2020), from Table 10

The high levels of unintentional acute pesticide poisoning in South and South-East Asia are in stark contrast to regional comparisons in pesticide use. Recent data provided by FAO (2022)[22] shows that pesticide use per area of cropland is lower in Asia than in the Americas, Oceania, Africa, and Europe, and also the global average. Additionally, pesticide use appears to be decreasing in recent years. Why then, is poisoning so high? What are the types of pesticides being used? What are the conditions of use?

Figure 1: Global and regional pesticide use

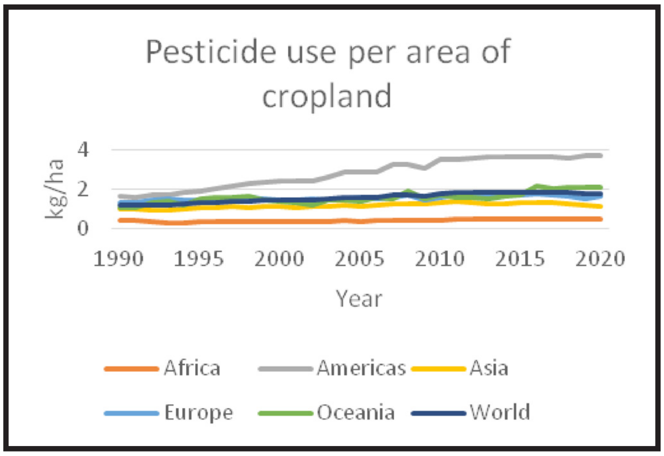
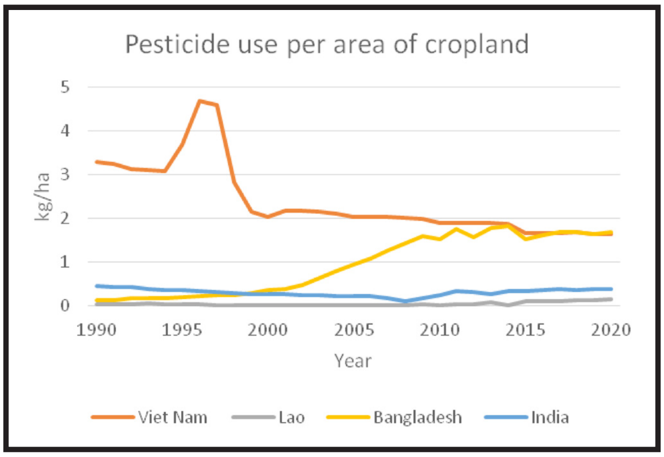


Figure 2: Pesticide use in the four countries



Source of data: FAOSTAT. https://www.fao.org/faostat/en/. Accessed 3-11-22

22. Wanner N, Tubiello FN. 2022. Pesticides use, pesticides trade and pesticides indicators: Global, regional and country trends, 1990-2020 FAOSTAT Analytical Brief 46.

3. Methodology

3.1 Data sources

The papers used for the Boedeker et al (2020) systematic review[23] were used as the starting point to further investigate UAPP in each of the four countries that this review covered. The papers were searched for additional information, particularly relating to pesticides used, conditions of use, and gender considerations. In addition, Pub Med and Research Gate were used in July and August 2022, dating from (and inclusive of) 2012 to July 2022, to search for each country using the country name and 'pesticide poisoning' as keywords. Additional information on residues in food, people, and the environment were also sought to better understand the nature of pesticide use. Studies conducted by Pesticide Action Network Asia and the Pacific (PANAP) and partners were also added. The WHO Mortality database[24] was searched for data, although none was found on mortality caused by pesticides for the four countries. The WHO confirmed that Bangladesh, India, Laos, and Vietnam do not report mortality rates to them.[25]

Table 3.1 Papers used to estimate UAPP

Country	Boedeker et al	New peer-reviewed	CPAM studies
Vietnam	3	1	4
Laos	0	2	1
Bangladesh	5	1	1
India	5	3	2

While Boedeker et al used data from 2006 to 2017, this review uses data from 2010 to 2022, to better reflect the current situation. Ideally, the time frame would be narrower, but the lack of published studies meant that a shorter time frame would result in insufficient data to analyse. An updated prevalence of UAPP was then derived. A systematic review process was not used.

In addition to these papers, community monitoring studies that PANAP has assisted partner organisations to carry out in their own countries have been included. These studies use the Community-based Pesticide Action Monitoring (CPAM) methodology, which was developed by PANAP in 1999 and has been refined over the years.[26] CPAM is a participatory action research approach to documenting and creating awareness of the hazards of pesticides and their impacts on human health and the environment. It involves trained community members undertaking the research and encourages organising and action.

Finally, UNFAOSTAT was searched for data on the pesticide use per area of cropland to get both regional figures and figures for the four individual countries for 1990-2020.

3.2 Assessment of UAPP

The prevalence of UAPP was reassessed to arrive at a new average for each country from 2010–2022. Using the methodology developed by Boedeker et al (2020), estimates of the number of occupational

23. Boedeker W, Watts M, Clausing P, Marquez E. 2020. The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. *BMC Public Health* 20:1875. https://doi.org/10.1186/s12889-020-09939-0
24. WHO Mortality Database. https://www.who.int/data/data-collection-tools/who-mortality-database Accessed Sept 2022.
25. WHO. 2022. pers comm with the Mortality Database Portal. Sept 17.
26. https://panap.net/about-cpam/
27. The World Bank DataBank. Population Estimates and Projections. https://databank.worldbank.org/source/population-estimates-and-projections/Type/TABLE/preview/on Accessed Dec 2020.

poisonings were then calculated, with updated data from the World Bank[27] on population size and percentage of employment in agriculture. The World Bank employment data may not include informal/ subsistence farming and does not include data pertaining to children under the age of 15 – and are known to be employed in India, at least – so estimations of cases are probably low for some countries.

Table 3.2: Population estimates for the 4 countries

	Year	Vietnam	Laos	Bangladesh	India
Total population	2019	96,462,108	7,169,456	163,046,173	1,366,417,756
Labour force	2019	55,898,817	3,748,218	69,229,775	482,700,285
% of labour force employed in agriculture	2019	37.22%	61.44%	38.30%	42.60%
Employed in agriculture	2019	20,805,540	2,302,905	26,515,004	205,630,321
% of female labour force employed in agriculture	2019	38.30%	63.54%	57.57%	54.69%
% of male labour force employed in agriculture	2019	36.23%	59.42%	30.14%	39.56%
Children population $\leq$14	2019	22,392,562	2,315,955	44,371,981	363,716,740

Source of data: The World Bank Databank
https://databank.worldbank.org/source/population-estimates-and-projections/Type/TABLE/preview/on

3.3 Pesticides implicated in causing UAPP

Information on the pesticides being used and, where known, poisoning cases, were collated in a table for each country, together with information on the following:

- Whether they meet the acute toxicity criterion for a Highly Hazardous Pesticide, as developed by the FAO/WHO Joint Meeting on Pesticide Management (JMPM).[28]
- Their LD_{50} (according to the University of Hertfordshire/IUPAC PPDB[29] and BPDB,[30] or if not available there, PUBCHEM[31]).
- Whether they are banned in the European Union[32] and for what reason (e.g., human health or environmental hazard), noting in particular if a pesticide was banned for reasons of acute toxicity for humans or mammals, or because of the need for PPE, which is generally not worn in the four countries of focus in this review.
- Pesticides included in the PAN HHP List due to their level of inhalation toxicity ('fatal if inhaled'), caused by the high risk of inhalation when spraying without a proper mask.
- For Bangladesh and India, information on pesticides that caused hospitalised poisonings were added where these incidents were known. It was noted that the hospital studies did not distinguish between unintentional and intentional pesticide poisonings. Therefore, it was difficult to determine if any of the pesticides were solely responsible for intentional poisonings.

The collated information was then assessed, taking into account the extent of pesticide use and how recent it was, to determine the pesticides most likely to be the cause of the UAPP, and therefore become a priority for regulatory action.

28. Highly Hazardous Pesticides. FAO. https://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/code/hhp/en/
29. University of Hertfordshire. Pesticide Properties Database. http://sitem.herts.ac.uk/aeru/iupac/
30. University of Hertfordshire. Bio-pesticides Properties Database. http://sitem.herts.ac.uk/aeru/bpdb/index.htm
31. National Library of Medicine. https://pubchem.ncbi.nlm.nih.gov/classification/#hid=72
32. EU Pesticides Database. https://food.ec.europa.eu/plants/pesticides/eu-pesticides-database_en
33. WHO. 2019. The WHO Recommended Classification of Pesticides by Hazard and guidelines to classification. World Health Organization, Geneva. https://www.who.int/publications/i/item/9789240005662

An LD_{50} of 2,000 mg/kg or below was determined as indicative of a pesticide likely to be toxic under the conditions of use in the four countries, despite the JMPM designation of acute toxicity being only < 50 mg/kg.[33] The World Health Organization classifies pesticides with an LD_{50} of 50–2,000 as being moderately toxic, and numerous pesticides that fall within this range are known to cause poisonings. For example, diafenthurion with an LD_{50} even slightly above this range, at 2,068 mg/kg, has caused occupational deaths in India;[34] malathion (LD_{50} 1788) has a case fatality rate of 20% in Bangladesh;[35] and atrazine (LD_{50} 1869) has resulted in symptoms of acute poisoning in Laos.[36]

In summary:

The collated lists of pesticides ('long list') were refined into shorter lists of those most likely to be implicated in UAPP by removing:

- pesticides with LD_{50} > 2,000mg/kg, unless they are known to have caused poisonings, and
- pesticides not often used or not used recently.

On the other hand, pesticides with a combination of the following characteristics were retained ('short list'):

- linked with any symptoms in the studies reviewed
- banned by the EU due to their acute toxicity or the need for PPE in their use, or due to concerns for applicators or bystanders
- LD_{50} < 2,000 mg/kg
- 'Fatal if inhaled' (H330) according to the EU or the Japan Globally Harmonised System (GHS)
- any other information supports its potential to cause UAPP under the conditions of use in the country.

Table 3.3 Long and short lists of pesticides

	Vietnam	Laos	Bangladesh	India
Long list	106	27	42	61
Short list	72	20	39	29

34. Reddy N, Kumar D. 2017. Pesticide Poisonings in Yavatmal District in Maharashtra: Untold Realities. https://pan-india.org/wp-content/uploads/2017/10/Yavatmal-Report_PAN-India_Oct-2017_web.pdf
35. Dewan G. 2014. Analysis of recent situation of pesticide poisoning in Bangladesh: is there a proper estimate? *Asia Pac J Med Toxicol* 3:76-83.
36. Shattuck A. 2021. Risky subjects: Embodiment and partial knowledges in the safe use of pesticide. *Geoform* 123:153-61.

4. Vietnam

4.1 General pesticide situation

Vietnam's population is roughly two-thirds rural, with 61,504,280 people living in rural areas and 37,779,860 in urban centres.[37]

Small-scale farmers dominate Vietnam's agriculture,[38] with rice being the main crop and occupying 35.9% of the total agricultural area.[39] The use of synthetic pesticides in Vietnamese agriculture began in the late 1950s, "promoted by the centralised government for use in the collectivised production that dominated agricultural policies and practices between 1959 and the early 1980s".[40] However, it was the mid-1980s reorientation of Vietnam's economy and agriculture to a market-based system that allowed private interests to import, formulate, distribute, and use pesticides, resulting in substantial increases in pesticide usage. Pesticide use rose sharply from about 91 tonnes/year in the 1950s to 32,000 tonnes in 2002 and 95,000 tonnes in 2012.[41] Pesticide use is said to be highest in the Mekong Delta area of Vietnam.[42]

A considerable number of studies have been carried out on the conditions of use of pesticides in various parts of Vietnam, including the Mekong Delta,[43] north,[44] and central[45] Vietnam. Crops included rice, vegetables, flowers, strawberries, and coffee. These studies report high usage of pesticides;[46, 47] a high number of different pesticides being used, including pesticides banned in the European Union

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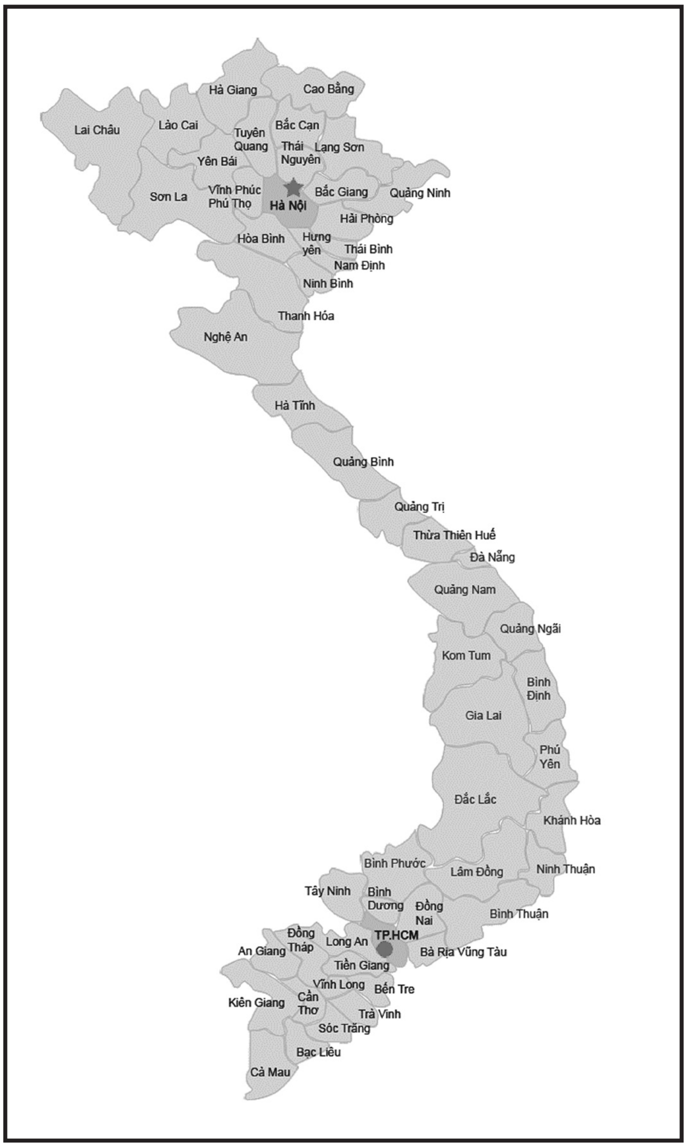
37. FAOSTAT. Food and Agriculture Organisation of the United Nations. https://www.fao.org/faostat/en/#country/237 . Accessed November 15th 2022.
38. Hoi PV, Mol AP, Oosterveer P, van den Brink PJ, Huong PT. 2016. Pesticide use in Vietnamese vegetable production: a 10-year study. *Int J Agric Sustain* 14(3).
39. Phong LT, Tan TA. 2020. Highly Hazardous Pesticides in Vietnam: A Situational Analysis. Research Centre for Rural Development, An Giang University, Vietnam; Health and Agricultural Policy Research Institute, University of Economics Ho Chi Minh City, Vietnam; IPEN.
40. Hoi Mol AP, Oosterveer P, van den Brink PJ, Huong PT. 2016. Pesticide use in Vietnamese vegetable production: a 10-year study. *Int J Agric Sustain* 14(3).
41. Hoi Mol AP, Oosterveer P, van den Brink PJ, Huong PT. 2016. Pesticide use in Vietnamese vegetable production: a 10-year study. *Int J Agric Sustain* 14(3).
42. Giao NT. 2021. The use of pesticides in triple-rice crop in the coastal district, Tra Vinh, Vietnam. *J Tourism, Hospit Environ Manag* 6(22):32-40.
43. Galli A, Winkler MS, Doanthu T, Fuhrimann S, Huynh T, Rahn E, Stamm C, Staudacher P, Van Huynh T, Loss G. 2022. Assessment of pesticide safety knowledge and practices in Vietnam: A cross-sectional study of smallholder farmers in the Mekong Delta. *J Occup Environ Hyg* 19(9):509-523.
44. Song NG, Thuy NT, Tiep NC, Ha TV, Que ND, Huong NT. 2021. Pesticide risk reduction of vegetable farmers: A case study in Vietnam. *J Environ Protect* 12:1055-68.
45. Giang CN, Le DB, Nguyen VH, Hoang TL, Tran TV, Huynh TP, Nguyen TQ. 2022. Assessment of pesticide use and pesticide residues in vegetables from two provinces in Central Vietnam. *PLoS ONE* 17(6): e0269789.
46. Houbraken M, Bauweraerts I, Fevery D, Van Labeke MC, Spanoghe P. 2016. Pesticide knowledge and practice among horticultural workers in the Lâm Đồng region, Vietnam: A case study of chrysanthemum and strawberries. *Sci Tot Environ* 550:1001-9.
47. Migheli M. 2020. Do trained farmers protect themselves when using pesticides? Evidence from rural Vietnam. *Environ Monit Assess* 192:424.
48. Sattler C, Schrader J, Farkas VM, Settele J, Franzen M. 2018. Pesticide diversity in rice growing areas of Northern Vietnam. *Paddy Water Environ* 16(2):339-52.
49. Nguyen TM, Ranamukhaarachchi SL, Nguyen PD. 2017. Pesticide use and health hazards among small-scale commercial vegetable growers in the central highland region of Vietnam. *Res on Crops* 18(3): 497-507.
50. Giang CN, Le DB, Nguyen VH, Hoang TL, Tran TV, Huynh TP, Nguyen TQ. 2022. Assessment of pesticide use and pesticide residues in vegetables from two provinces in Central Vietnam. *PLoS ONE* 17(6): e0269789.
51. Galli A, Winkler MS, Doanthu T, Fuhrimann S, Huynh T, Rahn E, Stamm C, Staudacher P, Huynh TV, Loss G. 2022. Assessment of pesticide safety knowledge and practices in Vietnam: A cross-sectional study of smallholder farmers in the Mekong Delta. *J Occup Environ Hyg* 19(9):509-523.
52. Giang CN, Le DB, Nguyen VH, Hoang TL, Tran TV, Huynh TP, Nguyen TQ. 2022. Assessment of pesticide use and pesticide residues in vegetables from two provinces in Central Vietnam. *PLoS ONE* 17(6):e0269789.

(one study on rice growing found 74 different pesticides, with 24 banned by the EU);[48] a low understanding of the risks of pesticides,[49, 50] and even which pesticides farmers were using;[51, 52] a generally low usage rate of the appropriate PPE;[53] and improper storage and disposal of pesticides and empty containers,[54, 55] although one study in the Gam Lam district of Hanoi found that 80% of households took their bottles and packages to storage tanks in accordance with regulations.[56] Nguyen et al (2107) stated that "the economy encouraged use of pesticides", perhaps referring to the influence of dealers on farmers and the latter's lack of awareness of safer alternatives.[57] A systematic review published in 2015[58] reported that 40 different compounds containing at least 36 different pesticides were being sold to farmers in north Vietnam from 2006 to 2009. The papers included in this review identify 107 pesticide active ingredients in use from 2015 to 2022, considerably more than in the other four countries; Cambodia, Laos, Myanmar, Thailand.

According to a report by the European Parliament, Vietnam is one of the main destinations for pesticides banned in the EU but still exported by EU countries. So, in March 2017, the European Commission carried out an audit to evaluate Vietnam's control of pesticides that are used on plant-based exports and are intended for the EU. According to the findings, "the measures and legislation were sufficient, but the implementation of controls was poor and there was evidence of poor training of local farmers on the safe use of pesticides."[59]

Residues found in vegetables,[60] in drinking water,[61, 62, 63] in the environment,[64, 65, 66] and in people confirm evidence of high pesticide use. Li and Kannan (2019)[67] reported that men and women in Hanoi had higher levels of organophosphate (OP) and pyrethroid metabolites in their urine than people from India, China, Korea, Greece, Saudi Arabia, USA, and Japan. Their subsequent paper[68] also reported higher levels of neonicotinoid residues in people from Hanoi than from people in eight other countries (the aforementioned seven countries plus Kuwait).

53. Galli A, Winkler MS, Doanthu T, Fuhrimann S, Huynh T, Rahn E, Stamm C, Staudacher P, Huynh TV, Loss G. 2022. Assessment of pesticide safety knowledge and practices in Vietnam: A cross-sectional study of smallholder farmers in the Mekong Delta. *J Occup Environ Hyg* 19(9):509-523.
54. Giang CN, Le DB, Nguyen VH, Hoang TL, Tran TV, Huynh TP, Nguyen TQ 2022. Assessment of pesticide use and pesticide residues in vegetables from two provinces in Central Vietnam. *PLoS ONE* 17(6):e0269789.
55. Giang CN, Le DB, Nguyen VH, Hoang TL, Tran TV, Huynh TP, Nguyen TQ. 2022. Assessment of pesticide use and pesticide residues in vegetables from two provinces in Central Vietnam. *PLoS ONE* 17(6): e0269789.
56. Song NV, Thuy NT, Tiep NC, Ha TV, Que ND, Huong NT. 2021. Pesticide risk reduction of vegetable farmers: A case study in Vietnam. *J Environ Protect* 12(12):1055-68.
57. Nguyen TM, Ranamukhaarachchi SL, Nguyen PD. 2017. Pesticide use and health hazards among small-scale commercial vegetable growers in the central highland region of Vietnam. *Res on Crops* 18(3): 497-507.
58. Richter CH, Custer, Steele JA, Wilcox BA, Xu J. 2015. Intensified food production and correlated risks to human health in the Greater Mekong Subregion: a systematic review. *Environ Health* 14:43.
59. European Parliament. 2021. The use of pesticides in developing countries and their impact on health and the right to food. Policy Department for External Relations Directorate General for External Policies of the Union PE 653.622 - January 2021. https://www.europarl.europa.eu/cmsdata/219887/Pesticides%20health%20and%20food.pdf
60. Giang CN, Le DB, Nguyen VH, Hoang TL, Tran TV, Huynh TP, Nguyen TQ. 2022. Assessment of pesticide use and pesticide residues in vegetables from two provinces in Central Vietnam. *PLoS ONE* 17(6): e0269789.
61. Wan Y, Tran TM, Nguyen VT, Wang A, Wang J, Kannan K. 2021. Neonicotinoids, fipronil, chlorpyrifos, carbendazim, chlorotriazines, chlorophenoxy herbicides, bentazon, and selected pesticide transformation products in surface water and drinking water from northern Vietnam. *Sci Total Environ* 750:141507.
62. Chau ND, Sebesvari Z, Amelung W, Renaud FG. 2015. Pesticide pollution of multiple drinking water sources in the Mekong Delta, Vietnam: evidence from two provinces. *Environ Sci Pollut Res* 22(12):9042-58.
63. Toan PV, Sebesvari Z, Bläsing M, Rosendahl I, Renaud FG. 2013. Pesticide management and their residues in sediments and surface and drinking water in the Mekong Delta, Vietnam. *Sci Tot Environ* 452-3:28-39.
64. Duong HT, Doan NH, Trinh HT, Kadokami K. 2021. Occurrence and risk assessment of herbicides and fungicides in atmospheric particulate matter in Hanoi, Vietnam. *Sci Tot Environ* 787: 147674.
65. Tran TA, Malarvannan G, Hoang TL, Nguyen VH, Covaci A, Elskens M. 2019. Occurrence of organochlorine pesticides and polychlorinated biphenyls in T sediment and fish in Cau Hai lagoon of Central Vietnam: Human health risk assessment. *Mar Pol Bull* 141:521-8.
66. Hoai PM, Sebesvari Z, Minh TB, Viet PH, Renaud FG. 2011. Pesticide pollution in agricultural areas of Northern Vietnam: Case study in Hoang Liet and Minh Dai communes. *Environ Pollut* 59(12):3344-50.
67. Li AJ, Kannan K. 2019. Urinary concentrations and profiles of organophosphate and pyrethroid pesticide metabolites and phenoxyacid herbicides in populations in eight countries. *Environ Int* 121(Pt 2):1148–1154.
68. Li AJ, Kannan K. 2020. Profiles of urinary neonicotinoids and dialkylphosphates in populations in nine countries. *Environ Int* 145:106120.



Some studies suggest that improved education reduces risky pesticide use behaviour;[69] some show the opposite – Hughes et al (2022)[70] found, across Vietnam, Thailand, and Laos, a higher health risk among those who had greater overall knowledge of pesticides.

Study locations:
Mekong Delta: Chau Thanh district; Thoi Lai district in Can Tho province

South Vietnam: Vinh Hanh, Vinh Binh, and Vinh Au Chau in the Thanh district of An Giang; Dong Thap, Tien Giang, Vinh Long, Tra Vinh, Hau Giang, Dong Nai

Central Highlands: Da Lat, Don Duong, Duc Trong regions, Lam Dong province

North Vietnam: Hai Duong, Vinh Phuc

North Central: Quang Binh, Thua Thien Hue

Hanoi: Dong Anh district: Van Duc, Dang Xa communes in Gia Lam district

Nam Dinh province: Hai Hau, Nghia Hung, Thuan Chau

Phu Tho province: Thai Binh

Thai Nguyen province: Ao Sen, Dong Cham

4.2 Gender dimensions of pesticide use

Employment statistics indicate a relatively even distribution of gender in agriculture in Vietnam: The World Bank[71] reported a 37% employment rate in agriculture in 2019, out of which 38% were women. However, very few studies provided gender-disaggregated data. There were a few that did, and which reported the following findings:

- Schreinemachers et al (2017):[72] 50% of their sample were women, and they reported that women made up 49% of the applicators in Vietnam. "Pesticide use was 42% less when a woman was in charge of pest management." However, the reported health impacts were not categorised by gender.
- Nguyen et al (2017):[73] stated that "vegetable production in Vietnam is male-dominated", based on their study that sampled 78% men and 22% women. There were no gender differences in the symptoms reported.

69. Migheli M. 2020. Do trained farmers protect themselves when using pesticides? Evidence from rural Vietnam. *Environ Monit Assess* 192:424.
70. Hughes et al, study in press. Data taken from presentation by Hughes D, Vo TV, Turnbull N, Sycareun V, Jordan S. 2022. Pesticides use and health impacts on framers in Thailand, Vietnam and Lao DPR. Ancient Capital conference on Science and Technology, Hue University, August 2022.
71. The World Bank. https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=VN
72. Schreinemachers P, Chen H-P, Nguyen TT, Buntong B, Bouapao L, Gautam S, et al. 2017. Too much to handle? Pesticide dependence of smallholder vegetable farmers in Southeast Asia. *Sci Total Environ* 593-594:470–7.
73. Nguyen TM, Ranamukhaarachchi SL, Nguyen PD. 2017. Pesticide use and health hazards among small-scale commercial vegetable growers in the central highland region of Vietnam. *Res on Crops* 18(3):497-507.

- Rengam et al (2018): reported a news item stating that in 2009, rural famers, especially women in the Hai Hau district of Nam Dinh province, had been continually poisoned by pesticides. Hai Hau district, where high-yielding rice and vegetables are grown, has a high percentage of women farmers as many of the men have left for the capital to find work.[74]

Washing clothes or equipment is often seen as women's work, and this adds another route of exposure to pesticides for women, although in the PANAP 2022 Field Survey (Diyana et al 2022), only 53.85% of women respondents in Hai Hau were washing clothes and spray equipment, whilst in Thuan Chau district, 64% of women and 62.5% of men do this task.[75] In the earlier study on school children in Hai Hau and Nghia Hung districts, there were more girls (36.5%) washing spray tanks or equipment than boys (28.8%).[76]

In the CPAM study[77] carried out by CGFED and PANAP in Hai Hau and Nghia Hung districts, involving 98 men and 102 women, 38.7% of the respondents said they were trained on how to apply pesticides, with a slightly higher percentage of women participating (39.6%) than men (37.1%). This training did not address the adverse effects of pesticides on human health and the environment. Furthermore, it didn't distinguish the level of pesticide use between men and women. Slightly more men (93.9%) than women (91%) wore protective clothing, but significantly more women (78.2%) reported pesticide poisoning symptoms than men (66.3%).

4.3 Conditions of use

Galli et al (2022)[78] reported that the use of PPE was generally very limited, although some wore surgical masks or cloth face coverings (62.0%) and gloves (36.8%), pointing out that surgical face masks can become soaked with pesticides and increase exposure rather than protect against them. When asked why they do not wear PPE, 83.0% of the farmers responded that it is not comfortable. Other reasons were that the PPE is not available (37.0%) or that the participants did not care about wearing PPE (10.8%)."

Most of the studies reported that many farmers did not wear the correct PPE, with some farmers even using tissues instead of a mask.[79] In the most recent survey, 51.92% of women who spray pesticides wore PPE whilst 48.08% of men did, although the PPE worn were below the appropriate standard.[80]

It was also reported that pesticide equipment is washed in communal water sources used for bathing and cooking.[81] In addition, the training rate in pesticide use was low – only 38.7% of farmers were trained according to the CGFED & PANAP 2020 survey[82] (and it is even fewer in the Diyana et al 2022 field survey). The training sessions also did not address the adverse effects of pesticides on human health and the environment. It should be noted that direct exposure to pesticides was common mainly due to leaking equipment and droplets falling off whilst spraying.

74. Rengam S, Serrana MS, Quijano I. 2018. Of Rights and Poisons: Accountability of the Agrochemical Industry. Penang: PAN Asia Pacific. https://panap.net/2018/10/of-rights-and-poisons-accountability-of-the-agrochemical-industry/
75. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf
76. CGFED, SRD, PANAP. 2020. School Children's Exposure to Pesticides in Vietnam: A Study in Three Districts. PAN Asia Pacific, Penang.
77. CGFED, PANAP. 2020. A community-based pesticide action monitoring (CPAM) in Hai Hau and Nghia Hung district, Nam Dinh province. Research Centre for Gender, Family and Environment in Development, PAN Asia Pacific, Penang.
78. Galli A, Winkler MS, Doanthu T, Fuhrimann S, Huynh T, Rahn E, Stamm C, Staudacher P, Huynh TV, Loss G. 2022. Assessment of pesticide safety knowledge and practices in Vietnam: A cross-sectional study of smallholder farmers in the Mekong Delta. *J Occup Environ Hyg* 19(9):509-23.
79. CGFED & PANAP. 2020. A community-based pesticide action monitoring (CPAM) in Hai Hau and Nghia Hung district, Nam Dinh province. Research Centre for Gender, Family and Environment in Development, PAN Asia Pacific, Penang.
80. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf
81. CGFED & PANAP. 2020. A community-based pesticide action monitoring (CPAM) in Hai Hau and Nghia Hung district, Nam Dinh province. Research Centre for Gender, Family and Environment in Development, PAN Asia Pacific, Penang.
82. CGFED & PANAP. 2020. A community-based pesticide action monitoring (CPAM) in Hai Hau and Nghia Hung district, Nam Dinh province. Research Centre for Gender, Family and Environment in Development, PAN Asia Pacific, Penang.

4.4 Pesticide poisonings

Despite the number of studies on the use and environmental impacts of pesticides in Vietnam, there are very few studies on the health impacts of the pesticides being used by farmers and workers.[83] Only five studies provided data on both the prevalence of health impacts and the pesticides being used. None of the studies were able to tie the health impacts to specific pesticides.

Rengam et al (2018) reported the following data on poisoning: in 2002, poisoning by pesticide residues in food affected a total of 7,647 people and caused 277 deaths in 37 provinces,[84] and that in 2003, chronic pesticide poisoning was estimated to have affected one million Vietnamese farmers.[85] Dang et al (2017)[86] reported that "According to the Treatment Department of the Ministry of Health, there were over 3,000 cases of pesticide poisoning, with nearly 3,000 victims and over 100 people dying in the first half of 2011." However, no reference was provided and there appears to be a lack of up-to-date data.

Richter et al (2015)[87] provided some insight into the pesticide poisoning situation in Vietnam:

> *"A self-surveillance study of 50 farmers in Vietnam found an under-reporting rate of 96% corresponding to untreated symptoms, while the WHO reported 7,170 cases of acute pesticide poisoning in Vietnam in 2002. In combination, these figures could thus accumulate to almost 180,000 cases of pesticide poisoning of various degrees per year in Vietnam alone. Furthermore, due to the growing market diversification brought about by the great number of annual registration or new products and compounds, risks associated with direct or indirect pesticide exposure are naturally becoming more complex and are continuously shifting. For instance, in 2004, a high incidence of poisoning from exposure to organophosphates and carbamates was reported by the World Bank. In 2012, the majority of fatalities directly linked to pesticides at the Poison Control centre were reported as paraquat poisoning.*
>
> *In spite of these findings, direct and indirect impacts of environmental pesticides on human health remain vastly under-researched and under-reported."*

A biological monitoring study carried out in 2009, followed by an exposure assessment in 2010, identified that the use of chlorpyrifos by rice farmers was likely causing adverse impacts on their health.[88, 89] Chlorpyrifos has recently been banned in Vietnam.

A recent study[90] using finger-prick tests to determine blood levels of acetylcholinesterase (AChE) identified that 33.9% of those sampled were at significant risk from exposure to organophosphate and carbamate insecticides. These figures were significantly lower than in Thailand (59.7%) and Laos (76.9%). However, this test does not identify risks from other pesticides, only that of organophosphates (Ops) and carbamates. According to the authors, the reason for the lower level of risk in Vietnam, as assessed by AChE levels, is

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83. Hughes D, Thongkum W, Tudpor K, Turnbull N, Yukalang N, Sychareun V, Vo TV, Win LL, Watkins A, Jordan S. 2021. Pesticides use and health impacts on farmers in Thailand, Vietnam, and Lao PDR: Protocol for a survey of knowledge, behaviours and blood acetyl cholinesterase concentrations. *PLoS ONE* 16(9): e0258134.
84. Xuyen, NT. 2003. Who will protect green vegetables? TriThucTre Newspaper, 101:14–16.
85. Oanh, NK. 2005, April. *Information on chemical safety and environmental protection: a testing model applicable for safely pesticide management.* Paper presented at the Vietnam National Conference on Environmental Protection, Hanoi, Vietnam.
86. Dang HV, Nguyen LT, Tran HT, Nguyen HT, Dang AK, Ly VD, Frazzoli C. 2017. Risk factors for non-communicable diseases in Vietnam: A focus on pesticides. *Front Environ Sci* 5:58.
87. Richter CH, Custer, Steele JA, Wilcox BA, Xu J. 2015. Intensified food production and correlated risks to human health in the Greater Mekong Subregion: a systematic review. *Environ Health* 14:43.
88. Phung DT, Connell D, Miller G, Hodge M, Patel R, Cheng R, Abeyewardene M, Chu C. 2012. Biological monitoring of chlorpyrifos exposure to rice farmers in Vietnam. *Chemosphere* 87:294-300.
89. Phung DT, Connell D, Miller G, Chu C. 2012b. Probabilistic assessment of chlorpyrifos exposure to rice farmers in Viet Nam. *J Expos Sci Environ Epidemiol* 22:417-23.
90. Hughes et al. Study in press. Data taken from presentation by Hughes D, Vo TV, Turnbull N, Sycareun V, Jordan S. 2022. Pesticides use and health impacts on farmers in Thailand, Vietnam and Lao DPR. Ancient Capital conference on Science and Technology, Hue University, August 2022.

not yet established. It could be due to a delay between exposure and testing, and/or it may be an artifact of testing rather than a picture of the true situation.

4.4.1 Information from Boedeker et al (2020)

Boedeker et al (2020) found only four studies post-2006 that were appropriate for estimating UAPP in Vietnam. These four studies on farmers and workers were averaged without weighting to arrive at a percentage occupational morbidity of 57.35%, with a range from 30% (based on 300 farmers) to 80% (based on 534 farmers).

- Thong & Phong 2011[91] – 45 farmworkers in rice cultivation in the Mekong Delta: Vinh Hanh, Vinh Binh, and Vinh An Chau in the Thanh district of An Giang.
- Schreinemachers 2017[92] – 300 farmers growing vegetables, region not specified.
- FAO 2013[93] – 251 farmers in Hanoi and Thai Binh, crops not specified.
- Rengam 2018[94] – 534 farmers in Hai Hau in Nam Dinh province and Ao Sen and Dong Cham in Thai Nguyen province growing rice and vegetables.

4.4.2 Information from recent peer-reviewed publications

Only one recent peer-reviewed study could be located:

- Nguyen et al (2017)[95] – 115 vegetable growers (78% men) in the Don Duong, Duc Trong and Da Lat districts of the Lam Dong province, Central Highlands region.

4.4.3 Information from PANAP community monitoring reports

Rengam et al (2018) reported two CPAM studies, in 2015 and 2017. Four other CPAM studies are reported here:

- RCRD, CGFED, SRD, PANAP (2015)[96] – 335 farmers (48.7% men and 51.3% women) in three ecological regions: An Giang, Nam Dinh, and Phu Tho provinces. These provinces represent the Mekong delta region, the plains of the Red River Delta, and the midland mountainous region. This study was carried out by An Giang University's Research Center for Rural Development (RCRD), the Research Centre for Gender, Family and Environment in Development (CGFED), and the Centre for Sustainable Rural Development (SRD). The majority of pesticide sprayers in Nam Dinh and Phu Tho were women, while those in An Giang were men.
- CGFED, SRD, PANAP (2020)[97] – two separate studies:
  - In 2018, CGFED conducted a CPAM study in the Hai Hau and Nghia Hung districts of Nam Dinh province in North Vietnam, to document the health impacts of pesticides on schoolchildren. 140 junior high school pupils from schools that are surrounded by rice fields were interviewed. 98.6% of students reported exposure to pesticides in their home or at school, with 91.4% reporting symptoms of UAPP.
  - At the same time, SRD and the Phu Luong district Agricultural Extension Station and school authorities initiated a CPAM study in Phu Luong district, Northeast Vietnam, of 80 school students and 20 teachers from schools located within agricultural villages. 97.5% of students reported exposure to pesticides, including 32.5% who entered newly sprayed fields and 11.2% who mixed pesticides with their bare hands; 36.2% reported vomiting after exposure.

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91. Thong TA, Phong LT. 2011. Impacts of pesticide application on the health of hired applicators in An Giang province, Vietnam. Research Center for Rural Development, An Giang University, Vietnam.
92. Schreinemachers P, Chen H-P, Nguyen TT, Buntong B, Bouapao L, Gautam S, et al. 2017. Too much to handle? Pesticide dependence of smallholder vegetable farmers in Southeast Asia. *Sci Total Environ* 593-594:470–7.
93. FAO. 2013. Empowering Farmers to Reduce Pesticide Use. Bangkok: Food and Agriculture Organization of the United Nations. FAO Regional IPM/Pesticide Risk Reduction Programme in Asia. FAO Regional Office for Asia and the Pacific, Bangkok. https://www.researchgate.net/publication/259080275_Empowering_Farmers_to_Reduce_Pesticide_Risks
94. Rengam S, Serrana MS, Quijano I. 2018. Of Rights and Poisons: Accountability of the Agrochemical Industry. PAN Asia Pacific, Penang. https://panap.net/2018/10/of-rights-and-poisons-accountability-of-the-agrochemical-industry/
95. Nguyen TM, Ranamukhaarachchi SL, Nguyen PD. 2017. Pesticide use and health hazards among small-scale commercial vegetable growers in the central highland region of Vietnam. *Res on Crops* 18(3):497-507.
96. RCRD, CGFED, SRD, PANAP. 2015. Knowledge, Attitude and Practice (KAP) Towards the Use of Chlorpyrifos and Paraquat and their Impact on Human Health and the Environment. PAN Asia Pacific, Penang.
97. CGFED, SRD, PANAP. 2020. School Children's Exposure to Pesticides in Vietnam: A Study in Three Districts. PAN Asia Pacific, Penang.

- CGFED, PANAP 2020[98] – also a combination of two studies:
  - 2018 in Hai Hau (Hai Long, Hai Son, and Hai Cuong communes) and Nghia Hung (Nghia Minh and Hoang Nam communes) – 200 farmers (102 women)
  - 2019 in Hai Hau – case studies of 11 survivors of pesticide poisoning
- Diyana et al 2022[99] – in 2021, PANAP worked with partner organisations CGFED to conduct a study in Hai Hau (52 farmers) and with SRD to conduct a study in Thuan Chau (51 farmers, mainly rice and coffee growing).

4.4.4 Summary of prevalence

Table 4.1 below summarises the information on prevalence of UAPP by Boedeker et al (2020) together with the new information provided in this review.

Table 4.1: Estimation of prevalence of UAPP in Vietnam

Study	Review status	Year	Sample	Population	Morbidity	Symptom range
Thong & Phong 2011	peer*	?	45	workers	60.00%	highest
Schreinemachers 2017	peer	2015	300	farmers	30.00%	highest
Rengam 2018		2015-17	534	farmers	84.00%	any
Nguyen et al 2017	peer	2016	115	farmers	33.00%	highest
RCRD et al 2015	CM**	2015	335	farmers	82.00%	any
CGFED et al 2020	CM	2018 2018	140 100	children children + teachers	91.40% 36.20%	any vomiting
CGFED et al 2020b	CM	2018	200	farmers	72.40%	any
Diyana et al 2022	CM	2019	Hai Hau: 52 Thuan Chau: 51	farmers farmers	26.92% 78.00%	any any
		Average		***farmers & workers*** ***children***	***58.29%*** ***63.80%***	

* **Peer** = Peer-reviewed journal publication

****CM** = Community monitoring study

Limitations: Three studies show morbidity only for the highest prevalence symptom, one study shows only one symptom, and the rest show the occurrence of any symptom. The three studies are likely to slightly underestimate the percentage of morbidity, as not all poisoning symptoms are experienced by all those affected, and should be regarded as a minimum level of UAPP.

Table 4.2: Estimation of UAPP in Vietnam

Population	Year	Population size	Fatal	Non-fatal (estimated)	Total cases	Morbidity
Total population	2019	96,462,108	?			
Agri labour force	2019	20,805,540	?	12,127,549		58.29%
Children – total	2019	21,716,369	?			
Children – rural[100]	2015–2016	14,332,803	?	9,144,328		63.80%

Source of population data: The World Bank Data Bank. Population Estimates and Projections. https://databank.worldbank.org/source/population-estimates-and-projections/Type/TABLE/preview/on Accessed Dec 2020.

The newly derived prevalence amongst farmers and workers of 58.29% UAPP – equating to 12,127,549 farmers and workers – is slightly higher than what was derived by Boedeker et al, of 57.35%, indicating that even with the more recent studies added, UAPP is not decreasing in Vietnam. The true incidence of UAPP is likely to be higher than this because 3 of the 9 studies reported only the prevalence of the most

98. CGFED & PANAP. 2020. A community-based pesticide action monitoring (CPAM) in Hai Hau and Nghia Hung district, Nam Dinh province. Research Centre for Gender, Family and Environment in Development, PAN Asia Pacific, Penang.
99. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf

common symptom, not for the occurrence of any symptom – not all symptoms are experienced by all those experiencing poisoning.

New in this review is information on UAPP in children: the 91.4% prevalence amongst school children in one district and 36.2% vomiting amongst students and teachers in another district (in other studies, vomiting is usually one of the least reported symptoms). These are extraordinarily high levels of pesticide poisoning that simply should not be happening because they threaten the health and welfare of these children throughout their lives. What this information shows is that more than 9 million rural children are experiencing pesticide poisoning.

4.5 Pesticides implicated in UAPP

Table 4.3 lists all the pesticides identified in the studies reviewed here, including whether they were commonly used, linked with symptoms, and are HHPs and/or banned in the EU. Here are some additional information:

- Thong & Phong (2011)[101] – one respondent reported feeling ill after spraying Kinelux (quinalphos), falling unconscious on the way home, and being hospitalised.
- RCRD et al (2015)[102] – one farmer was hospitalised for five days after being splashed on the face with emamectin benzoate when the bottled was opened; six months after the incident, the farmer is still unable to see clearly.
- Houbraken et al (2016)[103] – this study on pesticide knowledge and horticultural practices in growing strawberries and chrysanthemums in the Da Lat region found 62 different active ingredients being used, only a small number of which were identified in the paper.[104]
- Rengam et al (2018)[105] – the 2015 study in Hai Hau identified the following pesticides being used when poisoning occurred: buprofezin + imidacloprid, glyphosate, emamectin benzoate, imidacloprid, imidacloprid + nitenpyram + pymetrozine, and alpha-cypermethrin. One of the farmers had to be rushed to the hospital after spraying buprofezin, whilst another farmer suffered from blurred vision two months after spraying alpha-cypermethrin.
- Sattler et al 2018[106] – the methodologies involved in this study include retrieving discarded pesticide packaging and interviewing farmers to identify pesticides being used on 17 rice fields in two rice growing areas – specifically, Hai Duong and Vinh Phuc in northern Vietnam – in 2014-2015. They identified 74 different active ingredients, with a range of 4 to 40 per farm (average = 19), noting high usage of pesticides. All farms were using pesticides banned in Europe.
  - The most commonly applied pesticide was the fungicide niclosamide, which was applied on 14 sites, followed by the herbicide bensulfuron-methyl (12 sites), the herbicide quinclorac (12 sites), the insecticide cypermethrin (11 sites), and the fungicide hexaconazole (11 sites).
  - Pesticides applied in the highest quantity were the insecticides chlorpyrifos (711.74 g) and nereistoxin (547.2 g), and the fungicides niclosamide (464.39 g) and isoprothiolane (278.3 g).
  - In general, OPs, pyrethroids, and carbamates were the most commonly and frequently used by rice farmers.

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100. Two-thirds Vietnam population is rural according to: FAOSTAT. Food and Agriculture Organisation of the United Nations. https://www.fao.org/faostat/en/#country/237 . Accessed November 15th 2022.
101. Thong TA, Phong LT. 2011. Impacts of pesticide application on the health of hired applicators in An Giang province, Vietnam. Research Center for Rural Development, An Giang University, Vietnam.
102. RCRD, CGFED, SRD, PANAP. 2015. Knowledge, Attitude and Practice (KAP) Towards the Use of Chlorpyrifos and Paraquat and their Impact on Human Health and the Environment. PAN Asia Pacific, Penang.
103. Houbraken M, Bauweraerts I, Fevery D, Van Labeke MC, Spanoghe P. 2016. Pesticide knowledge and practice among horticultural workers in the Lâm Ðồng region, Vietnam: A case study of chrysanthemum and strawberries. *Sci Tot Environ* 550:1001-9.
104. Houbraken M, Bauweraerts I, Fevery D, Van Labeke MC, Spanoghe P. 2016. Pesticide knowledge and practice among horticultural workers in the Lâm Ðồng region, Vietnam: A case study of chrysanthemum and strawberries. *Sci Tot Environ* 550:1001-9.
105. Rengam S, Serrana MS, Quijano I. 2018. Of Rights and Poisons: Accountability of the Agrochemical Industry. PAN Asia Pacific, Penang.
106. Sattler C, Schrader J, Farkas VM, Settele J, Franzen M. 2018. Pesticide diversity in rice growing areas of Northern Vietnam. *Paddy Water Environ* 16(2):339-52.

- CGFED, SRD, PANAP (2020)[107] – have cases studies of survivors of pesticide poisoning in 2019, including the following:
  - A farmer and the farmer's family fell ill after eating morning glory leaves that had been growing next to a field that was sprayed with hexaconazole four days earlier; the farmer required hospital treatment.
  - Those who sprayed isoprothiolane experienced dizziness, sweating, and irritation.
  - Those who sprayed the pesticides isopothiolane and abamectin experienced severe tiredness.
- Truong et al (2021)[108] – the Environmental Impact Quotient (EIQ) model, developed by Kovach et al[109] at Cornell University, was applied in identifying the pesticides used in mango cultivation in southern Vietnam and which are posing the greatest health risk to farmers. These pesticides were paclobutrazol, mancozeb, propiconazole, ziram, and carbendazim.
- Galli et al (2022)[110] – at least 96.2% of the participants in the Mekong Delta area had used at least one WHO Class II (moderately hazardous LD_{50} 50-2000) pesticide during the past year.
- Diyana et al (2022)[111] – one woman who reported multiple symptoms of dizziness, blurred vision, hand tremors, headache, excessive sweating, sleeplessness or insomnia, and skin rashes had 30 years' experience in pesticide spraying and used deltamethrin, emamectin benzoate, hexaconazole, nitenpyram, and isoprothiolane on her farm.

Table 4.3 below lists the pesticides found to be in use in the studies specifically for Vietnam. It also differentiates pesticides that are most commonly used, those reported to be applied in the highest quantities or associated with the highest exposure or risk, and those that caused symptoms of UAPP. It also identifies those that are regarded as HHPs, especially with regard to acute toxicity, and those that have been banned (or refused approval) in the European Union, especially for acute toxicity.

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107. CGFED, SRD, PANAP. 2020. School Children's Exposure to Pesticides in Vietnam: A Study in Three Districts. PAN Asia Pacific, Penang.
108. Truong H, Pham NT, Nguyen TT. 2021. Influences of agrochemicals on health and ecology in Vietnamese mango cultivation. *Sci World J* 6434309.
109. Kovach J, Petzoldt C, Degni J, Tette J. 1992. A method to measure the environmental impact of pesticides. *NY Food Life Sci Bul* 139:1-8.
110. Galli A, Winkler MS, Doanthu T, Fuhrimann S, Huynh T, Rahn E, Stamm C, Staudacher P, Huynh TV, Loss G. 2022. Assessment of pesticide safety knowledge and practices in Vietnam: A cross-sectional study of smallholder farmers in the Mekong Delta. *J Occup Environ Hyg* 19(9):509-23.
111. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf

Key to Tables 4.3 and 4.4

X = most commonly used (i.e., by highest number, of farmers)
x = less often used
X = applied in highest quantities
X = high exposure
X = greatest health risk (EIQ)
X = being used when symptoms occurred

HHPs:
X = pesticides meeting the JMPM criteria for acute toxicity
x = pesticides meeting the JMPM criteria for chronic toxicity, or meeting the requirements of the Stockholm or Rotterdam Conventions
X = pesticides listed in PAN HHPs list (2021) for reasons of inhalation toxicity (H330) but not meeting the JMPM criteria
x = pesticides listed in PAN HHPs list for reasons of endocrine disruption or cancer but not GHS cancer, or environmental effects and therefore not meeting the JMPM criteria

EU:
x = not approved; reasons for ban:
a = acute toxicity – human, mammalian, or GHS warning; or concerns for operator exposure even when correct PPE is worn
c = chronic health effects
d = dietary concerns
e = environmental concerns
i = lack of info
p = need for PPE, or concern expressed for operators; for example, for carbendazim: "operators, who must wear suitable protective clothing, in particular gloves, coveralls, rubber boots, and face protection or safety glasses during mixing, loading, applying, and cleaning of the equipment"[112]

Other Information
o = other information supports acute toxicity
o(si) = other information supports skin irritant and/or sensitiser
LD_{50} – bold = ≤100

112. EC. 2010. Review report for the renewal of active substance carbendazim finalised in the Standing Committee on the Food Chain and Animal Health at its meeting on 23 November 2010 in view of the renewal of inclusion of carbendazim in Annex I of Directive 91/414/EEC. SANCO/13063/2010 final 22 November 2010. European Commission.

Table 4.3: Pesticides found in use in Vietnam (the Long List)

Study No	1	2	3	4	5	6	7	8	9	10	11	12	13	HHP	EU ban	LD_{50}
Region	Mekong Delta: Chau Thanh district	Nam Dinh prov: Hai Hau	Hanoi: Dong Anh district	Dài Lat region	Cen. Highlands Lam Dong Prov: Da Lat, Don Duong, Duc Trong regions,	North: Hai Duong & Vinh Phuc	Nam Dinh Prov: Hai Hau. Ao, Thai Nguyen Pro: Sen & Dong Cham	Nam Dinh Prov: Hai Hau & Nghia Hung	Hanoi: Van Duc, Dang Xa commune, Gia Lam district	South: An Giang, Dong Thap, Tien Giang, Vinh Long, Tra Vinh, Hau Giang, Dong Nai	North Central: Quang Binh, Thua Thien Hue	Mekong Delta: Thoi Lai district: Can Tho Prov.	Hai Hau and Thuan Chau districts			
Ref	Thong & Phong 2011	RCRD et al 2015	Hoi et al 2016	Houbraken et al 2016	Nguyen et al 2017	Sattler et al 2018	Rengam et al 2018	CGFED et al 2020	Song et al 2021	Truong et al 2021[113]	Galli et al 2022	Diyana et al 2022				
Crop	rice	rice, veg	veg	strawberry, flowers	veg	rice	rice, veg	rice, veg	veg	mango	veg	rice	rice, veg, fruit, coffee			
Pesticide																
2,4-D					x					x				x		300
abamectin		x	x		X	x	x	X	X	x	x			**X**		**8.7**
acetamaprid		x	x			x	x									146
acetochlor						x					X			x	x c, e, o(si)	1,929
atrazine													x		x e, i	1,869
azadirachtin									X		x					5,000
avermectin			x					X			x			**X**		**8.7**
azoxystrobin		x		X	x	x				x		x				5,000
B. subtilis									X							5,000
B. thuringienis									X							5,050
bensulfuron-methyl		**x**				X	x					X				5,000
bromadiolone						x								**X**	x a, p, e, i	**0.56**
buprofezin		X				x	X	X								1,635
butachlor			x			x	x					X		x	x? o(si)	2,000

113. Truong H, Pham NT, Nguyen TT. 2021. Influences of agrochemicals on health and ecology in Vietnamese mango cultivation. *Sci World J* 6434309.

carbaryl						x								x	x a, c, e	614
carbendazim				X	X	x		x		X	x			x	x p, e, i	1,0000
carbosulfan						x								X	x i	**101**
cartap					X	x									x i	325
chitosan						x										16,000
chloranthraniprole		x				x	x		X					x		5,000
chlorfenapyr					x									x	x e, i	**45**
chlorfluazuron		x					x		x				x	x	x e	8,500
chlorothalonil					x		x	x						X	x e, i	5,000
chlorpyrifos	x	x	x		x	X	x	x	x	x		x	x	x X	x c, e	**66**
copper hydroxide			x		X									X		489
cymoxanil						x			X							356
cyromazine					x											3,387
cypermethrin	x				X	x	x	x		x	X	x	x	x		287
cypermethrin - alpha		X	x			X	x	X	x				x	x	x d, p, e, o (si)	**40**
cypermethrin - beta		x				x								x	x e, i	**93**
cyproconazole		x				x	x	x						x	x e, i	350
deltamethrin							x	x					x	x		**87**
diafenthiuron				X	x				X					x	x ?, o	2,068
diazinon				X										x	x a, p, e	1,139
difenoconazole		x			x	x	x	x		x	X	x	x			1,453
dimethoate													x	x	x c, e, i	245
diniconazole					x										x a, e, i	474
diquat dibromide													x	X	x a, e, i	1,000
emamectin benzoate		X				x	x		X	x	x	x	X	x		**81.5**
endosulfan			x											x X	x e, i	**38**
ethoxysulfuron						x		x							x e	3,270
etofenprox						x								x		2,000
eugenol						x										1,930
fenclorim						x										5,000
fenitrothion							x							x	x, e, i	330
fenobucarb			x			x					X	X	x	x	x ?	620

fipronil		x				x	x	X			X	X	x	x	x e	**92**
fluazifop-p-butyl											X			**x**		2,451
flufiprole											x				x ?	4,640
glyphosate		X			X		x	X		x			x	x		2,000
hexaconazole		x				X	x	XX			x	X	X		x ? o(si)	2189
imidacloprid		X			X	x	x	X		x			x	x	x p, e, i	131
indoxacarb			x			x	x		x		x		x	x	x e, i	179
iprobenfos		x				x	x								x ?	680
iprodione					x									x	x c, e	2,000
isoprocarb						x							x		x e	403
isoprothiolane		x				X	x	X			X		X		x ?	1,190
kasugamycin						x									x ?	21,000
lambda-cyhalothrin	x					x	x						x	X	o	**56**
lufenuron											x			x	x e	2,000
mancozeb			x		X	x		x	x	X	x	x		**x**	x c, e, i	5,000
matrine						x			X						x ?	10,000
metalaxyl						x				x	x	x				669
metolachlor					x										x ?	1,200
metsulfuron-methyl													x			5,000
myclobutanil						x									x ?	1,600
nereistoxin		x	x			X	x								x ?	**92.6**
niclosamide		x				X X	x								x ?	5,000
ningnanmycin		x				x	x								x	?
nitenpyram		X					x						X	x	x ?	1,575
oxolinic acid						x									x	525
paclobutrazol										X						1,336
paraquat					X	x	x	x		x				X	x p, e	110
pencycuron					x										x ?	5,000
permethrin		x	x		X	x	x	x	X	x				x	x ?, o(si)	430
phoxim						x									x ?	2,000
polyoxin B						x	x								x ?	21,000
pretilachlor						x		x			X	X			x ?	6,099
profenofos						x								x	x ?	358

propanil												X			x e, i	960
propiconazole		x				x	x	X		X		X	x	x	x c	550
propineb				X X	x					x		X		x	x i	5,000
propisochlor						x									x e, i	2,290
pymetrozine		X				x	x	x				x		x	x c, e, i	5,820
pyrazosulfuron-ethyl						x									x	5,000
quinalphos	X							x						x	x ?	**71**
quinclorac		x				X	x								x ?	2,680
quizalfop-p-ethyl											x					1,182
spinetoram									x			x		x		5,000
spirotetramat									X			x				2,000
streptomycin						x									x ?	9,000
sulphur		x					x									2,000
tebuconazole										x	X	x		X		1,700
thiamethoxam	x	x				x	x	X			x			x	x e	1,563
thiophanate-methyl			x		x	x		x						x	x e, o(si)	5,000
thiosultap (Na & monosultap)						x									x ?	333
trichlorfon		x					x	x						X	x p, e, i	212
tricyclazole		x				x	x					X	x		x p, c, e	289.7
trifloxystrobin										x	X	x				2,000
triflumezopyrim												x			x ?	5,000
validamycin		x	x		x	x	x				x			x	x ?	20,000
warfarin						x								X	x p, e	**10.4**
zeatin (cytokinin)									x						x ?	5,000
zinc phosphide						x								X		**12**
zineb			x		x										x i, o(si)	5,200
ziram										X				X		267

Table 4.4: Pesticides potentially involved in UAPP in Vietnam (the Short List)

Study No.	1	2	3	4	5	6	7	8	9	10	11	12	13	HHP	EU bans	LD_{50} mg/kg
Date of study	2011	2015	2016	2016	2017	2018	2018	2020	2021	2021	2022	2022	2022			
Pesticide																
2,4-D					x					x				x		300
abamectin		x	x		X	x	x	X	X	x	x			X		**8.7**
acetamaprid		x	x			x	x									146
acetochlor						x					X			x	x c, e, o(si)	1,929
atrazine													x		x e, i	1,869
avermectin			x					X			x			X		**8.7**
bromadiolone						x								X	x a, p, e, i	**0.56**
buprofezin		X				x	X	X								1,635
butachlor			x			x	x					X		x	x? o(si)	2,000
carbaryl						x								x	x a, c, e	614
carbosulfan						x								X	x i	**101**
cartap					X	x									x i	325
chlorfenapyr					x									x	x e, i	**45**
chlorpyrifos	x	x	x		x	X	x	x	x	x		x	x	x X	x c, e	**66**
copper hydroxide			x		X									X		489
cymoxanil						x			X							356
cypermethrin	x				X	x	x	x		x	X	x	x	x		287
cypermethrin - alpha		X	x			X	x	X	x				x	x	x d, p, e, o(si)	**40**
cypermethrin - beta		x				x								x	x e, i	**93**
cyproconazole		x				x	x	x						x	x e, i	<350
deltamethrin							x	x					x	x		**87**
diafenthiuron				X	x				X					x	x ?, o	2,068
diazinon				X										x	x a, p, e	1,139
difenoconazole		x			x	x	x	x		x	X	x	x			1,453
dimethoate													x	x	x c, e, i	245
diniconazole					x										x a, e, i	474
diquat dibromide													x	X	x a, e, i	1,000
emamectin benzoate		X				x	x		X	x	x	x	X	x		**81.5**

endosulfan			x											x X	x e, i	**38**
etofenprox						x								x		2,000
eugenol						x										1,930
fenitrothion							x							x	x, e, i	330
fenobucarb			x			x					X	X	x	x	x ?	620
fipronil		x				x	x	X			X	X	x	x	x e	**92**
glyphosate		X			X		x	X		x			x	x		2,000
hexaconazole		x				X	x	XX			x	X	X		x ? o(si)	2,189
imidacloprid		X			X	x	x	X		x			x	x	x p, e, i	131
indoxacarb			x			x	x		x		x		x	x	x e, i	179
iprobenfos		x				x	x								x ?	680
iprodione					x									x	x c, e	2,000
isoprocarb						x							x		x e	403
isoprothiolane		x				X	x	X			X		X		x ?	1,190
lambda-cyhalothrin	x					x	x						x	X	o	**56**
lufenuron											x			x	x e	2,000
metalaxyl						x				x	x	x				669
metolachlor					x										x ?	1,200
myclobutanil						x									x ?	1,600
nereistoxin		x	x			X	x								x ?	**92.6**
nitenpyram		X					x						X	x	x ?	1,575
oxolinic acid						x									x	525
paclobutrazol										X						1,336
paraquat					X	x	x	x		x				X	x p, e	110
permethrin		x	x		X	x	x	x	X	x				x	x ?, o(si)	430
phoxim						x									x ?	2,000
profenofos						x								x	x ?	358
propanil												X			x e, i	960
propiconazole		x				x	x	X		X		X	x	**x**	x c	550
propisochlor						x									x e, i	2,290
pymetrozine		X				x	x	x				x		x	x c, e, i	5,820
quinalphos	X							x						x	x ?	**71**
quizalfop-p-ethyl											x					1,182

spirotetramat									X			x				2,000
sulphur		x					x									2,000
tebuconazole										x	X	x		X		1,700
thiamethoxam	x	x				x	x	X			x			x	x e	1,563
thiosultap (Na and monosultap)						x									x ?	333
trichlorfon		x					x	x						X	x p, e, i	212
tricyclazole		x				x	x					X	x		x p, c, e	289.7
trifloxystrobin										x	X	x				2,000
warfarin						x								X	x p, e	**10.4**
zinc phosphide						x								X		**12**
ziram										X				X		267

Table 4.4 summarizes the 72 pesticides found to be in use on crops that are most likely to be responsible for much of the UAPP in Vietnam. The government has already banned six of them:[114]

- trichlorfon in 2017
- paraquat in 2019
- glyphosate in 2020
- chlorpyrifos and fipronil in 2021
- endosulfan
- 2,4-D

The government has also banned carbofuran, which was not found, and carbendazim and thiophanate-methyl, which were in use but less likely to be contributing to UAPP, although may be responsible for other negative impacts including chronic health effects and environmental damage.

That leaves 63 pesticides still in use, likely to be causing the high levels of UAPP, according to this analysis. Refer to Table 8.3 in the Summary for priorities for banning.

4.8 Pesticide Management in Vietnam

Vietnam adopted the International Code of Conduct on the Distribution and Use of Pesticides, of the Food and Agriculture Organization, in 1990 and issued a comprehensive decree on pesticide management in 1993.[115] However, its implementation of the Code remains patchy, exposing farmers, workers, children, communities, and the environment to the impacts of unnecessary pesticide use, which jeopardises health, welfare, livelihoods, and human rights. There are two areas of concern where the Code is not being implemented:

- *Article 3.6 Pesticides whose handling and application require the use of personal protective equipment that is uncomfortable, expensive, or not readily available should be avoided, especially in the case of small-scale users and farm workers in hot climates.*
- *Article 7.5 Prohibition of the importation, distribution, sale, and purchase of highly hazardous pesticides may be considered if, based on risk assessment, risk mitigation measures or good marketing practices are insufficient to ensure that the product can be handled without unacceptable risk to humans and the environment.*

Implementation of Article 3.6 of the Code would be the single most important step in reducing UAPP in Vietnam. It is clear from the numerous studies carried out in Vietnam that adequate PPE is not worn by most farmers, and will never be. Article 7.5 provides further basis for banning pesticides involved in UAPP. In recent years, the government has banned several HHPs, including paraquat, glyphosate, and chlorpyrifos – the PAN Consolidated List of Banned Pesticides lists 42 bans for Vietnam.[116] However, there are many more being used, and some of these are likely to be causing UAPP.

In 2017 and 2018, the government of Vietnam established several decrees and policies that support organic farming,[117, 118] paving the way for the development of organic farming as a means for reducing exposure to toxic pesticides.

114. Phong LT, Tan TA. 2020. Highly Hazardous Pesticides in Vietnam: A Situational Analysis. Research Centre for Rural Development, An Giang University, Vietnam; Health and Agricultural Policy Research Institute, University of Economics Ho Chi Minh City, Vietnam; IPEN.
115. Rengam S, Serrana MS, Quijano I. 2018. Of Rights and Poisons: Accountability of the Agrochemical Industry. PAN Asia Pacific, Penang.
116. PAN. 2022. PAN International Consolidated List of Banned Pesticides. PAN Asia Pacific, Penang. https://pan-international.org/pan-international-consolidated-list-of-banned-pesticides/
117. Decision No.1393/QĐ-TTg on approval of national strategies on green growth dated September 25, 2015, stipulating the imperative to implement sustainable organic agriculture solutions; Decree 109/2018/NĐ-CP dated August 29, 2018 on organic farming; the Ministry of Science and Technology released Decision 3883/QĐ-BKHCN (December 29, 2017) and Decision 3965/QĐ- BKHCN (December 26, 2018), stipulating organic farming production criteria. As reported by Phong & Tran 2020.
118. Phong LT, Thanh VD, Long TX. 2021. Alternatives for Reducing Highly Hazardous Pesticides in Rice Production: Case of the An Giang Province, Vietnam. Research Centre for Rural Development, An Giang University – Vietnam National University, Ho Chi Minh City.

4.9 Conclusions

It is clear that, although UAPP appears to be lower in Vietnam than in some other neighbouring countries, it is still unacceptably high, and that the government must take action to resolve the problem.

In Vietnam, there is high usage of pesticides, including HHPs and pesticides banned in their country of origin. In particular, there is high usage of pesticides that require the use of PPE, which is seldom worn to the required standard. Relying on education to ensure farmers wear the correct PPE has failed to solve the problem – and never will: the PPE is hot, uncomfortable, expensive and, even if it is worn, it does not provide complete protection.[119] Resources used for education on spraying would be more beneficially directed to training farmers in agroecological management of pests, diseases, and weeds. The government's decrees and policies that support organic farming are welcomed and should form a basis for steering farmers away from harmful pesticides.

As the agricultural sector in Vietnam consists predominantly of small-scale farmers, there should be no place for pesticides that require the use of PPE. The government must follow Article 3.6 of the International Code and prevent the sale of these pesticides, since the pesticide industry has failed to act ethically and take responsibility for ceasing sales of pesticide that require PPE in countries where it is known that farmers do not use it. A plan to phase out all HHPs and assist farmers to transition to agroecology should be developed, and the import of pesticides that have been banned in their country or region of origin – whether it be the EU, India, or China – should be banned.

This chapter has attempted to identify the pesticides that are most likely causing the problem in Vietnam. Apart from the community monitoring studies carried out by PANAP and its partners, there are very few studies focussing on health impacts and the pesticides that cause them.

The Vietnam government has been proactive recently in banning a number of HHPs that are likely contributing to UAPP. It has, therefore, shown itself willing and able to address the problem, although more HHPs needed to be banned now to better protect farmers, workers and their communities, consumers, and the environment.

4.10 Recommendations for Vietnam

1. Ban the pesticides in the Short List (Table 4.4) to reduce the level of UAPP, beginning with the priority pesticides (refer Table 8.2).
2. Ban pesticides banned by the EU.
3. Ban any other pesticides that were banned in their country of origin, e.g., China, India, and Brazil.
4. Phase out other HHPs responsible for chronic health and environmental impacts.
5. Fully implement Article 3.6 of the Code by ensuring pesticides that require PPE are not available to farmers in Vietnam.
6. Replace these pesticides with agroecology, including shifting resources from training farmers in using sprays to training them in implementing agroecological practices that prevent the need for highly toxic pesticides, and enabling farmers to take advantage of organic methods and resources.

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119. Garrigou A, Laurent C, Berthet A, Colosio C, Jas N, Daubas-Letourneux V, Jackson Filho JM, Juzel JN, Samuel O, Baldi I, Lebailly P, Galey L, Goutolle4 F, Judon N. 2020. Critical review of the role of PPE in the prevention of risks related to agricultural pesticide use. *Safety Sci* 123:104527.

5. Lao PDR

Lao People's Democratic Republic or Lao PDR/Laos is a landlocked South-East Asian country with a total land area of 236,800 sq km, surrounded mainly by Vietnam and Thailand but also bordering Cambodia in the south and China and Myanmar in the north. Nearly two-thirds of the 7,262,300 population live in rural areas (4,579,660 in 2021).[120]

At present, 72% of the agricultural land is dedicated to rice production, with other important crops being maize, coffee, sugarcane, cassava, sweet potato, and industrial tree crops such as rubber, eucalyptus, acacia,[121] and more recently, bananas.[122]

According to the Word Bank, 61% of employment in 2019 was in agriculture (59% of male employment and 64% of female employment).[123]

Study areas:
Kham district of Xiengkhouang province in north-eastern Laos
Houn district, Oudomxay province, northern Laos

120. FAOSTAT. https://www.fao.org/faostat/en/#country/120. Food and Agriculture Organization of the United Nations. Accessed Nov 15.
121. FAO. 2022. Laos at a glance. Food and Agriculture Organization of the United Nations. https://www.fao.org/laos/fao-in-laos/laos-at-a-glance/en/. Accessed Oct 1.
122. Wentworth A, Pavelic P, Kongmany S, Sotoukee T, Sengphaxaiyalath K, Phomkeona K, Deevanhaxy P, Choulamany V, Manivong V. 2021. Environmental Risks from Pesticide Use: The Case of Commercial Banana Farming in Northern Lao DPR. IWMI Research Report 177. https://www.iwmi.cgiar.org/publications/iwmi-research-reports/iwmi-research-rep.
123. World Bank https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=LA. Accessed Oct 1.

Lao's rich biodiversity is an indispensable source of food and income for the country's rural poor. However, food security is a major issue. About 80% of the rural population are subsistence farmers relying on rice, livestock, and a collection of wild foods. Yet, agricultural production is becoming more commercialised, with about 33% of farmers now producing mainly to sell.[124]

However, the transition of Laotian agriculture from subsistence to commercial has been accompanied by rapid and uncontrolled increase in pesticide use. It is difficult to get accurate up-to-date information on what and how much pesticide is in use. Average pesticide application is said to be lower than in neighbouring countries and was reportedly 0.1 kg/ha in 2015 compared to 2.8 kg/ha in Cambodia, 8.4 kg/ha in Thailand, and 16.2 kg/ha in Vietnam.[125] Note that this was based on import statistics, and illegal importation of unregistered, even banned pesticides is commonly regarded as accounting for a substantial proportion of pesticide imports in Laos, with legal imports likely to be "only a fraction of the total imported".[126] Thus, the actual rates of usage are likely to be much higher.[127]

In 2011-2013, PANAP and partner organisation the Sustainable Agriculture and Environment Development Association (SAEDA) carried out a survey of illegal pesticides in Laos, specifically in three areas bordering Thailand, China, Myanmar, and Vietnam.[128] They found that 85% of the pesticide products in Xiengkhouang province, bordering China, had Chinese labels. Banned pesticides being sold included methomyl and paraquat, carrying Chinese and Thai labels.

Pesticide use has been increasing rapidly; legal insecticide imports increased from 0.08 tonnes in 2006 to 19.53 in 2012, whilst for herbicides, it was 0.4 to 23.58 tonnes over the same time period.[129] Shattuck (2021)[130] reported a "stunning increase" in the use of agrichemicals, with legal pesticide imports increasing by more than 3,600% between 2006 and 2016 – this translated from "near zero pesticide use to 2-3 times the recommended rates of application on average over 10 years". This dramatic increase in pesticide imports accompanied the rapid conversion, over the last 10 years in the country's north, of "forests, fields, and fallows to monocultural maize destined for feedlots in China and Cambodia."[131]

According to the International Water Management Institute,[132] commercial banana farming, which relies on intensive use of agrochemicals, has rapidly expanded in the northern provinces of Laos since 2008, with ensuing increase in pesticide use. Environmental contamination with imidacloprid and paraquat was found in association with these farms.

Although this intensive use of pesticides is primarily associated with commercial maize and banana cropping, it is also reported to have spread to subsistence and local market crops as well, including for paddy rice, upland rice, and vegetables.[133]

124. FAOSTAT. 2022. Lao People's Democratic Republic. https://www.fao.org/faostat/en/#country/120 Accessed Oct 1.
125. Wentworth A, Pavelic P, Kongmany S, Sotoukee T, Sengphaxaiyalath K, Phomkeona K, Deevanhaxy P, Choulamany V, Manivong V. 2021. Environmental Risks from Pesticide Use: The Case of Commercial Banana Farming in Northern Lao DPR. IWMI Research Report 177. https://www.iwmi.cgiar.org/publications/iwmi-research-reports/iwmi-research-rep
126. Rassapong S, Syfongxay C, Phanthanivong I, Syhalad B, Phimmahthut S, Manyvong T, Keothongkham B, Hongsibsong S, Shattuck A, Bartlett A. 2018. Pesticide Use in Lao PDR: Health and Environmental Impacts. Lao Upland Rural Advisory Service (LURAS). http://www.laofab.org
127. Wentworth A, Pavelic P, Kongmany S, Sotoukee T, Sengphaxaiyalath K, Phomkeona K, Deevanhaxy P, Choulamany V, Manivong V. 2021. Environmental Risks from Pesticide Use: The Case of Commercial Banana Farming in Northern Lao DPR. IWMI Research Report 177. https://www.iwmi.cgiar.org/publications/iwmi-research-reports/iwmi-research-rep
128. Vázquez C, Tasaka K, Makarady K, Monourm C, Sopha Y. 2013. Illegal pesticide Trade in the Mekong Countries: Case Studies from Cambodia and Lao DPR. CEDAC, SAEDA and PAN Asia Pacific, Penang.
129. Rassapong S, Syfongxay C, Phanthanivong I, Syhalad B, Phimmahthut S, Manyvong T, Keothongkham B, Hongsibsong S, Shattuck A, Bartlett A. 2018. Pesticide Use in Lao PDR: Health and Environmental Impacts. Lao Upland Rural Advisory Service (LURAS). http://www.laofab.org
130. Shattuck A. 2021. Risky subjects: Embodiment and partial knowledges in the safe use of pesticide. *Geoform* 123:153-61.
131. Shattuck A. 2021. Risky subjects: Embodiment and partial knowledges in the safe use of pesticide. *Geoform* 123:153-61.
132. Wentworth A, Pavelic P, Kongmany S, Sotoukee T, Sengphaxaiyalath K, Phomkeona K, Deevanhaxy P, Choulamany V, Manivong V. 2021. Environmental Risks from Pesticide Use: The Case of Commercial Banana Farming in Northern Lao DPR. IWMI Research Report 177. https://www.iwmi.cgiar.org/publications/iwmi-research-reports/iwmi-research-rep
133. Rassapong S, Syfongxay C, Phanthanivong I, Syhalad B, Phimmahthut S, Manyvong T, Keothongkham B, Hongsibsong S, Shattuck A, Bartlett A. 2018. Pesticide Use in Lao PDR: Health and Environmental Impacts. Lao Upland Rural Advisory Service (LURAS). http://www.laofab.org

5.1 Conditions of use

When Shattuck[134] conducted a survey in the Kham district of Xiengkhouang province in north-eastern Laos – a centre of smallholder maize growing – she found that there had been multiple efforts to train farmers in the safe use of pesticides. Despite this, many farmers did not wear the necessary PPE because of the heat. The need to repair leaking equipment resulted in pesticide exposure to hands. Some people simply mixed pesticides with their bare hands. Some people did wear masks but suffered acute poisoning symptoms anyway. Shattuck (2021) describes the condition under which herbicides were being mixed in some areas:

> "Young men in teams of two and three will be mixing herbicides in blue tarps strung up over bamboo frames in the streambeds, yellow pipes like long snakes delivering their milky waters to silver spray nozzles high on the slopes. Herbicides are mixed from their concentrated forms in these tarps with long sticks and small red pumps to suck up the surface waters as they run down the limestone hills. The teams work in pairs – mostly young men – one manning the small pumps sucking up the herbicide mixed up in the tarps, the other sometimes 500m up the slope, coating the landscape with droplets of spray. They wear hats and cotton gloves, long sleeve cotton shirts or cheap Chinese fleece jackets. Most wear cotton masks or fabric tied around their face."

Atrazine was one such herbicide she found being mixed in this manner. Although Shattuck reported that she didn't witness carelessness, what she did observe was very far from appropriate practice or protection. This method of mixing and application is believed to be resulting in application rates 2-4 times the recommended rates.[135]

Photos from the Laos Upland Rural Advisory Service (LURAS)[136] depicting this operation show men with just flipflops on their feet, bare lower legs and arms, and bare hands but with cloth masks on. Men carrying out the actual spraying have bare hands but are wearing rubber boots. Women with knapsack sprayers have cloths over their faces and covered arms and legs but bare hands.

A video[137] shows the conditions under which Hmong women were undertaking herbicide spraying operation in Oudomxay province in May 2015. In the video, a woman is standing in a river filling a big blue drum of water with concentrated herbicides, including paraquat and glyphosate. She has only flipflops on her feet and no gloves. A small child walks past her and so does another woman who appears to have been bathing in the stream. A woman nearby cooks rice and washes the lid of the pot in the water right beside the herbicide mixing drum and containers of herbicide concentrate. Meanwhile, several women are further up the slope, one of whom sprays the vegetation wearing gloves, boots, and mask but carelessly sprays in the direction of another woman who is handling the hose that leads from the herbicide drum and who is wearing only flipflops. The woman who is spraying has gloves on, whilst those handling the hose do not. The sprayer walks through the wet vegetation after she has sprayed. Then, a youth wanders through the stream by the herbicide drum.

A second video[138] shows a small child handling a packet of herbicide, mixing it in a drum with a stick, without gloves, and then playing with a younger child in the stream beside the discarded herbicide packet.

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134. Shattuck A. 2021. Risky subjects: Embodiment and partial knowledges in the safe use of pesticide. *Geoform* 123:153-61.
135. Rassapong S, Syfongxay C, Phanthanivong I, Syhalad B, Phimmahthut S, Manyvong T, Keothongkham B, Hongsibsong S, Shattuck A, Bartlett A. 2018. Pesticide Use in Lao PDR: Health and Environmental Impacts. Lao Upland Rural Advisory Service (LURAS). http://www.laofab.org
136. Lao Uplands. 2016. The Toxic Landscape. Herbicides and hybrid maize in Xieng Khuang Province https://www.flickr.com/photos/33057984@N00/sets/72157652878571659/
137. LaoFAB Video.2015. Pesticide use in upland Laos. https://www.youtube.com/watch?v=xpaeHfcrs-Q Accessed Dec 2022.
138. Lao Farmer Network. Herbicide use in upland Laos. July 2016. https://www.youtube.com/watch?v=7aNdPYAsmqQ Accessed Dec 2022.

Shattuck also reported seeing women and children with hands stained purple as a result of sowing maize seed treated with a mixture of insecticide, fungicide, and growth promoter. The same stained hands would later scoop sticky rice, chop vegetables, and feed children.

5.2 Pesticide poisoning

The number of studies on the impacts of pesticides on human health in Laos is extremely limited.

5.2.1 Information from Boedeker et al (2020)

Only one peer-reviewed published study was available for Boedeker et al (2020):

- Schreinemachers et al (2017)[139] reported a 39% incident rate for highest symptom incidence, from a sample of 300 farmers growing yard-long bean and leaf mustard.

However, this data was from 2005 so is not used here.

There was not, and still is not, any mortality data available from the WHO Cause of Death database.

5.2.2 Information from other peer-reviewed studies

There is still very little peer-reviewed published information:

- Shattuck (2021)[140] – this survey of maize farmers found a 92% prevalence of UAPP symptoms, which included vomiting, skin rashes and burns, hard skin on hands, dizziness, faintness, difficulty breathing and "lung problems", eye irritation, headache, impotence, tiredness, numb lips, dry mouth, bitter taste in mouth, loss of consciousness, etc.
- Hughes et al[141] – their study in Laos, Thailand, and Vietnam found a high level of risk from organophosphate and carbamates in Laos: 76.9% of those sampled in Laos were regarded as at significant risk (compared with 59.7% in Thailand and 33.9% in Vietnam).[142] Crops and regions were not identified in the published study protocol, nor was a prevalence of symptoms.

5.2.3 Information from PANAP community monitoring reports

In 2021, PANAP[143] worked with partner organisation SAEDA to conduct a study in Kham district, Xiengkhouang province involving 52 farmers (59.3% women). However, no information was provided by the respondents on symptoms of poisoning.

5.2.4 Other information

A 2015 survey in Xiengkhouang province estimated that farmers applied nearly 50 times the national average of herbicides. Blood testing in the same province the following year found that 49% of farmers had "unsafe" levels of cholinesterase inhibition caused by exposure to organophosphate and carbamate insecticides.[144]

Residues in food were also a problem, with further testing in Xiengkhouang and in the capital Vientiane revealing that a higher percentage of people consuming vegetables from the market (45%) had

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139. Schreinemachers P, Chen H-P, Nguyen TT, Buntong B, Bouapao L, Gautam S, et al. 2017. Too much to handle? Pesticide dependence of smallholder vegetable farmers in Southeast Asia. *Sci Total Environ* 593-594:470–7.
140. Shattuck A. 2021. Risky subjects: Embodiment and partial knowledges in the safe use of pesticide. *Geoform* 123:153-61.
141. Hughes D, Thongkum W, Tudpor K, Turnbull N, Yukalang N, Sychareun V, Vo TV, Win LL, Watkins A, Jordan S. 2021. Pesticides use and health impacts on farmers in Thailand, Vietnam, and Lao PDR: Protocol for a survey of knowledge, behaviours and blood acetyl cholinesterase concentrations. *PLoS ONE* 16(9): e0258134.
142. Hughes et al. Study in Press. Data taken from presentation by Hughes D, Vo TV, Turnbull N, Sycareun V, Jordan S. 2022. Pesticides use and health impacts on farmers in Thailand, Vietnam and Lao DPR. Ancient Capital conference on Science and Technology, Hue University, August 2022.
143. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf
144. Rassapong S. 2016. Pesticides: A cause for concern. Briefing note. https://laowomenorg.files.wordpress.com/2017/09/rassapong_2016_-_luras_pesticides_briefing_lores_.pdf

unacceptable levels of cholinesterase inhibition than did farmers (35%). 52.4% of samples of fresh fruit and vegetables contained organophosphate (OP) and carbamate residues, with the highest incidence (54%) in Xiengkhouang and the lowest (27%) in Houaphan. Of the 422 schoolchildren tested for OPs and carbamates, 33% had unacceptable levels of residues, higher than farmers and other consumers. These children were exposed either through residues in food or from living near fields where the pesticides are used. In a second, smaller study of 20 farmers, students, and government officials, 85% had OP and 25% glyphosate residues. A consistent finding in these surveys is that higher-income groups – i.e., those with access to food markets – had higher levels of residues, indicating that a major problem with a contaminated food supply is the result of pesticides overuse. The problem appears to be nationwide, with unacceptable levels of OPs found in students in Vientiane as well as Xiengkhouang. However, there was no indication of the pesticides that may have been involved in these findings other than that they would have been OPs and/or carbamates, and pyrethroids, and no testing for herbicides apart from the one study on glyphosate.[145]

There appears to be no studies on the impacts of pesticides in the banana plantations, with media reports providing scant information on illegal paraquat use and fungicides applied post-harvest, resulting in ill health for workers who are becoming weak and thin or developing rashes.[146] Pesticides washing out of the banana plantations are also believed to be poisoning fish in the Ton River.[147]

5.2.5 Summary of prevalence

Table 5.1 below summarises the information on prevalence of UAPP from Boedeker et al (2020) together with the new information provided in this review.

Table 5.1: Estimation of prevalence of UAPP in Laos

Study	Review status	Year	Sample	Crop	Morbidity	Symptom range
Shattuck 2021	peer	2017-8	27 applicators	maize	92.00%	any
Rassapong 2016	?	2016	767		49.00%	unsafe cholinesterase levels
Hughes et al 2022	peer	?		bananas	76.90%	cholinesterase depression
			Average		***72.63%***	

To average these results is not very satisfactory: only one study was based on all symptoms of UAPP, but that was only in maize crops and only for 27 applicators, and the other studies were based only on cholinesterase inhibitors. However, no other data could be found. Averaging the results reveals a prevalence of 76.9% UAPP compared with 39% in Boedeker et al (2020), resulting in an increased estimate of UAPP for Laos, now over one and a half million farmers and farm workers.

Table 5.2: Estimation of UAPP in Laos

Population	Year	Population size	Fatal	Non-fatal (estimated)	Total cases	Morbidity
Total population	2019	7,169,456	?	?		?
Agricultural	2019	2,302,905	?	1,672,600	?	72.63%
Children $\leq$ 14	2019	2,315,955	?	?	?	?

Source of population data: The World Bank DataBank. Population Estimates and Projections. https://databank.worldbank.org/source/population-estimates-and-projections/Type/TABLE/preview/on Accessed Dec 2020.

145. Rassapong S, Syfongxay C, Phanthanivong I, Syhalad B, Phimmahthut S, Manyvong T, Keothongkham B, Hongsibsong S, Shattuck A, Bartlett A. 2018. Pesticide Use in Lao PDR: Health and Environmental Impacts. Lao Upland Rural Advisory Service (LURAS). http://www.laofab.org
146. Goh B, Marshall A. 2017. Cash and chemicals: for Laos, Chinese banana boom a blessing and curse. Emerging Markets, May 12. https://www.reuters.com/article/us-china-silkroad-laos-idUSKBN187334
147. Leuaki X. 2019. Poisoned fish worries village as Laos district promotes good agricultural practices. Feb 6. Earth Journalism Network. https://earthjournalism.net/stories/poisoned-fish-worries-village-as-laos-district-promotes-good-agricultural-practices

5.3 Pesticides implicated in UAPP

Only four studies provided information on the pesticides being used, and of these, only one could link pesticide use with health impacts: Shattuck (2021),[148] who did not provide a full list of pesticides used (instead referring mostly to herbicides) but did mention two pesticides linked to symptoms in her survey about maize cropping:

- 2,4-D – loss of consciousness
- atrazine – burn-like rash

Rassapong et al (2018) reported that atrazine, paraquat, cypermethrin, and chlorpyrifos had all been measured in various environmental compartments, particularly in sediment, but in the case of atrazine also in water.[149] As reported earlier, environmental contamination with paraquat and imidacloprid was also found in association with banana cultivation.[150] A 2016 government report details carbendazim, glyphosate, paraquat, dicofol, and cypermethrin in environmental samples.[151]

Key to Tables 5.3 and 5.4

X = most commonly used
x = less often used
X = being used when symptoms occurred

HHPs:
X = pesticides meeting the JMPM criteria for acute toxicity
x = pesticides meeting the JMPM criteria for chronic toxicity or meeting the requirements of the Stockholm or Rotterdam Conventions
X = pesticides listed in PAN HHPs list (2021) for reasons of inhalation toxicity (H330) but not meeting the JMPM criteria
x = pesticides listed in PAN HHPs list for reasons of endocrine disruption or cancer but not GHS cancer, or environmental effects, and therefore not meeting the JMPM criteria

EU:
x = not approved; reasons for ban:
a = acute toxicity – human, mammalian, or GHS warning; or concerns regarding operator exposure even when correct PPE is worn
c = chronic health effects
d = dietary concerns
e = environmental concerns
i = lack of info
p = need for PPE, or concern expressed for operators; for example, for carbendazim: "operators must wear suitable protective clothing, in particular gloves, coveralls, rubber boots and face protection or safety glasses during mixing, loading, application, and cleaning of the equipment"[152]

Other Information
o = other information supports acute toxicity
o(si) = other information supports skin irritant and/or sensitiser
LD_{50} – bold = $\leq$ 100

148. Shattuck A. 2021. Risky subjects: Embodiment and partial knowledges in the safe use of pesticide. *Geoform* 123:153-61.
149. Rassapong S, Syfongxay C, Phanthanivong I, Syhalad B, Phimmahthut S, Manyvong T, Keothongkham B, Hongsibsong S, Shattuck A, Bartlett A. 2018. Pesticide Use in Lao PDR: Health and Environmental Impacts. Lao Upland Rural Advisory Service (LURAS). http://www.laofab.org.
150. Wentworth A, Pavelic P, Kongmany S, Sotoukee T, Sengphaxaiyalath K, Phomkeona K, Deevanhaxy P, Choulamany V, Manivong V. 2021. Environmental Risks from Pesticide Use: The Case of Commercial Banana Farming in Northern Lao DPR. IWMI Research Report 177. https://www.iwmi.cgiar.org/publications/iwmi-research-reports/iwmi-research-rep
151. Lao Ministry of Natural Resource and Environment. 2016. Pesticide residues in soil (Report no 5604/MORE). Cited in Rassapong et al 2018.
152. EC. 2010. Review report for the renewal of active substance carbendazim finalised in the Standing Committee on the Food Chain and Animal Health at its meeting on 23 November 2010 in view of the renewal of inclusion of carbendazim in Annex I of Directive 91/414/EEC. SANCO/13063/2010 final. 22 November 2010. European Commission.

Table 5.3: Pesticides in use in Laos

Study	1	2	3	4	5	HHP	EU bans	LD_{50}
Region	Xiengkhouang	Houn district, Oudomxay province, North Laos	Kam district, Xiengkhouang		Kam district, Xiengkhouang			
Ref	Rassapong et al 2018	Wentworth et al 2021	Shattuck 2021	Hughes et al 2021	PANAP 2022			
Crop	veg, maize	banana	rice	bananas	rice, veg, maize			
Pesticide								
2,4-D	X		X			x		300
abamectin					x	**X**		**8.7**
acetamiprid		x						146
atrazine	X		X				x e, i	1,869
azoxystrobin		x						5,000
bifenthrin		x				x	x e, p	**54.5**
carbaryl	X					x	x a, c, e	614
carbofuran		x				**X**	x a, e	**7**
chlorothalonil		x				X	x e, i	5,000
chlorpyrifos	x	x				**x** X	x c, e	**66**
cypermethrin	X				x	x		287
fenbuconazole		x				x	x a, p	2,000
fenproparthrin		x				X	x ?	870
glyphosate	X				x	x		2,000
imidacloprid		x				x	x p, e, i	131
iprodione		x				x	x c, e	2,000
kresoxym-methyl		x				x		5,000
mancozeb		x				**x**	x c, e, i	5,000
metsulfuron-methyl	X							5,000
paraquat	X	x				X	x p, e	110
prochloraz		x					x ?	1,027
propineb		x				x	x i	5,000
pyridaben		x				x		161
tebuconazole		x				X		1,700
thiamethoxam		x				x	x e	1,563
thiophanate methyl		x				x	x e, o(si)	5,000
thiram		x					x c, e	1,800
OPs				x				
carbamates				x				

Table 5.4: Pesticides most likely involved in UAPP in Laos

Study	1	2	3	4	5	HHP	EU bans	LD_{50}
Year	2018	2021	2021	2021	2022			
Pesticide								
2,4-D	X		X			x		300
abamectin					x	**X**		**8.7**
acetamiprid		x						146
atrazine	X		X				x e, i	1,869
bifenthrin		x				x	x e, p	**54.5**
carbaryl	X					x	x a, c, e	614
carbofuran		x				**X**	x a, e	**7**
chlorpyrifos	x	x				**x** X	x c, e	**66**
cypermethrin	X				x	x		287
fenbuconazole		x				x	x a, p	2,000
fenproparthrin		x				X	x ?	870
glyphosate	X				x	x		2,000
imidacloprid		x				x	x p, e, i	131
iprodione		x				x	x c, e	2,000
paraquat	X	x				X	x p, e	110
prochloraz		x					x ?	1,027
pyridaben		x				x		161
tebuconazole		x				X		1,700
thiamethoxam		x				x	x e	1,563
thiram		x					x c e	1,800
OPs				x				
carbamates				x				

5.4 Conclusions

The data shows that Laos has a massive problem with toxic pesticides, both in terms of human health and environmental damage. With a populace heavily dependent on subsistence farming and collection of wild foods, it cannot afford to poison its people or its food supply. The Strategic Plan for National Organic Agriculture Development 2025, Vision Towards 2030, indicates a way forward for Laos to achieve the growth in prosperity of its rural people without poisoning them or the environment.

The information on poisoning in Laos is scant, but it nevertheless indicates a serious problem. More surveys linking symptoms to pesticides used would be useful, but in the absence of these and on the basis of the existing information, Laos should rapidly phase out the pesticides on the priority list in Chapter 8 as a start, and at the same time, upskill farmers in agroecological practices. The conditions of use are such that no pesticides requiring proper protective equipment should be available to farmers. It is not reasonable to expect farmers in Laos to use PPE that is unsuitable for hot, humid climates.

Moreover, the problem of illegal pesticides is enormous. It is essential to work together with Thailand and Vietnam to ban problem pesticides and to focus border control on the northern border with China.

Similar to Vietnam, the Laotian government has failed to fully implement the International Code of Conduct on the Distribution and Use of Pesticides, and in particular:

- *Article 3.6 Pesticides whose handling and application require the use of personal protective equipment that is uncomfortable, expensive, or not readily available should be avoided, especially in the case of small-scale users and farm workers in hot climates.*
- *Article 7.5 Prohibition of the importation, distribution, sale, and purchase of highly hazardous pesticides may be considered if, based on risk assessment, risk mitigation measures or good marketing practices are insufficient to ensure that the product can be handled without unacceptable risk to humans and the environment.*

It is clear from the few studies carried out in Laos that adequate PPE is not worn by most farmers.

Ultimately, helping farmers adopt agroecological practices can be the most effective long-term solution in reducing the use of hazardous pesticides by removing the need for them.

5.5 Recommendations for Lao PDR

1. Work with Thailand and Vietnam to ban problem pesticides in order to reduce illegal traffic across the borders.
2. Seek assistance from ASEAN/UN/China to implement border control of illegal pesticide traffic on the northern border with China.
3. Fully implement Article 3.6 of the International Code of Conduct on Pesticide Management.
4. Phase out the pesticides in Table 5.4 to stop UAPP, beginning with the priority pesticides in Table 8.3.
5. Ban pesticides banned by the EU.
6. Ban any other pesticides banned in their country of origin, e.g., China, India, and Brazil.
7. Develop government policies to support agroecology.
8. Shift resources into training farmers on the implementation of agroecological practices.

6. Bangladesh

6.1 General pesticide situation

Bangladesh is one of the most densely populated and intensely farmed agricultural nations, with smallholder farms covering approximately 70% of the country, and 87% of rural inhabitants deriving their income from agricultural activities. 99% of farms are small holder, and the average size is less than one hectare.[153]

Pesticide use in Bangladesh has grown more than 12-fold (1,225%) over the last 30 years, from 1,266 tonnes in 1990 to 15,506 tonnes in 2020. In terms of intensity of use, pesticide use per area of cropland in 2020 was 1.67kg/ha, slightly less than at its peak of 1.77kg/ha in 2013, but dramatically more than 1990's 0.13 kg/ha.[154]

Numerous studies have reported findings of multiple residues of pesticides in food, including vegetables, fish, poultry, and in the environment, including in water from paddy fields, fish ponds, lakes, rivers, and in the soil.[155] One study reported finding diazinon, carbofuran, carbaryl, and malathion in water used in rice and vegetable fields emphasising that its presence in the water suggests that these particular pesticides were being used intensively.[156]

Illegal and banned smuggled pesticides of high but unknown toxicity have previously been reported as being used, particularly in border areas of Bangladesh.[157, 158] One survey found a formulation of diazinon which had been banned by the Bangladesh government, being used by 29% of respondents.[159]

Over the years, Bangladesh has banned a number of pesticides, which has helped to reduce the rate of mortality from pesticide poisoning – particularly the bans of endosulfan in 1998, and the restrictions on use in agriculture of dichlorvos, dicrotophos, disulfoton, ethyl parathion, methyl parathion, mercury compounds, monocrotophos, and phosphamidon in 2004 – without apparent reduction in agricultural output.[160]

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153. Ali MP, Kabir MM, Haque SS, Qin X, Nasrin S, Landis D, Holmquist B, Ahmed N. 2020. Farmer's behavior in pesticide use: Insights study from smallholder and intensive agricultural farms in Bangladesh. *Sci Total Environ* 747:141160.
154. FAOSTAT. https://www.fao.org/faostat/en/#data/RP . Food and Agriculture Organization of the United Nations. Accessed November15th, 2022.
155. Sarker A, Islam T, Rahman S, Nandi R, Kim J-E. 2021. Uncertainty of foodstuffs, associated environmental and health risk to humans – a critical case of Bangladesh with respect to global food policy. *Environ Sci Pol Res* 28(39):54448-54465.
156. Chowdhury MA, Banik S, Uddin B, Moniruzzamin M, Karim N, Gan SH. 2012. Organophosphorus and carbamate pesticide residues detected in water samples collected form paddy and vegetable fields of the Savar and Dhamrai Upazilas in Bangladesh. *Int J Environ Res Pub Health* 9:3318-29.
157. Anwar AF, Yunnus A. 2013. Groundwater vulnerability to pesticides in Northwest Bangladesh. *Environ Earth Sci* 70:1971-81.
158. Shammi M, Hasan N, Rahman MM, Begum K, Sikder MT, Bhuiyan MH, Uddin MK. 2017. Sustainable pesticide governance in Bangladesh: socio-economic and legal status interlinking environment, occupational health and food safety. *Environ Syst Decis* 37(3):243-60.
159. Rengam S, Serrana MS, Quijano I. 2018. *Of Rights and Poisons: Accountability of the Agrochemical Industry*. PAN Asia Pacific, Penang.
160. Chowdhury FR, Dewan G, Verma VR, Knipe DW, Isha IT, Faiz MA, Gunnell DJ, Eddleston M. 2018. Bans of WHO Class 1 pesticides in Bangladesh—suicide prevention without hampering agricultural output. *Int J Epidemiol* 1750-84.

Study areas:
Burichong Upazila
Savar Upazila and Mehendiganj Upzila
Kaligonj and Jhenidah Sadar Upazila in Jhenidah district
Satkhira district
Manikganj and Cumilla districts
Islampur upazila in the district of Jamalpur
Khulna region (south-west Bangladesh)

6.2 Gender dimensions of pesticide use

According to Ali et al (2020),[161] farmers and farm-holding in Bangladesh are generally male-dominated, except in the tribal areas[162] where there are more farms maintained by women, although they did not include this area in their study. Not surprisingly, most of the Bangladesh studies cited in this review involve male respondents. The exceptions are the two studies by PANAP, both of which included women. The first one,[163] in Satkhira district, involved 40 women in a sample of 599 farmers. Data was not gender-

161. Ali MP, Kabir MM, Haque SS, Qin X, Nasrin S, Landis D, Holmquist B, Ahmed N. 2020. Farmer's behavior in pesticide use: Insights study from smallholder and intensive agricultural farms in Bangladesh. *Sci Total Environ* 747:141160.
162. Areas where indigenous people of Bangladesh live.
163. Rengam S, Serrana MS, Quijano I. 2018. *Of Rights and Poisons: Accountability of the Agrochemical Industry*. PAN Asia Pacific, Penang.

disaggregated, however. The second study, Diyana et al (2022),[164] included 50% women in Manikgani district and 51% women in Cumilla district. Although the women were not involved in the actual spraying in Manikgani, they were in Cumilla, and in both districts, they were involved in mixing and loading the pesticides, washing the spraying equipment and the clothing used when spraying was done, and in working in the sprayed fields.

6.3 Conditions of use

Ali et al (2020)[165] conducted a survey of 917 farmers (all but three were men) in four regions of Bangladesh and reported that most farmers from the South-East region said they were wearing masks, gloves, and long-sleeved clothes when spraying. However, that is contrary to other studies that reported a very low incidence of PPE usage. For example, Diyana et al (2022) reported that of the 50 farmers surveyed in the centre of the country, none wore any PPE during pesticide application for two reasons: 1) because it was not available (48%), and 2) because it was too expensive (52%). Between these two results lie those of Shammi et al (2018)[166] who found that use of a cloth for partial face clothing was reported by 69% of farmers in Savar Upazila and 62% in Mehendiganj Upazila; and only 14% and 5%, respectively, wore full PPE. Ali et al did acknowledge that their survey sample had an unusually high rate of literacy (28%), whereas illiteracy is very common among farmers in Bangladesh. Their sample also did not include farmers from tribal areas. Miah et al (2014)[167] also reported that, although 93% of farmers were using "partial protection measures", these were only shirt and loin cloth or trousers and nobody was wearing mask goggles or gumboots. Akhter et al (2016)[168] reported that 80% farmers were not taking any type of protective measures.

In 2014, Miah et al reported that "most farmers spray two days in a week but sometimes apply pesticides every day and harvest vegetable soon after; more than three-fourths don't know about the waiting period before collection. Consequently, pesticide residues (diazinon and quinalphos) are detected in 67% of marketed vegetables (long yard bean)."

In addition, spillages and accidents are common. Diyana et al (2022) reported that 62% of respondents experienced these during spraying, mixing, and loading of pesticides, with 80.65% of the incidents occurring during decanting.

Akhter et al (2016)[169] found that 75% of farmers could not read labels, and Miah et al found that only 23% of applicators follow instructions written on bottles or packets, with 34% using higher-than-recommended doses.

The conditions of use of pesticides in Bangladesh are such that users and other individuals, including consumers, are very vulnerable to adverse impacts on their health. Where information was available on the pesticides used, all were using organophosphate insecticides, as well as other pesticides. The use of illegal and banned pesticides adds to the already-high risk.

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164. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf
165. Ali MP, Kabir MM, Haque SS, Qin X, Nasrin S, Landis D, Holmquist B, Ahmed N. 2020. Farmer's behavior in pesticide use: Insights study from smallholder and intensive agricultural farms in Bangladesh. *Sci Total Environ* 747:141160.
166. Shammi M, Sultana A, Hasan N, Rahman MM, Islam MS, Bodrud-Doza M, Uddin Mk. 2020. Pesticide exposures towards health and environmental hazard in Bangladesh: A case study on farmer's' perceptions. *J Saudi Soc Agri Sci* 19(2):161-73.
167. Miah SJ, Hoque A, Paul A, Rahman A. 2014. Unsafe use of pesticide and its impact on health of farmers: A case study in Burichong Upazila, Bangladesh. *IOSR J Environ Sci Toxicol Food Technol* 8(1):57-67.
168. Akhter MN, Chakaborty TK, Ghosh P, Jahan S, Ghosh GC, Hossain SA. 2016. Assessment of the using patterns of pesticides and its impact on farmers health in the Jhenidah District of Bangladesh. *Am J Environ Protect* 5(5): 139-144.
169. Akhter MN, Chakaborty TK, Ghosh P, Jahan S, Ghosh GC, Hossain SA. 2016. Assessment of the using patterns of pesticides and its impact on farmers health in the Jhenidah District of Bangladesh. *Am J Environ Protect* 5(5): 139-144.

6.4 Poisonings

Pesticide poisoning has long been regarded as a major issue in Bangladesh, and is one of the top 10 health problems.[170] In 2014, Dr Gourab Dewan of Bangladesh's Rangamati General Hospital summarised 16 studies and reports on pesticide poisonings in Bangladesh, published between 2003 and 2013, and concluded the following:[171]

- Pesticide poisoning accounted for an estimated 39.1% of total poisoning cases that required being admitted to hospitals, which in turn were an estimated 7.1% of all hospital admissions.
- Pesticide poisoning was responsible for 72.6% of total poisoning-related deaths.
- Approximately 0.7 deaths per 100,000 population was due to pesticide poisoning.
- Intentional ingestion was the most common cause of poisonings, but unintentional poisonings also resulted in hospital admissions.
- The majority of cases were due to WHO Class II pesticides [moderately toxic LD_{50} 50-2000].
- The reported frequency of different pesticides involved in poisonings was OPs in 89.8% of cases, rodenticides in 4.3%, carbamates in 4.0%, unknown compounds in 1.6%, and pyrethroids in 0.3% of cases.

Most reports refer only to hospital admissions and deaths and fail to report on non-hospitalised cases of pesticide poisonings. Also, there is often no indication of how many of the pesticide poisonings are occupational, accidental, or intentional.[172, 173, 174] Other studies don't identify how many poisonings involved pesticides or which pesticides. For example, in Sarkar et al (2013),[175] 10.8% (103) of hospitalised poisoning cases were unintentional and causes included "spraying in the field, taking poison bottle mistakenly as medicine syrup, using lice killer on hair, and taking medicines inappropriately and excessively by people who suffer from psychiatric illness".

Government health bulletins[176] record pesticides as a cause of poisonings/deaths. In 2013, bulletins reported the following deaths for 2012:[177]
- 65 deaths (2%) at Kulna Medical College Hospital from "intentional self-poisoning by and exposure to pesticides".
- 88 deaths (14.26%) at Dinajpur Medical College Hospital from "assault by pesticides".
- 45 deaths (1.04%) at M.A.G. Osmani Medical College Hospital from "pesticides, unspecified".

In 2014, the government bulletin recorded the following for 2013:[178]
- 120 deaths (4.17%) at Shahid Ziaur Rahman Medical College Hospital from "intentional self-poisoning by and exposure to pesticides".

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170. Dewan G. 2014. Analysis of recent situation of pesticide poisoning in Bangladesh: is there a proper estimate? *Asia Pac J Med Toxicol* 3:76-83.
171. Dewan G. 2014. Analysis of recent situation of pesticide poisoning in Bangladesh: is there a proper estimate? *Asia Pac J Med Toxicol* 3:76-83.
172. Amin MR, Basher A, Sattar A, Awal A, Sapan MR, Ghose A, Faiz MA. 2017. Baseline survey on cases of poisoning and its outcome in Bangladesh. *Open Acc J Toxicol* 2(2):1-6.
173. Hasan AM, Haque MM. 2011. A clinical study to see the predictive utility of the Glasgow Coma Scale in acute organophosphorus poisoning. *Dinajpur Med Col J* 4(2):56-61.
174. Verma V, Paul S, Ghose A, Eddleston M, Konradsen F. 2017. Treatment of self-poisoning at a tertiary-level hospital in Bangladesh: cost to patients and government. *Trop Med Int Health* 22(12):1551-60.
175. Sarkar D, Shaheduzzaman M, Hossain MI, Amed M, Mohammad N, Basher A. 2013. Spectrum of acute pharmaceutical and chemical poisoning in northern Bnagaldesh. *Asia Pac J Med Toxicol* 2(1):2-5.
176. The only Health bulletin since 2015 was apparently published in 2020 but it could not be accessed.
177. Health Bulletin 2013. Ministry of Health & Family Welfare, Government of the People's Republic of Bangladesh. http://www.dghs.gov.bd/index.php/en/publications/health-bulletin/dghs-health-bulletin
178. Health Bulletin 2014. Ministry of Health & Family Welfare, Government of the People's Republic of Bangladesh. http://www.dghs.gov.bd/index.php/en/publications/health-bulletin/dghs-health-bulletin

In 2015, the government bulletin recorded the following for 2014:[179]

- the toxic effect of pesticides as the 10th highest cause of admissions to hospital, at 16,303 (1.27%).

More recently, 114 fatal OP cases were recorded at Sir Salimullah Medical College morgue in Dhaka from January to December 2017. They were mainly suicides, but some were accidental.[180] However, again, it was not indicated how many of these were occupational and how many were accidental.

Yet, there is no national pesticide poisoning surveillance system in Bangladesh and, as a result, data on acute occupational pesticide poisoning is sketchy and likely to grossly underrepresent the actual picture. According to Amin et al (2017),[181] a large number of poisoning cases remain unreported "due to lack of information and awareness at community level" and because "there is no systematic record keeping system for poisoning." Most of the emphasis in investigating pesticide poisonings has been placed on fatal cases, which are often intentional poisonings.[182, 183]

Accidental cases, especially if they involve children, may be reported by the media; but occupational cases, even if they involve hospitalisation, are generally overlooked. Note the bullet points above where the reports refer to "intentional self-poisoning and exposure", which indicates that some of the cases assumed to be intentional self-poisoning may be accidental and/or occupational.

- In 2019, a 23-day-old infant was hospitalised with OP poisoning as a result of being wrapped in a cloth that had been used during spraying, presumably for protection. The baby survived.[184]

In contrast to intentional poisonings, the only information available on UAPP is from a small handful of studies.

6.4.1 Information on UAPP from Boedeker et al (2020)

Of the six studies analysed by Boedeker et al (2020), two were pre-2010, and are not included here. The original six studies were averaged without weighting to arrive at a percentage occupational morbidity of 57.35% – with a range from 30% (based on 300 farmers) to 80% (based on 534 farmers). Removing the two pre-2010 studies results in a revised, increased average percentage occupational morbidity of 65.35% for the period between 2012-2017.[185]

- Miah et al 2014[186] – 120 farmers selected for high, medium, and low level of vegetable production in the Bharella, Mokam and Rajapur unions of Burichong Upazila.
- Akhter et al 2016[187] – 80 farmers growing mainly vegetable crops in the Kaligonj and Jhenidah Sadar Upazilas in the district of Jhenidah.

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179. Health Bulletin 2015. Ministry of Health & Family Welfare, Government of the People's Republic of Bangladesh.
180. Sumon SR, Asha MT, Rahman MZ, Tabassum R, Mollika FA, Khan BH. 2021. An autopsy-based study on socio-economical pattern of organophosphorus poisoning cases recorded from Sir Salimullah Medical College Morgue. *Mymensingh Med J 30(1):111-114.*
181. Amin MR, Basher A, Sattar A, Awal A, Sapan MR, Ghose A, Faiz MA. 2017. Baseline survey on cases of poisoning and its outcome in Bangladesh. *Open Acc J Toxicol* 2(2):1-6.
182. Konradsen F, van der Hoek W, Cole DC, Hitchinson G, Daisley H, Singh S, Eddleston M. 2003. Reducing acute poisoning in developing countries—options for restricting the availability of pesticides. *Toxicology* 192:249-61.
183. Dewan G. 2014. Analysis of recent situation of pesticide poisoning in Bangladesh: is there a proper estimate? *Asia Pac J Med Toxicol* 3:76-83.
184. Das JC, Hasan SH, Sharmin T, Chowdhury M, Khyrunnessa F, Paul N, Faisal MA, Sharma JD, Paul S, Muhuri BR. 2019. Organophosphorus compounds poisoning in a neonate" A case report. *Mymensingh Med J* 28(2):470-3.
185. Based on dates of data collection rather than dates of publication.
186. Miah SJ, Hoque A, Paul A, Rahman A. 2014. Unsafe use of pesticide and its impact on health of farmers: A case study in Burichong Upazila, Bangladesh. *IOSR J Environ Sci Toxicol Food Technol* 8(1):57-67.
187. Akhter N, Chakraborty TK, Ghosh P, Jahan S, Gosh GC, Hossain SA. 2016. Assessment of the using patterns of pesticides and its impact on farmers' health in the Jhenidah District of Bangladesh. *Am J Environ Prot* 5(5):139.

- Akter et al 2018[188] – 101 male vegetable farmers in the Palbandha and Char Goalini unions in Islampur Upazila in the district of Jamalpur.
- Rengam et al 2018[189] – 534 farmers (77%) and workers, including 40 women, growing rice and vegetable in the five sub-districts of Satkhira district.

6.4.2 Information from other peer-reviewed publications

Only one other peer-reviewed study was found:

- Sumon et al (2016)[190] – surveyed 38 rice-prawn farm owners in six villages[191] in Khulna region (south-west Bangladesh) in 2012, and found a prevalence of any symptom of 81%, with the highest symptom (vomiting) having a prevalence of 51%.

6.4.3 Information from PANAP community monitoring reports

Only one community monitoring study was available:

- Diyana et al (2022)[192] – in 2021, PANAP worked with partner organisations BARCIK (Bangladesh Resource Center for Indigenous Knowledge) and SHISUK (Shikkha Shastha Unnayan Karzakram) to conduct studies in Singair sub-district in Manikgani district and Daudkandi Upazila in Cumilla district. Singair is 30 kilometres from the capital city of Dhaka.

6.4.4 Summary of prevalence

Table 6.1 below summarises the information from Boedeker et al together with the new information provide in this review.

Table 6.1: Estimation of prevalence of UAPP in Bangladesh

Study	Review status	Year	Sample	Population	Morbidity	Symptom range
Miah et al 2014	peer rev.	2012	120		55.0%	highest symptom
Sumon et al 2016	peer rev.	2012	38		81.0%	any symptom
Akhter et al 2018	peer rev.	2015-16	101		60.4%	highest symptom
Akhter et al 2016	peer rev.	2016	80		84.0%	highest symptom
Islam et al 2016	peer rev.	2016	200		65.0%	any symptom
Rengam et al 2018	community	2017	534		62.0%	highest symptom
Diyana et al 2022	community	2022	99		21.0%	any symptom
Average %					***61.2%***	

Limitation: Four () studies report morbidity only for the highest prevalence symptom and these are likely to underestimate the percentage of morbidity, as not all those affected experienced poisoning symptoms, and should be regarded as a minimum level of UAPP. One study (Summon et al) that did provide prevalence for any symptom (81%) also provided prevalence of the highest reported symptom at a significantly lower rate (52%). However, this study had a small sample number.

188. Akter M, Fan L, Rahman MM, Geissen V, Ritsema CJ. 2018. Vegetable farmers' behaviour and knowledge related to pesticide use and related health problems: A case study from Bangladesh. *J Clean Prod* 200:122-33.
189. Rengam S, Serrana MS, Quijano I. 2018. Of Rights and Poisons: Accountability of the Agrochemical Industry. Penang: PAN Asia Pacific, Penang. Available from: https://panap.net/2018/10/of-rights-and-poisons-accountability-of-the-agrochemical-industry/
190. Sumon KA, Rico A, Ter Horst MM, Van den Brink PJ, Maque MM, Rashid H. 2016. Risk assessment of pesticides used in rice-prawn concurrent systems in Bnagladesh. *Sci Tot Environ* 568:498-506.
191. Kaligati, Gutudia, Rudhagora, Dhopakhola, Moddapara, Kola.
192. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf

Table: 6.2: Estimation of UAPP in Bangladesh

Population type	Year (av)	Population size	Fatal	Non-fatal (estimated)	Morbidity
total population	2019	163,046,173			
agricultural	2019	26,515,004	?	16,227,182	61.2%
children ≤14	2019	44,371,981	?	?	?

Source of population data: The World Bank DataBank. Population Estimates and Projections. https://databank.worldbank.org/source/population-estimates-and-projections/Type/TABLE/preview/on Accessed Dec 2020.

6.5 Pesticides implicated in UAPP

Of the six studies that provided information on the prevalence of occupational UAPP, four provided information on the pesticides being used. One other study,[193] which reported poisoning but not its prevalence, provided information on the pesticides being used. Refer to Table 6.3 for details.

Some pesticides stand out as likely causes of UAPP: in Miah et al 2014, which reported 55% morbidity, chlorpyrifos was being used by 82.5% of the farmers, and in Islam et al (2016) where 70% of farmers were using carbofuran and morbidity was 65%.

In addition to the pesticides implicated in occupational studies for Bangladesh, pesticides involved in hospital-reported poisonings are also provided here – note that many of the reports do not specify which pesticide was the cause. As previously stated, some of these poisoning cases are intentional and some are unintentional, but the failure of the reports to adequately separate the two means that they must all be reported here. They are listed in Table 6.3 and are collated with other pesticides in Table 6.4 to determine the pesticides most likely to be involved in UAPP in Bangladesh. The fact that some of them will have been used for intentional poisonings should not undermine their use for this purpose, as these are pesticides that are readily available to farmers and are sufficiently toxic to cause poisoning and therefore likely to be implicated in UAPP. It is noteworthy that Amin et al's (2017)[194] reported 88% of 1,320 hospitalised pesticide poisonings were caused by organophosphates, and Dewan 2014[195] reported that of 314 such poisonings, 71.3% were caused by OPs and 22.3% by carbamates. Dewan also reported mortality rates of:

- malathion – 20.0%
- organophosphates – 8.9%
- carbamates – 1.4%
- rodenticides – 3.0%

Unfortunately, only a few of the papers identify the specific pesticides involved. A hospital-level study[196] in Dhaka of 223 children admitted with accidental poisoning in 2019–2020 found that 26.5% of these were caused by ingestion of pesticides. It also revealed that the vast majority of cases occurred in the children's homes, but it does not identify the pesticides involved.

193. Islam MS, Alam MS, Uddin MN, Al Zabir A, Islam MS, Haque KA, Ashraful Islam SM, Hoassain SA. 2016. Farm level pesticides use in Patuakhali and Comilla region of Bangladesh and associated health risk. *J Health Environ Res* 2(4):20-6.
194. Amin MR, Basher A, Sattar A, Awal A, Sapan MR, Ghose A, Faiz MA. 2017. Baseline survey on cases of poisoning and its outcome in Bangladesh. *Open Acc J Toxicol* 2(2):1-6.
195. Dewan G. 2014. Analysis of recent situation of pesticide poisoning in Bangladesh: is there a proper estimate? *Asia Pac J Med Toxicol* 3:76-83.
196. Ahmed A, Hasanul Banna Siam M, Shojon M, Hasan MM, Raheem E, Hossain MS. 2022. Accidental poisoning in children: A single centre case series study in Bangladesh. *BMC Paediatrics Open* 6:3001541.

Table 6.3: Pesticides involved in hospital-reported poisonings in Bangladesh

Pesticides	Dewan 2014[197]	Shadequl-Islam et al 2012[198]	Hasan & Haque 2011[199]
aluminium phosphide	x		
chlorpyrifos	x	x	x
cypermethrin	x	x	
diazinon	x		
dichlorvos	x		
dimethoate	x	x	
fenitrothion	x		
fenthion	x		x
malathion	x	x	
monocrotophos	x		x
paraquat	x		
phenthoate	x		x
pretilachlor	x		
quinalphos	x		x
zinc phosphide	x		

Chlorpyrifos and cypermethrin combination

Individually, both of these insecticides are toxic, and cause even more of a problem when mixed together. Several sources have identified this combination as prominent in causing occupational poisonings, including in Bangladesh.[200] In Tanzania, 15% of the farmers (out of 1,124 farmers surveyed) reported health effects from Duduba 450 EC, which contains chlorpyrifos + cypermethrin; and in Benin, 130 out of 261 poisoning incidents were caused by chlorpyrifos + cypermethrin formulations.[201] In Bangladesh, they have been reported to be used in combination, trade name Nitro, by Rengam et al (2018) and Diyana et al (2022), and by Miah et al (2014). Summon et al (2016) identifies both these active ingredients in use but does not mention if they are used in the Nitro (or other) combination. In Bangladesh, it has been observed that the chlorpyrifos/cypermethrin formulation behaves unpredictably in people in that those who have been poisoned seem to recover, are sent home from the hospital, but they relapse badly and, in some instances, die.[202]

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197. Dewan G. 2014. Analysis of recent situation of pesticide poisoning in Bangladesh: is there a proper estimate? *Asia Pac J Med Toxicol* 3:76-83.
198. Shadequl-Islam AH, Basher A, Rashid M, Islam M, Arif SM, Abdl Faiz M. 2012. Pattern of pre-hospital treatment received by cases of pesticide poisoning. *Int J Med Toxicol Forens* Med 2(3):88-96.
199. Hasan AM, Haque MM. 2011. A clinical study to see the predictive utility of the Glasgow Coma Scale in acute organophosphorus poisoning. *Dinajpur Med Col J* 4(2):56-61.
200. Pers. Comm. Nov 2022. Mark Davis, consultant with Centre for Pesticide Suicide Prevention, the University of Edinburgh.
201. Pers. Comm. Nov 2022. Dr Sheila Willis, Head of International Programme, PAN UK. Data being prepared for publication.
202. Pers. Comm. Nov 2022. Mark Davis, consultant with Centre for Pesticide Suicide Prevention, the University of Edinburgh.

Key to Tables 6.4 and 6.5:

X = most commonly used (i.e., by highest number of farmers)
x = less often used
X = being used when symptoms occurred

HHPs:
X = pesticides meeting the JMPM criteria for acute toxicity
x = pesticides meeting the JMPM criteria for chronic toxicity or meeting the requirements of the Stockholm or Rotterdam Conventions
X = pesticides listed in PAN HHPs list (2021) for reasons of inhalation toxicity (H330), but not meeting the JMPM criteria
x = pesticides listed in PAN HHPs list for reasons of endocrine disruption or cancer but not GHS cancer, or environmental effects, and therefore not meeting the JMPM criteria

EU:
X = not approved; reasons for ban:
a = acute toxicity – human, mammalian, or GHS warning; or acute impurities or concerns for operator exposure even when correct PPE is worn
c = chronic health effects
d = dietary concerns
e = environmental concerns
i = lack of info
p = need for PPE, or concern expressed for operators; for example, for carbendazim: "operators, who must wear suitable protective clothing, particularly gloves, coveralls, rubber boots, and face protection or safety glasses during mixing, loading, application, and cleaning of the equipment"[203]
? = reason not found

Other information
o = other information supports acute toxicity
LD_{50} – bold = ≤ 100

Table 6.4: Pesticides found in use in Bangladesh in surveys reporting UAPP

Study No	1	2	3	4	5	6		HHP	EU bans	LD_{50}
Region	**Comilla district**	**Jhenidah district**	**Patuakhali & Comilla districts**	**Satkhira district**	**Khulna district**	**Manikganj district**				
Ref	**Miah et al 2014**	**Akhter et al 2016**	**Islam et al 2016**	**Rengam et al 2018**	**Summon et al 2016**	**PANAP 2022**	**Hospitals**			
Crop	**veg**	**veg**	**rice**		**rice-prawn**	**veg, rice, jute, maize**				
Pesticide										
2,4-D				x				x		300
abamectin		x		x		x		**X**		**8.7**
acephate				x				x	x ?	945
acetamiprid				x						146
aluminium phosphide							**X**	**X**		**8.7**
carbendazim	x	x	x	x				**x**	x p, e, i	10,000
carbofuran			**X**	x	x	x		**X**	x a, e	**7**
carbosulfan	**X**			**X**		x		**X**	x i	101
cartap				x	x				x i	325
chlorpyrifos	**X**			**X**	x	x	**X**	**x**	**x** X c, e	**66**
chlorophenoxy acetic acid						x			x ?	850
cymoxanil				x						356

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203. EC. 2010. Review report for the renewal of active substance carbendazim finalised in the Standing Committee on the Food Chain and Animal Health at its meeting on 23 November 2010 in view of the renewal of inclusion of carbendazim in Annex I of Directive 91/414/EEC. SANCO/13063/2010 final. 22 November 2010. European Commission.

cypermethrin	x		x	X	x	x	X	x		287
diazinon	X		x	X			X	x	x a, p, e	1,139
dichlorvos							X	X	x	**80**
difenoconazole		x		X						1,453
dimethoate		x		x			X	x	x c, e, i	245
edifenfos		x						X	x a	150
emamectin benzoate				x				x		**81.5**
fenitrothion				x			X	x	x e, i	330
fenthion							X	x		250
fenobucarb				x					x ?	620
fenvalerate	x			x				x	x ?	451
fipronil				x		x		x	x e	**92**
imidacloprid				x	x	x		x	x p, e, i	131
isoprocarb					x				x e	403
lambda-cyhalothrin	x	x	x	x		x		X	o	**56**
malathion	x	x		x	x		X	x		1,778
mancozeb	x		x	x		x		x	x c, e, i	5,000
metalaxyl			x	x						669
monocrotophos							X	X		**14**
nitrobenzene (Flora)				x				x	x ?	390
paraquat						x	X	X	x p, e	110
phenthoate				x	x				x a	249
pretilachlor							X		x ?	6,099
propiconazole				x			X	x	x c	550
quinalphos	x						X	x	x ?	**71**
quizalofop-p-ethyl				x						1,182
sulphur				x	x					2,000
terbuthylazine		x								1,000
thiamethoxam			x	X	x			x	x e	1,563
zinc phosphide							X	X		**12**

Table 6.5: Pesticides most likely causing UAPP in Bangladesh

Study No	1	2	3	4	5	6		HHP	EU bans	LD_{50}
Ref	**2012**	**2016**	**2016**	**2017**	**2012**	**2022**	**Hospitals**			
Pesticide										
2,4-D				x				x		300
abamectin		x		x		x		X		**8.7**
acephate				x				x	x ?	945
acetamiprid				x						146
aluminium phosphide							X	X		**8.7**
carbofuran			X	x	x	x		X	x a,e	**7**
carbosulfan	X			X		x		X	x i	101
cartap				x	x				x i	325
chlorpyrifos	X			X	x	x	X	x	**x** X c, e	**66**
chlorophenoxy acetic acid						x			x ?	850

cymoxanil				x						356
cypermethrin	x		x	X	x	x	X	x		287
diazinon	X		x	X			X	x	x a,p,e	1,139
dichlorvos							X	X	x	**80**
difenoconazole		x		X						1,453
dimethoate		x		x			X	x	x c, e, i	245
edifenfos		x						X	x a	150
emamectin benzoate				x				x		**81.5**
fenitrothion				x			X	x	x e, i	330
fenthion							X	x		250
fenobucarb				x					x ?	620
fenvalerate	x			x				x	x ?	451
fipronil				x		x		x	x e,	**92**
imidacloprid				x	x	x		x	x p, e, i	131
isoprocarb					x				x e	403
lambda-cyhalothrin	x	x	x	x		x		X	o	**56**
malathion	x	x		x	x		X	x		1,778
metalaxyl			x	x						669
monocrotophos							X	X		**14**
nitrobenzene (Flora)				x				x	x ?	390
paraquat						x	X	X	x p, e	110
phenthoate				x	x				x a	249
propiconazole				x			X	x	x c	550
quinalphos	x						X	x	x ?	**71**
quizalofop-p-ethyl				x						1,182
sulphur				x	x					2,000
terbuthylazine		x								1,000
thiamethoxam			x	X	x			x	x e	1,563
zinc phosphide							X	X		**12**

6.8 Pesticide Management in Bangladesh

Between 1996 and 2007, the Bangladesh government banned or restricted 21 pesticides, including all WHO Class 1 pesticides, because of the high rate of suicide deaths from pesticide poisoning in the country. In the years following the bans, there were 35,071 fewer suicide deaths from pesticides, without any apparent harmful effect on productivity of rice paddy, the main crop. Similar results have occurred in Sri Lanka and South Korea: pesticide bans to reduce deaths from suicides have not resulted in any reduced agricultural output.[204]

Unfortunately, the effect on UAPP, including deaths does not appear to have been recorded. Although a number of WHO Class 1 OPs[205] were banned for use on rice and other lowland crops in 2000, many more Class 2 OPs unfortunately remained in practice and likely continue to be the cause of the high level of UAPP.

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204. Chowdhury FR, Dewan G, Verma VR, Knipe DW, Isha IT, Faiz MA, Gunnell DJ, Eddleston M. 2018. Bans of WHO Class I pesticides in Bangladesh – suicide prevention without hampering agricultural output. *Int J Epidemiol* 175-84.
205. Dichlorvos, dicrotophos, disulfoton, ethyl parathion, methyl parathion, monocrotophos, phosphamidon – Chowdhury et al 2018.

Again, Article 3.6 of the International Code of Conduct on the Distribution and Use of Pesticides is not being implemented.

- *Article 3.6 Pesticides whose handling and application require the use of personal protective equipment that is uncomfortable, expensive or not readily available should be avoided, especially in the case of small-scale users and farm workers in hot climates.*

As with Vietnam and Laos, implementation of Article 3.6 of the Code would be the single most important step in reducing UAPP in Bangladesh. It is clear from the numerous studies carried out in Bangladesh that adequate PPE is not worn by most farmers, and never will be.

6.9 Conclusions

The available studies reveal a smaller number of different pesticides in use in Bangladesh than in Vietnam or India. However, they are almost all classified as WHO I or II and hence are too toxic for the conditions of use. Bangladesh has shown itself to be responsive to the problems caused by pesticides and has banned a number – but not all – of the culprits. Now it needs to respond in a similar fashion to the problem of UAPP and get rid of the pesticides responsible. But its farmers will need significant help from national and international sources to replace these pesticides with safer, agroecological practices that will support not only farmer's health and livelihoods, but also the environment and particularly biodiversity that is essential to ecological balance and agroecosystem health.

This review of available surveys of acute pesticide poisoning in Bangladesh has revealed that, although there are a number of analyses of hospitalised cases and there is a good understanding of intentional self-harm, the same cannot be said for occupational poisoning. And yet, the available information indicates that there is a considerable problem.

6.10 Recommendations

1. Implement Article 3.6 of the International Code of Conduct on Pesticide Management, which means prohibiting the manufacture or importation of any pesticides that require PPE.
2. Phase out all pesticides on Bangladesh's short list (Table 6.5), beginning with the immediate ban of any pesticides in the priority list in Table 8.3, including any formulations containing the combination of chlorpyrifos and cypermethrin, which is emerging in a number of countries as being responsible for a number of poisonings including deaths.
3. Develop a national policy on replacing HHPs with agroecological practices and national and international assistance with training for farmers on their implementation, so as to remove farmers' perceived need for toxic pesticides.
4. All hospitalised cases should be data-segregated for occupational and accidental causation, including recording the pesticides involved.
5. Intensify monitoring of non-hospitalised occupational poisoning to more accurately identify the scale of the problem and to identify the pesticides causing the harm.

7. India

7.1 General pesticide situation

India is one of the largest pesticide producing and exporting countries in the world. In 2022 India produced 255,000 metric tonnes of pesticides.[206] It is reported to be the 4th largest exporter of pesticides, with a value of US $4.5 billion during 2021, according to the website World's Top exporters.[207]

Not surprisingly, India suffers from extensive contamination of the environment,[208, 209] food,[210] and people.[211, 212]

Agriculture and associated industries are the largest providers of livelihoods in India. As much as 70% of rural households still depend primarily on agriculture for their livelihood, and 82% of farmers are small-scale and marginal producers, according to FAO.[213] Despite the huge amount of pesticide being produced in the country and the widespread use of highly toxic pesticides, "India still accounts for a quarter of the world's hungry people and home to over 190 million undernourished people. Incidence of poverty is now pegged at nearly 30%", also according to FAO.

The areas of study in India included in this analysis are: Yavatmal, Wayanad, Kolhapur district (Mahar.), Malwa (Punjab), Namsai district (AP), Kinnaur district of Himachal Pradesh, Chittoor, Andhra Pradesh, Barargh and Sundargarh district of Western Odisha, Kanpur region of Uttar Pradesh, Idukki district (Kerala), Madhya Pradesh, Karnataka, Rajasthan, Maharashtra, Punjab, Arunachal Pradesh, Andhra Pradesh, Telangana, and West Bengal.

7.2 Gender dimensions of pesticide use

Most of the studies from India reviewed here involved primarily men as respondents,[214] although some have engaged with women.[215] One recent study reported only on women: Venugopal et al (2021)[216] reported that 50% of the workload in tea plantations in South India is carried out by women, and in their cross-sectional analysis, 68% of the women continued that work even when they were pregnant up to the sixth month. Only 16% of them wore PPE. Pesticides were detected in workplace air samples, and a number of chronic health conditions were reported (acute symptoms were not discussed). An earlier study,[217] noting that while the majority of men (73%) were closely linked with pesticide spraying and only

206. Statista. Volume of pesticide produced across India from financial year 2015 to 2021. https://www.statista.com/statistics/726938/india-pesticides-production-volume/ Accessed Dec 5, 2022.
207. Workman D. 2022. Top Pesticide Exporters. https://www.worldstopexports.com/top-pesticides-exporters/ Accessed Dec 2022.
208. Sackaria M, Elango L. 2020. Organic micropollutants in groundwater in India – A review. *Water Environ Res* 92(4):504-23.
209. Kumar S, Kausik G, Villarreal-Chiu JF. 2016. Scenario of organophosphate pollution and toxicity in India: A review. *Environ Sci Pollut Res Int* 23(10):9480-91.
210. Gill JP, Bedi JS, Singh R, Fairoze MN, Hazarika RA, Gaurav A, Satpathy SK, Chauhan AS, Lindahl J, Grace D, Kumar A, Kakkar M. 2020. Pesticide residues in peri-urban bovine milk from India and risk assessment: A mulitcenter study. *Sci Rep* 10(1):8054.
211. Anand N, Chakraborty P, Ray S. 2021. Human exposure to organochlorine, pyrethroid and neonicotinoid pesticides: Comparison between urban and semi-urban regions of India. *Environ Pollut* 270:116156.
212. Bedi JS, Gill JP, Aulakh RS, Kaur P, Sharma A, Pooni PA. 2013. Pesticide residues in human breast milk: risk assessment for infants from Punjab, India. *Sci Total Environ* 463-464:720-6.
213. FAO. India at a Glance. https://www.fao.org/india/fao-in-india/india-at-a-glance/en/ Accessed Dec 2022.
214. Kaur M. 2016. Practices and health related toxic symptoms of pesticide use among farm workers. *Glob J Res Anal* 5(9):290-1.
215. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf
216. Venugopal D, Karunamoorthy P, Beerappa R, Sharma D, Aambikapathy M, Rajasekar K, Gaikwad A, Kondhalkar S. 2021. Evaluation of workplace pesticide concentration and health complaints among women workers in tea plantations, South India. *J Expo Svi Environ Epidemiol* Apr 1. doi: 10.1038/s41370-020-00284-3. Online ahead of print.
217. Patil DA, Katti RJ. 2012. Modern agriculture, pesticides and human health: A case of agricultural labourers in western Maharashtra. *J Rural Dev* 31(3):14.

5% of women were, women nevertheless continued to work in the fields when pesticides were being sprayed. If the woman is pregnant, the foetus is at risk from pesticides crossing the placenta,[218, 219] or if she is breast-feeding, the infant is at risk from pesticides contaminating her breast milk.[220] The study further noted the social risks of this practice: "females are a major part of a family, and when a woman gets sick or dies due to sickness, the family is left behind in crisis and chances of social disintegration". In a study carried out in Yavatmal, where cotton and soybeans were primarily being grown with intercropped pigeon peas,[221] 68.75% of women carried out spraying.[222]

National Crime Bureau Records show that almost twice as many men as women are killed or reported injured by pesticides.[223]

7.3 Conditions of use

Most of the studies reported that the majority of the respondents did not wear proper PPE, one study[224] reporting that 88% of farmers did not wear PPE, although 70% did wear a scarf across their faces. 97% did not use gloves even when mixing pesticides and 96% ate whilst they were spraying. Farmers who were poisoned while spraying BT cotton in Yavatmal in 2017 were not wearing PPE, not even long-sleeved shirt or pants, because of the heat.[225]

A 2015 study on paraquat[226] use found that none of the workers wore complete PPE when mixing, spraying, or dispersing (e.g., mixed with sand, salt, fertiliser) the herbicide, 76% of farmers wore only their normal daily clothes, while 6% used plastic sheets as aprons.

More recent studies indicate a somewhat improved use of PPE: Kumari & John (2018)[227] reported 61% were wearing a mask, whilst Wayanad reported that 63% wore some PPE; but a second, later study in Yavatmal[228] found that only 66% of farmers were wearing PPE, with more men using them than women.

Mixing pesticides with one's bare hands is a major risk for poisoning, and the incidence of this practice is high: Patil & Katti (2012)[229] reported that 73% of farmers were using their bare hands to mix pesticides, while Kumari & John (2018)[230] reported a rate of 13%.

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218. Yang C, Song G, Lim W. 2019. A mechanism for the effect of endocrine disrupting chemicals on placentation. *Chemosphere* 231:326-36.
219. Kumar SN, Vaibhav K, Bastia B, Singh V, Ahluwalia M, Agrawal U, Borgohain D, Raisuddin S, Jain AK. 2021. Occupational exposure to pesticides in female tea garden workers and adverse birth outcomes. *J Biochem Mol Toxicol* 35(3): e22677.
220. Kao CC, Que DE, Bongo SJ, Tayo LL, Lin YH, Lin CW, Lin SL, Gou YY, Hsu WL, Shy CG, Huang KL, Tsai MH, Chao HR. 2019. Residue levels of organochlorine pesticides in breast milk and its associations with cord blood thyroid hormones and the offspring's neurodevelopment. *Int J Environ Res Public Health* 23;16(8):1438.
221. Black gram, chickpea, wheat, turmeric, ginger, vegetables, sorghum, and groundnut were also being grown.
222. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf
223. National Crime Records Bureau. Accidental Deaths & Suicides in India https://ncrb.gov.in/sites/default/files/adsi
224. Patil DA, Katti RJ. 2012. Modern agriculture, pesticides and human health: A case of agricultural labourers in western Maharashtra. *J Rural Dev* 31(3):14.
225. Reddy N, Kumar D. 2017. Pesticide Poisonings in Yavatmal District in Maharashtra: Untold Realities. PAN India, Kerala. https://pan-india.org/untold-realities-of-pesticide-poisonings-in-yavatmal-district-in-maharashtra/
226. Kumar D. 2015. Conditions of Paraquat Use. Kerala: PAN India. http://www.pan-india.org/paraquat-in-india-too-big-a-risk-for-farmers-and-workers/
227. Kumari D, John S. 2018. Safety and occupational health hazards of agricultural workers handling pesticides: A case study. In: Siddiqui NA, Tauseef SM, Bansal K, editors. Advances in Health and Environment Safety. Singapore: Springer Singapore. p. 75–82. http://link.springer.com/10.1007/978-981-10-7122-5_9
228. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf
229. Patil DA, Katti RJ. 2012. Modern agriculture, pesticides and human health: A case of agricultural labourers in western Maharashtra. *J Rural Dev* 31(3):14.
230. Kumari D, John S. 2018. Safety and occupational health hazards of agricultural workers handling pesticides: A case study. In: Siddiqui NA, Tauseef SM, Bansal K, editors. Advances in Health and Environment Safety. Singapore: Springer Singapore. p. 75–82. http://link.springer.com/10.1007/978-981-10-7122-5_9

The 2017 study by the Society for Rural Education and Development (SRED)[231] on floriculture in Tamil Nadu reported child labourers using their bare hands and not wearing protective gloves when plucking flowers that had been recently sprayed. The children were observed on some occasions to enter and work in the fields immediately after pesticide spraying. A second study, in 2019,[232] reported that 21% of children were mixing pesticides using their bare hands, and 8% were spraying them. 39% played with empty pesticide containers.

One study found that storage of pesticide containers in homes was found to increase the chances of moderate or severe poisoning.[233] Kumari (2015) reported that 78% of the paraquat sprayers stored the paraquat in their homes, some even using the empty containers as water vessels in toilets and bathrooms. Kumari & John (2018)[234] also reported a high percentage of farmers storing pesticides in their homes (65%) and reusing containers (4.8%).

Not being able to read the labels on containers was another condition that increases the vulnerability of farmers and workers to pesticide poisoning.[235]

7.4 Poisonings

Poisoning is regarded as an important public health problem in India, with pesticides a major cause of morbidity and mortality, although the true incidence is not known.[236] Pesticide poisoning has been a major issue in India for many years, as a means for suicide, as a cause of occupational injury and death, and as a cause of accidental death of children, often resulting from the storage of pesticides in homes and kitchens in particular.

The National Crime Records Bureau (NCRB) records data on deaths and injuries from accidental exposure to pesticides (and from suicides, separately). Pesticides was found to be the cause of 33% of the total 21,196 accidental deaths from poisoning in 2019. Clearly, unintentional deaths from pesticides are increasing.

Table 7.1: Accidental deaths from pesticides recorded by the NCRB

Year	Total deaths	Women	Men	Transgender
2017	6,739	2,174	4,565	0
2018	7,543	2,469	5,074	0
2019	6,962	2,160	4,800	2
2020	7,437	2,324	5,113	0
2021	7,950	2,442	5,363	0

Source: National Crime Records Bureau. Accidental Deaths & Suicides in India https://ncrb.gov.in/sites/default/files/adsi

231. SRED. 2017. Study Among Children Working in Floriculture in Thazhavedu and Nemili Villages of Tiruvallur District. Society for Rural Education and Development. Reported in Rengam et al 2018.
232. Paminutan M, Rengam S. 2020. Toxic Blooms: Impacts of Pesticides on Children in the Floriculture Industry in Tamil Nadu, India. PAN Asia Pacific, SRED, PAN India. https://panap.net/resource/toxic-blooms-impacts-of-pesticides-on-children-in-the-floriculture-industry-in-tamil-nadu-india/
233. Reshma H, Jayalakshmi R. 2020. Prevalence of acute pesticide poisoning among pesticide applicators in cardamon plantations: a cross-sectional study from Idukki District, Kerala. *Indian J Occup Environ Med* 24(3):188-93.
234. Kumari D, John S. 2018. Safety and occupational health hazards of agricultural workers handling pesticides: A case study. In: Siddiqui NA, Tauseef SM, Bansal K, editors. Advances in Health and Environment Safety. Singapore: Springer Singapore. p. 75–82. http://link.springer.com/10.1007/978-981-10-7122-5_9
235. Kumar D. 2015. Conditions of Paraquat Use. Kerala: PAN India. http://www.pan-india.org/paraquat-in-india-too-big-a-risk-for-farmers-and-workers/
236. Murari A. 2018. Poisonings in India. Editorial. *Ind J Med Specialities* 9:105-6.

In 2020, Madhya Pradesh had the highest number of recorded deaths from accidental intake of pesticides (1384) followed by Karnataka (943), Rajasthan (922), Maharashtra (707), and Punjab (702).[237]

Lohan et al (2022) provided another approach to unintentional fatalities.[238] During the four-year period from 2012-2015, there were 1,993 fatalities related to agricultural work in Punjab, and 19.62% of these were caused by pesticide application using sprayers. With an annual fatality rate in Punjab of 14.14 per 100,000 workers, this equates to 2.77 deaths per 100,000 workers from occupational pesticide exposure.

Table 7.2: Accidental injuries from pesticides recorded by the NCRB

Year	Total	Women	Men	Transgender
2017	589	221	368	0
2018	256	44	211	1
2019	186	53	133	0
2020	63	27	36	0

Source: National Crime Records Bureau. Accidental Deaths & Suicides in India https://ncrb.gov.in/sites/default/files/adsi

However, the data from the NCRB does not give the full picture of UAPP, as the vast majority of cases are not reported to the authorities.

7.4.1 Information from Boedeker et al (2020)

Boedeker et al (2020) found 11 studies, post-2006, that were appropriate for the estimation of UAPP in India. These 11 studies on farmers and workers were averaged without weighting to arrive at a percentage occupational morbidity of 62%, with a range from 19.4% (based on 300 farmers) to 100% (based on 80 farmers). Six of these studies are discarded here because their sampling dates were either pre-2010 or largely pre-2010; the amended occupational morbidity for the remaining papers is 92.75%.

- Patil & Katti 2012:[239] 78 workers, closely linked with applying pesticides, in a cash crop zone in Maharashtra, from Shirol region of Kolhapur district; included nine cases of hospitalisation among the 62 cases of sickness reported in the survey.
- Kaur 2016:[240] 88 farmworkers in the Malwa region of Punjab, 99% of whom were engaged in spraying pesticides daily during harvesting season (crop not identified).
- Kumar 2015:[241] purposive sample of 23 paraquat users from Arunachal Pradesh (small-scale tea gardens) and Andhra Pradesh – daily labourers working in small scale tea gardens in Namsai district but also daily labourers working in cotton, paddy, and vegetable farms; and eight male workers from Andhra Pradesh, Madhya Pradesh, Telangana, and West Bengal.
- Kumari & John 2018:[242] 96 workers using mainly fungicides in apple orchards in eight randomly selected villages of Kinnaur district of Himachal Pradesh (Sangla, Rakcham, Kamroo, Sungra, Nichar, Kangos, Lutuksa, and Bhabanagar).
- Rengam et al 2018:[243] 80 farmers and workers in mango orchards in Chittoor, Andhra Pradesh.

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237. NCRB. 2021. Accidental Deaths and Suicides in India 2020. National Crime Records Bureau, Ministry of Home Affairs. https://ncrb.gov.in/en/search/node/accidental%20deaths%20%26%20suicides%202021
238. Lohan SK, Singh P, Kumar S. 2022. Agricultural work-related fatalities and injuries in Punjab (India). *Inj Prev* May 6 online ahead of print. DOI: 10.1136/injuryprev-2022-044566 Lohan SK, Singh P, Kumar S. 2022. Agricultural work-related fatalities and injuries in Punjab (India). *Inj Prev* May 6 online ahead of print. DOI: 10.1136/injuryprev-2022-044566
239. Patil DA, Katti RJ. 2012. Modern agriculture, pesticides and human health: A case of agricultural labourers in western Maharashtra. *J Rural Dev* 31(3):14.
240. Kaur M. 2016. Practices and health related toxic symptoms of pesticide use among farm workers. *Glob J Res* Anal 5(9):290–1.
241. Kumar D. 2015. Conditions of Paraquat Use. PAN India, Kerala. http://www.pan-india.org/paraquat-in-india-too-big-a-risk-for-farmers-and-workers/
242. Kumari D, John S. 2018. Safety and occupational health hazards of agricultural workers handling pesticides: A case study. In: Siddiqui NA, Tauseef SM, Bansal K, editors. Advances in Health and Environment Safety. Singapore: Springer Singapore. p. 75–82. http://link.springer.com/10.1007/978-981-10-7122-5_9
243. Rengam S, Serrana MS, Quijano I. 2018. Of Rights and Poisons: Accountability of the Agrochemical Industry. Penang: PAN Asia Pacific; 2018. Available from: https://panap.net/2018/10/of-rights-and-poisons-accountability-of-the-agrochemical-industry/

7.4.2 Information from other peer-reviewed publications

Four other studies were found in the peer-reviewed literature:

- Seth & Mahananda 2016:[244] 200 rice farmers in Barargh and Sundargarh district of Western Odisha
- Kanojia & Tripathi 2018:[245] 100 "farm women of landless, marginal, or small farmer category" growing rice in the Kanpur region of Uttar Pradesh
- Reshma & Jayalakshmi 2020:[246] 300 pesticide applicators (79.3% men) in cardamon plantations in Idukki district, Kerala found a prevalence of 100% of at least one sign or symptom of acute pesticide poisoning. Organophosphates (OP) were the most common pesticide used (51%), followed by pyrethroids (35.7%), pyrazole (7.7%), and thiophosphorous (5.7%). None of the pesticide applicators used proper PPE due to the discomfort of using them and equipment costs. The OP diethquinalphion (36.7%) was the most used pesticide.

7.4.3 Information from community monitoring studies

There were three additional community monitoring studies carried out by PANAP and its partners:

- PAN India 2017:[247] from July 6 to October 5, 2017, 450 poisoning cases and 23 deaths were reported at Yavatmal Medical College Hospital, Maharashtra, amongst Bt cotton farmers. The total number of farmers in the catchment area is not known, so a prevalence cannot be derived, although the pesticides used were provided.
- Paminutan & Rengam 2020:[248] a study of 24 children in the floriculture industry in Tamil Nadu reported an 88% prevalence of acute symptoms.
- Diyana et al 2022:[249] a survey of 66 farmers in Yavatmal and 35 in Wayanad (17 of whom did not use pesticides).

7.4.4 Summary of prevalence

Table 7.3 summarises the information on prevalence of UAPP from Boedeker et al (2020) together with the new information provided in this review.

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244. Seth P, Mahananda MR. 2016. Impact of pesticides on farmer's health of Western Odisha. *Int J Environ Agric Res* 2(12):101-7.
245. Kanojia N, Tripathi S. 2018. Occupational health hazards and their causes among women in Indian agriculture. *Int J Adv Res* 6(7):463-8.
246. Reshma H, Jayalakshmi R. 2020. Prevalence of acute pesticide poisoning among pesticide applicators in cardamon plantations: a cross-sectional study from Idukki District, Kerala. *Indian J Occup Environ Med* 24(3):188-93.
247. Reddy N, Kumar D. 2018. Pesticide Poisoning in Yavatmal District in Maharashtra: Untold Realities. PAN India, Kerala. https://pan-india.org/untold-realities-of-pesticide-poisonings-in-yavatmal-district-in-maharashtra/
248. Paminutan M, Rengam S. 2020. Toxic Blooms: Impacts of Pesticides on Children in the Floriculture Industry in Tamil Nadu, India. PAN Asia Pacific, SRED, PAN India. https://panap.net/resource/toxic-blooms-impacts-of-pesticides-on-children-in-the-floriculture-industry-in-tamil-nadu-india/
249. Diyana A, Rajendran D, Watts M, Rengam S, Alviar E. 2022. Field Survey: Use and Impacts of Pesticides in Four Countries in Asia. PAN Asia Pacific, Penang. https://files.panap.net/resources/Field-Survey-use-and-impacts-of-pesticides.pdf

Table 7.3: Estimation of prevalence of UAPP in India

Study	Year	Sample size	Population	Pesticide	Morbidity	Symptom range
Kaur 2016	2010	88	sprayers	all	90.91%	highest
Patil & Katti 2012	2010	78	workers	all	97.44%	highest
Kumar 2015	2014-2015	23	workers	paraquat	91.30%	any
Seth & Mahananda 2016	2015	200	farmers	all	58.00%	highest
Kumari & John 2018	2016	91	W	all	84.00%	highest
Rengam 2018	2017	80	F&W	all	100.00%	any
Kanojia & Tripathi 2018	?	100	women workers	all	90.00%	highest
Paminutan & Rengam 2020	2019	24	children in floriculture	all	88.00%	any
Reshma & Jayalakshmi 2020	2018	300	cardamon pesticide applicators	all	100.00%	any
Diyana et al 2022	2019	101	farmers	all	39.14%	any
	Average				***83.88%***	

*** Limitations:*** Five studies show morbidity only for the highest-prevalence symptom, so the average should be taken as a low estimate.

Table 7.4: National estimates for India

Population type	Year	Population size	Fatal	Non-fatal (estimated)	Morbidity
Total population	2019	1,366,417,756	6,962	?	?
Agriculture	2019	205,630,321	?	172,482,713	83.88%
Children	2019	363,716,740	155	?	?

Source of population data: The World Bank DataBank. Population Estimates and Projections. https://databank.worldbank.org/source/population-estimates-and-projections/Type/TABLE/preview/on Accessed Dec 2020.

7.4.5 Children

Children are particularly prone to unintentional poisoning in India, through ingestion and dermal or inhalation exposure.[250] The unintentional poisoning cases may be occupational, as these happen when children enter recently sprayed fields and pluck flowers using their bare hands.[251] Poisoning may be the result of storing pesticides in homes and particularly in kitchens; see Box 7.1 for real-life examples of children mistaking pesticide for tea or milk powder. Poisoning may also be the result of ingesting residues in food, as in the case of the death of a five-year-old and the hospitalisation of four other children who ate mangoes suspected to contain organophosphate residues.[252] The repurposing of pesticide containers as food containers also resulted in poisoning. In July 2013, 23 children in Bihar died and more than 48 required medical treatment after consuming a free school lunch of rice, soybeans, and lentils cooked with oil contaminated with monocrotophos. The oil, which was used to cook the foods that were sold to the school, had been stored in a pesticide container.[253] See Box 2 for other recent incidents.

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250. Varghese P, Erickson TB. 2022. Pesticide poisoning among children in India: The need for an urgent solution. *Global Ped Health* 9:1-7.
251. SRED. 2017. Study Among Children Working in Floriculture in Thazhavedu and Nemili Villages of Tiruvallur District. Society for Rural Education and Development. Reported in Rengam et al 2018.
252. TNN. 2018. 5-yr-old dies, three kids in hospital after eating mangoes laced with toxic pesticide. Times of India, Jun16. https://timesofindia.indiatimes.com/city/bareilly/5-yr-old-dies-three-kids-in-hospital-after-eating-mangoes-laced-with-toxic-pesticide/articleshow/64607052.cms
253. Idrovo AJ. 2014. Food poisoned with pesticide in Bihar, India: new disaster, same story. *Occup Environ Med* 71:228.

Paediatric pesticide poisoning is not new in India, with a number of studies showing high levels of hospital admissions. For example, 15% of paediatric admissions at the Government Hospital for Children in Srinagar from 1983-1988 were from pesticides poisoning.[254] But the problem continues and appears to be getting worse. According to Varghese & Erickson (2022), pesticides now account for more than a third of all paediatric poisoning cases.

Table 7.5: Deaths from accidental intake of pesticides – below 14 years

Year	Total	Women	Men	Transgender
2017	153	72	81	0
2018	168	75	93	0
2019	155	87	68	0
2020	159	80	79	0
2021	178	92	86	0

National Crime Records Bureau. Accidental Deaths & Suicides in India https://ncrb.gov.in/sites/default/files/adsi

Organophosphates are reported to be common causes of recorded child poisoning, and are responsible for 19.8% of poisonings in Mangalore in 2010-2011,[255] 11% of poisoning cases in a Bangalore hospital,[256] and 24.7% of cases at the Bankura Sammillani Medical College in West Bengal.[257] Other common poisoning causes are rodenticides, which are responsible for a further 14.8% of the poisonings in Mangalore, aluminium phosphide (responsible for 11% of cases in Bangalore), and zinc phosphide (responsible for 5.14% of cases in Mandya Institute of Medical Sciences).[258] In Haryana, aluminium phosphide had a fatality rate of 46.67% in 30 children.[259]

Some studies are less exact, such as a study from Burdwan Medical College in West Bengal, which referred only to agricultural pesticides (38.9% of cases) and household pesticides and rodenticides (9.9%);[260] and a study from Indira Gandhi Medical College Shimla, which reported that 38.2% of paediatric poisoning cases were due to "pesticides and insecticides".[261] Another study reported that 80% of paediatric poisonings took place in the victims' home.[262]

A recent analysis[263] of 592 acute poisoning cases over 18 months in a West Bengal tertiary care hospital found that 20% were caused by pesticides, including rat and lice killers. On the other hand, it reported that 60.64% of cases were unintentional, and these occurred mainly among 1-10-year-olds (149 cases, 100% of that age group) and 11-20-year-olds (55 cases or 44.35% of that age group).

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254. Varghese P, Erickson TB. 2022. Pesticide poisoning among children in India: The need for an urgent solution. *Global Ped Health* 9:1-7.
255. Ram P, Kanchan T, Unnikrishan B. 2014. Pattern of acute poisonings in children below 15 years--a study from Mangalore, South India. *J Forensic Leg Med* 25:26-9.
256. Devaranavadagi RA, Patel S, Shanka P. 2017. A study on profile of poisoning in pediatric population. *Int J Contemp Pediatr* 4(3):810-5.
257. Mandal A, Pal AC, Das PK, DuttaAK. 2016. Clinico-epidemiological profile of poisoning in children in a medical college and hospital. *J Dental Med Sci* 15(4):55-5.
258. Sridhar PV, Sandeep M, Thammanna PS. 2017. Clinical profile and outcome of poisoning in pediatric age group at a tertiary care teaching hospital, Mandya, Karnataka, India. *Int J Contemp Pediat* 3(2):514-7.
259. Sharma A, Dishant, Gupta V, Kausil JS, Mittal K. 2014. Aluminium phosphide (celphos) poisoning in children: A 5-year experience in a tertiary care hospital from northern India. *Ind J Crit Care Med* 18(1):33-6.
260. Sil A, Gosh TN, Bhattacharya S, Konar MC, Soren B, Nayek K. 2016. A study of clinic-epidemiological profile of poisoning in children in a rural tertiary care hospital. *J Nepal Paediatr Soc* 36(2):105-9.
261. Sharma J, Kaushal RK. 2014. Profile of poisoning in children. *Ped Oncall J* 11(2):40-2.
262. Tarvadi PV, Bakkannavar SM, Manjunath S, Palimar V, Kumar GP, Shetty M. 2013. *Nitte J Health Sci* 3(2):25-8.
263. Chatterjee S, Verma VK, Hazra A, Pal J. 2020. An observational study on acute poisoning in a tertiary care hospital in West Bengal, India. *Perspect Clin Res* 11:75-80.

Box 7.1: Children, tea, and pesticides

Oct 28, 2022 – Mainpuri district, Uttar Pradesh: "Three of a family, including two children and a neighbour, died after drinking morning tea when one of the kids mistakenly put pesticides instead of tea powder into the pan, police said on Thursday".

[Uttar Pradesh: Morning tea kills 4 as kid puts pesticide in pan in Mainpuri. Times of India. https://timesofindia.indiatimes.com/city/agra/uttar-pradesh-morning-tea-kills-4-as-kid-puts-pesticide-in-pan-in-mainpuri/articleshow/95131972.cms?utm_source=newsletter&utm_medium=email&utm_campaign=this_month_on_protectourchildren_4_killed_as_insecticide_mistaken_for_tea_glyphosate_linked_to_lower_birth_weights&utm_term=2022-11-13]

Jan 13, 2018 – Bahdinpur, Patna: "At least four persons, including two children, died at the Bahdinpur village under Paru police station in Muzaffarpur district on Saturday after they wrongly used pesticide named 'Thymate' [phorate] for making tea.

The Times of India. 4 of a family die after consuming pesticide instead of tea in Muzaffarpur. https://timesofindia.indiatimes.com/city/patna/4-of-a-family-die-after-consuming-pesticide-instead-of-tea-in-muzaffarpur/articleshow/62488562.cms

Nov 2, 2017 – Darbhanga, Bihar: "Four members of a family, including a 10-year-old girl, died on Thursday after drinking tea inadvertently mixed with poisonous pesticides in Bihar's Darbhanga district, police said. The minor girl, Archana, mixed pesticides while preparing tea, mistaking the packet for the one containing tea leaves."

Hindustan Times. 10-year-old makes tea with pesticide in Bihar's Darbhanga, 4 of a family dead. https://www.hindustantimes.com/india-news/10-year-old-makes-tea-with-pesticide-in-bihar-s-darbhanga-4-of-a-family-dead/story-uOTnh1jd6HQMeOwhJXBEFN.html The tea was later reported to have been laced with Thimet (phorate). https://www.newindianexpress.com/nation/2018/jan/13/seven-people-die-after-consuming-toxic-tea-in-bihar-in-two-days-1753056.html

Oct 18, 2017 – East Champaran district, Bihar: "Three members of a family, including two children, died after consuming tea laced with pesticide in Bihar's East Champaran district, police said. Rai had kept some pesticide in his house and Menaka, said to be mentally challenged, inadvertently mixed some pesticide with tea leaves, milk, and sugar while preparing tea..."

Business Standard. Three of a family die after drinking tea laced with pesticide. https://www.business-standard.com/article/pti-stories/three-of-a-family-die-after-drinking-tea-laced-with-pesticide-117101801023_1.html

Box 7.2: Other recent child poisoning incidents

June 22, 2020 – Chittoor: "In a freak incident, two children died at AL Puram of Gudipala mandal in the district on Monday. On Monday, Govindamma (70), grandmother of the children, cooked chicken curry. By mistake, she mixed pesticides in the chicken curry thinking that it was chicken masala."

The Hans India. Chittoor: 2 children die after consuming pesticide laced chicken curry. https://www.thehansindia.com/andhra-pradesh/chittoor-2-children-die-after-consuming-pesticide-laced-chicken-curry-629524

May 25, 2020 – Patna, Bihar: "A 14-year-old girl died and her nine-year-old younger sister fell ill after consuming pesticide… Police said it's still not clear whether the girls deliberately consumed pesticide after they were scolded by their father, or accidentally drank it while playing."

Karmakar D. Girl dies after consuming pesticide in Bihar. The Times of India. https://timesofindia.indiatimes.com/city/patna/girl-dies-after-consuming-pesticide/articleshow/75955035.cms

Dec 31, 2018 – Ratlam District, Madhya Pradesh: "A child drank pesticide, unable to cope with hunger after being refused wheat from the local ration shop."

Child drinks insecticide due to hunger in MP, NCPCR sends team. Jan 7, 2019. Business Standard. https://www.business-standard.com/article/pti-stories/child-drinks-insecticide-due-to-hunger-in-mp-ncpcr-sends-team-119010700313_1.html

July 27, 2018 – Udhampur: "A 13-year old girl died after she consumed poisonous pesticide mistaking it as medicine for stomach pain."

13-year old girl mistakenly consumes pesticide, dies. Daily Excelsior. https://www.dailyexcelsior.com/13-year-old-girl-mistakenly-consumes-pesticide-dies/

Jun 21, 2018 – Khopoli: "Two days after the food poisoning incident led to the death of three children, it is being suspected that a cloth which had traces of an insecticide was used to cover food cooked for guests at Subhash Mane's residence at Mahad village near Khopoli. Dr. Ajit Gawli, Raigad district civil surgeon, said some of the patients told him that the cloth used to cover food had the odour of an insecticide. 'The serum test reports of two patients indicated presence of organophosphate compound in the food.'"

The Hindu. Insecticide suspected for Khopoli food poisoning; report awaited. https://www.thehindu.com/news/cities/mumbai/insecticide-suspected-for-khopoli-food-poisoning-reports-awaited/article24213866.ece

Jan 29, 2018 – Odisha: "On Sunday, at least four members of a family were taken ill after eating toxic cauliflower curry in Tantia Barbatia village under Erasama police limits of the district. They have been admitted to Erasama Community Health Centre. Three members of the family had died after eating toxic cauliflower curry in Panthanivas Sahi under Rambha police limits in Ganjam district recently." "Farmers spray methyl parathion on cauliflowers to make it appear extremely white."

The New Indian Express. Odisha: pesticide-laced vegetables take a toll on public health. https://www.newindianexpress.com/states/odisha/2018/jan/29/odisha-pesticide-laced-vegetables-take-a-toll-on-public-health-1764875.html

7.5 Pesticides implicated in UAPP in India

Of the 10 studies that provided information on the prevalence of occupational UAPP, seven provided information on the pesticides being used. One study[264] simply stated that OPs were the most common pesticide used (51%), followed by pyrethroids (35.7%), pyrazole (7.7%), and "thiophosphorous" (5.7%). Two other studies,[265] which reported chronic health problems and acute symptoms but not prevalence, did provide information on the pesticides being used. Refer to Table 7.6 for details.

7.5.1 Other information on pesticides linked to poisonings

Lambda-cyhalothrin was responsible for a recent occupational death, that of a 54-year-old farmer, when a pipe on his sprayer burst during spraying operations.[266]

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264. Reshma H, Jayalakshmi R. 2020. Prevalence of acute pesticide poisoning among pesticide applicators in cardamon plantations: a cross-sectional study from Idukki District, Kerala. *Indian J Occup Environ Med* 24(3):188-93.
265. Islam MS, Alam MS, Uddin MN, Al Zabir A, Islam MS, Haque KA, Ashraful Islam SM, Hoassain SA. 2016. Farm level pesticides use in Patuakhali and Comilla region of Bangladesh and associated health risk. *J Health Environ Res* 2(4):20-6.
266. Naveen A, Sahu MR, Mohanty MK, Mohanty RR, Sethy M, Velayutham. 2022. Lethal neurotoxicity in lambda-cyhalothrin poisoning: a rare case report. *Am J Forensic Med Pathol* doi: 10.1097/PAF.0000000000000789. Online ahead of print Sep 13.

A recent study in tertiary care teaching hospital in East Godavari district, Andhra Pradesh found that chlorpyrifos was responsible for 10% of poisoning cases of farmers and farmworkers, with 25% of these having a "poor outcome".[267] The authors state that chlorpyrifos is the ninth most widely used pesticide for agricultural purposes in India.

Hospital-based surveys and cases reported to poisoning centres provide a considerable amount of information on pesticide poisoning in India. Unfortunately, they often do not separate intentional from unintentional and particularly for the causative agents. However, pesticides, and particularly insecticides, do play a major role in these poisonings. Some of the recent studies are summarised below to indicate the extent of the problem.

- *Pannu et al 2022*:[268] A study of acute poisoning cases at a hospital in North India over the periods December 2016 – December 2017 and September 2019 – December 2019 found that 65.7% of the cases were caused by pesticides, with paraquat ingestion becoming more common (increasing from 3.5% to 12.4%), as OP and aluminium phosphide poisoning declined slightly. 21.9% of the cases were unintentional, with inhalation responsible for 1.5% of these and dermal exposure for 1.2%. Paraquat had a case fatality rate of 42.9%, zinc phosphide 16.7%, and aluminium phosphide 12.9%.
- *Karunarathne et al 2021*:[269] A systematic review of poisoning deaths in India from 1999-2018 concluded that pesticides were responsible for 94.5% of the cases, with aluminium phosphide and OPs predominating, and paraquat becoming more of a problem in the last 10 years. There was no indication how many of these deaths were the result of unintentional exposure.
- *Goswami et al 2021*:[270] A three-year hospital-based study of acute poisoning in Guwahati, Assam found that OPs were involved in 61.9% of fatal cases and carbamates in 18.4%. 26.5% of accidental deaths were in the age groups 0-11 and 11-20 years. Of 244 cases, 34 were accidental.
- *Pagdhun et al 2020*:[271] A three-year (2015-2017) observational study of cases reported to the Poisons Information Centre in Hyderabad found insecticides to be the causative agent in 26.29% of cases, including acephate, phorate, aldrin, carbofuran, aluminium phosphide, chlorpyrifos, cypermethrin, DDT, gamexin [lindane], dimethoate, imidacloprid, malathion, and monocrotophos. It did not state how many of the 1,373 cases were unintentional, although most of them were likely intentional as it did state that 91.62% were ingested (but it cannot be assumed that all ingested cases were intentional, especially where children are involved).
- *Sarkar & Santra 2022*:[272] A hospital-based study of 50 admitted patients in West Bengal due to the ingestion of herbicides, reported the following:

Pesticide	Frequency	Case fatality
Paraquat	64%	56.2%
Pretilachlor	20%	0
Glyphosate	16%	12.5%

- *Iyyadurai et al 2014*:[273] An observational study at Christian Medical College & Hospital in Vellur, Tamil Nadu of 1,177 patients admitted over the period between 2011 and 2012 found that the combination

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267. Acharya A, Panda A. 2022. Clinical epidemiology and predictors of outcome in chlorpyrifos poisoning in farming and allied agricultural workers in East Godavari, Andhra Pradesh. *Indian J Occup Environ Med* 26(2):116-21.
268. Pannu AK, Bhalla A, Vamshi V, Upadhyay MK, Sharma N, Kumar S. 2022. Changing spectrum of acute poisoning in North India: A hospital based descriptive study. *Turk J Emerg Med* 22:192-9.
269. Karunarathne A, Bhalla A, Sethi A, Perera U, Eddleston M. 2021. Importance of pesticides for lethal poisoning in India during 1999 to 2018: a systematic review. *BMC Public Health* 21:1441.
270. Goswami O, Mahanta P, Kalita D, Konwar R, Yadav DS. 2021. A three-year study on acute poisoning cases brough for medico-legal autopsy in a north-eastern city of India. *Open Access Emerg Med* 13:45-50.
271. Pagdhune A, Kunal K, Patel KA, Patel AB, Mishra S, Palkhade R, Muhamed J. 2020. Poisoning cases reported to Poison Information Centre, Ahmedabad, India: A three year observational study. *Cent Asian J Global Health* 9(1).
272. Sarkar TS, Santra G. 2022. A clinic-epidemiological study of acute self-poisoning by different types of herbicidal substances used in agricultural fields: *A study from patients admitted in a tertiary care hospital in West Bengal. I Assoc Physicians India* 70(8):11-12.
273. Iyyadurai R, Peter JV, Immanuel S, Begum A, Zachariah A, Jasmine S, Abhilash KP. 2014. Organophosphate-pyrethroid combination pesticides may be associated with increased toxicity in human poisoning compared to either pesticide alone. *Clin Toxicol* 52(5):538-41.

of chlorpyrifos and cypermethrin resulted in more seizures, more days on ventilators, and more deaths than either chlorpyrifos or cypermethrin alone. The authors asserted that although seizures were higher with cypermethrin than chlorpyrifos, the dominant effects of the mixture were those of chlorpyrifos rather than cypermethrin, because of its higher concentration.

Pesticide	Seizures (% of patients)	Ventilator	Deaths
Chlorpyrifos (20%)	3.9%	15.7%	0
Cypermethrin (15%)	18.8%	42.3%	0
Chlorpyrifos (50%) + Cypermethrin (5%)	15.6%	53.5%	4

Numerous other studies[274] report on a combination of intentional and accidental poisonings involving the following pesticides: aluminium phosphide, zinc phosphide, phorate, dimethoate, endosulfan, paraquat, chlorpyrifos, cypermethrin, dichlorvos, 2,4-D, monocrotophos, glyphosate, methyl parathion, malathion, carbosulfan, diazinon, fenitrothion, and copper sulphate.

7.5.2 Other information on pesticides in use

A study[275] on the use of five pesticides found that these were very commonly used by the respondents: chlorpyrifos by 79.73%, glyphosate by 77.97%, fipronil by 74.89%, paraquat by 68.28%, and atrazine by 47.58%. This study did not include health impacts, and is therefore not included in the table.

Key to tables 7.6 and 7.7:

X = most commonly used (i.e., by highest number of farmers)
x = less often used
X = high exposure
X = greatest health risk (EIQ)
X = being used when symptoms occurred

HHPs:
X = pesticides meeting the JMPM criteria for acute toxicity
x = pesticides meeting the JMPM criteria for chronic toxicity or meeting the requirements of the Stockholm or Rotterdam Conventions
X = pesticides listed in PAN HHPs list (2021) for reasons of inhalation toxicity (H330), but not meeting the JMPM criteria
x = pesticides listed in PAN HHPs list for reasons of endocrine disruption or cancer but not GHS cancer, or environmental effects, and therefore not meeting the JMPM criteria

EU:
Reasons for ban:
a = acute toxicity – human, mammalian, or GHS warning; or concerns for operator exposure even when correct PPE is worn
c = chronic health effects
d = dietary concerns
e = environmental concerns
i = lack of info
p = need for PPE, or concern expressed for operators; for example, for carbendazim: "operators, who must wear suitable protective clothing, in particular gloves, coveralls, rubber boots, and face protection or safety glasses during mixing, loading, application, and cleaning of the equipment"[276]
? = reason not found

Other information
o = other information supports acute toxicity
o (si) = other information supports skin irritant and/or sensitiser

LD_{50} – **bold** = ≤ 100

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274. For example: (i) Mundri S, Bhengra A, Guria J. 2018. Types and frequencies of poisoning related deaths in Ranchi: an autopsy based study. *Int J Sci Res* 7(8):47-8. (ii) Pate RS, Rojekar MV, Hire RC. 2017. Trends of poisoning cases in tertiary care teaching hospitals in western Indian population. *Int J Med Toxicol Forens Med* 7(3):177-84. (iii) Loyi M, Thounaojam M, Shah MI. 2017. Insecticide poisoning in Manipur. *Int J Health Sci Res* 7(9):1-8. (iv) Vinoj J, Pius PS, Indhuja, Arthi. 2016. Poisoning profile in a tertiary medical hospital. *J Evid Based Med Health* 3(43):2162-4. (v) Seklvaraj T, Sudharson T. 2016. Demographic and clinical profile of organophosphorus poisoning cases in a medical college hospital, Tamil Nadu. *Ind J Forens Commun Med* 3(2):124-7. (vi) Khosya S, Meena SR. 2016. Current trends of poisoning: an experience at a tertiary care hospital Hadoti regiona, Rajasthan, India. *J Clin Toxicol* 6(2). (vii) Shakuntala, Yogesh G. 2015. Analysis of organophosphorus poisoning, at tertiary care hospital: a report. *J Evidence Based Med Healthcare* 2(4): 421-30.
275. PAN India. 2017. Reality of Pesticide Use in India: A Study on Five pesticides. In Rengam et al 2018.
276. EC. 2010. Review report for the renewal of active substance carbendazim finalised in the Standing Committee on the Food Chain and Animal Health at its meeting on 23 November 2010 in view of the renewal of inclusion of carbendazim in Annex I of Directive 91/414/EEC. SANCO/13063/2010 final. 22 November 2010. European Commission.

Table 7.6: Pesticides found in use in India (Long List)

Study No.	1	2	3	4	5	6	7	8	9		HHP	EU ban	LD_{50}
Region	Shirol region of Kolhapur district, Western Maharashtra	Andhra P., Arunachal, Assam, Chhattisgarh, Himachal P., Madya P., Telangana, Uttar P., W. Bengal	Western Odisha	Yavatmal, Maharashtra	Kinnaur district, Himachal Pradesh	Chittoor district, Andhra Pradesh	Thiruvallur district, Tamil Nadu	Valparai, Coimbatore district, Tamil Nadu	Yavatmal, Maharashtra	Other poisoning info			
Ref	Patil & Katti 2012	Kumar 2015	Seth & Mahanada 2016	Reddy & Kumar 2017	Kumari & John 2018	Rengam et al 2018	Paminutan & Rengam 2020	Venugopal et al 2021	Diyana et al 2022	various refer to text			
Crop	cash cropping	various	rice	cotton	apples	mango	jasmine	tea	various				
Pesticide													
acephate			X	X					x	X	x	x i	945
alachlor	x										x		930
aldicarb	x										X		**0.93**
aluminium phosphide										X	X		**8.7**
atrazine	x											x e, i	1,869
bifenthrin							x				x	x e, p	**54.5**
buprofezin			X										1,635
captan					x						x		2,000
carbaryl	x										x	x a, c, e	614
carbendazim	x				X			x			x	x p, e, i	10,000
carbofuran	x									X	X	x a, e	**7**
carbosulfan					x						X	x i	**101**
cartap			x									x i	325
chlorpyrifos	x		x		x		x		x	X	x X	x c, e	**66**
chlorpyrifos methyl								x			x		5,000
copper oxide				x									300

cymoxanil						x							356
cypermethrin	x		X	X			X		x	X	x		287
DDT	x									X	x	x	113
diafenthiuron				X					x		x	x ?, o	2,068
dichlorvos			x						x		X	x	**80**
dicofol	x										x	x	578
difenoconazole					x								1,453
dimethoate	X					x			x	X	x	x c, e, i	245
dodine					x						x		851
emamectin benzoate							x				x		**81.5**
endosulfan	X					x					x X	x e, i	**38**
ethion					x		x	x			x	x	208
fenthion	x										x	x	250
fipronil				X					x		x	x e	**92**
glyphosate				x							x		2,000
imidacloprid				X			x		x	X	x	x p, e, i	131
lambda-cyhalothrin			x				x			X	X	o	**56**
lindane	x								x	X	x		163
malathion	x									X	x		1,778
mancozeb					x	x			x		x	x c, e, i	5,000
metiram						x					x		5,000
metsulfuron-methyl									x				5,000
monocrotophos	X			X		x	X		X	X	X	x	**14**
paraquat		X					x			X	X	X p, e	110
parathion-methyl	x				x				X		X	x p	**3**
phenthoate							x				x	x a	249
phorate	x								X	X	X	x	**2**
profenofos	x		x	X			x				x	x	358
propargite						x			x		x		2,639
propineb					x		x				x	x i	5,000
propisochlor												x e, i	2,290
pymetrozine											x	x c, e, i	5,820

pyraclostrobin						x							5,000
quinalphos	**X**					x	x		x		x	x ?	**71**
simazine	x										x		5,000
spinosad				x					x		x		2,000
spirotetramat							x						2,000
thiamethoxam			x				x	x			x	x e	1,563
thiophanate-methyl					x			x			x	x e, o(si)	5,000
thiodicarb							x		x		x	x	**50**
transfluthrin							x						5,000
triasulfuron							x						5,000
triazaphos							**X**		**X**		**X**	x	**66**
zinc phosphide										**X**	**X**		**12**
ziram					x						**X**		267

Table 7.7: Pesticides potentially involved in UAPP in India (Short List)

Study No.	1	2	3	4	5	6	7	8	9		HHP	EU ban
Date	2010	2014-2015	2015	2017	2016	2017	2019	201?	2019	Hospitals		
Pesticide												
acephate			X	X					x	X	x	x i
alachlor	x										x	
aldicarb	x										X	
aluminium phosphide										X	X	
atrazine	x											x e, i
bifenthrin							x				x	x e, p
buprofezin			X									
captan					x						x	
carbaryl	x										x	x a, c, e
carbofuran	x									X	X	x a, e
carbosulfan					x						X	x i
cartap			x									x i
chlorpyrifos	x		x		x		x		x	X	x X	x c, e
copper oxide				x								
cymoxanil						x						
cypermethrin	x		X	X			X		x	X	x	
DDT	x									X	x	x
diafenthiuron				X					x		x	x ?, o
dichlorvos			x						x		X	x
dicofol	x										x	x
difenoconazole					x							
dimethoate	X					x			x	X	x	x c, e, i
dodine					x						x	
emamectin benzoate							x				x	
endosulfan	X					x					x X	x e, i
ethion					x		x	x			x	x
fenthion	x										x	x
fipronil				X					x		x	x e
glyphosate				x							x	
imidacloprid				X			x		x	X	x	x p, e, i
lambda-cyhalothrin			x				x			X	X	o
lindane	x								x	X	x	
malathion	x									X	x	
monocrotophos	X			X		x	X		X	X	X	x
paraquat		X					x			X	X	X p, e
parathion-methyl	x				x				X		X	x p
phenthoate							x				x	x a
phorate	x								X	X	X	x
profenofos	x		x	X			x				x	x
quinalphos	X					x	x		x		x	x ?
spinosad				x					x		x	
spirotetramat							x					
thiamethoxam			x				x	x			x	x e
thiodicarb							x		x		x	x
triazaphos							X		X		X	x
zinc phosphide										X	X	
ziram					x						X	

7.8 Pesticide Management in India

7.8.1 Pesticide regulation

India has an excellent publicly available database of registered and banned pesticides.[277] It also has publicly available data on registered pesticide poisonings, differentiating those that are intentional or unintentional, those in children and adults and by gender, including transgender.[278]

India also has the power to ban pesticides, although this is severely limited by the power of the pesticide industry to prevent it, such as by threatening court action.[279]

Of the 47 pesticides listed in Table 7.3, 10 have been banned:[280]

- alachlor
- aldicarb
- carbaryl
- dichlorvos – manufacture still permitted for export
- endosulfan
- fenthion
- lindane
- parathion-methyl
- phorate – manufacture still permitted for export
- triazophos – manufacture still permitted for export

In addition, the ban of another 27 pesticides has been proposed. In May 2020, the Ministry of Agriculture issued a gazette notification[281] proposing the ban of:

- acephate
- atrazine
- benfurocarb
- butachlor
- captan
- carbendazim
- carbofuran
- chlorpyrifos
- deltamethrin
- dicofol
- dimethoate
- dinocap
- diuron
- malathion
- mancozeb
- methomyl
- monocrotophos
- oxyfluorfen
- pendimethalin
- quinalphos
- sulfosulfuron
- thiodicarb
- thiophanate methyl
- thiram
- zineb
- ziram

If these bans proceed, another 11 pesticides implicated with UAPP would be gone, leaving just 26 of those linked to UAPP, including paraquat, which is known to have caused a number of poisonings.

However, the bans still have not been implemented more than a year and a half later. Additionally, a subsequent gazette notice proposed that the manufacture of these pesticides be permitted for export purposes.[282]

It seems that the pesticide industry has enormous political influence in India, demonstrated by the softening of the proposed bans in order to continue allowing the manufacture of pesticides for export

277. Directorate of Plant Protection, Quarantine & Storage. http://ppqs.gov.in/divisions/cib-rc/registered-products
278. National Crime Records Bureau. Accidental Deaths & Suicides in India https://ncrb.gov.in/sites/default/files/adsi
279. Pandey S. 2020. Move to ban 27 pesticides will hand over Rs 12,000-cr market to China: Indian manufacturers. The Print, Jun 10. https://theprint.in/india/move-to-ban-27-pesticides-will-hand-over-rs-12000-cr-market-to-china-indian-manufacturers/438973/
280. Government of India. List of Pesticides Which are Banned, Refused Registration, and Restricted in Use (as on 01.10.2022). http://ppqs.gov.in/divisions/cib-rc/registered-products Accessed Dec 9,2022.
281. Gazette of India. CG-DL-E-18052020-219423. Extraordinary. PART II- Section 3—Subsection (ii). New Delhi Monday May 18, 2020/Vaisakha 28, 1942. https://egazette.nic.in/WriteReadData/2020/219423.pdf
282. Tiwari R. 2020. Govt may set up expert panel to evaluate industry voice before decision on banning pesticides. The Economic Times, Jun17. https://economictimes.indiatimes.com/industry/indl-goods/svs/chem-/-fertilisers/govt-may-set-up-expert-panel-to-evaluate-industry-voice-before-decision-on-banning-pesticides/articleshow/76421172.cms

and the delay in deciding on the bans. This influence was also evident in the role India recently played in stalling the EU's proposal to list chlorpyrifos under the Stockholm Convention at the POPs Review Committee in October 2022 (author's personal observation).

India's continued manufacture of pesticides for export, which it has banned for human health or environmental reasons or for lack of data, is unethical. These same problems apply to every other country where it exports the banned products, many of which are causing poisoning problems in other countries in the region. It is simply unethical and unjustifiable to export chlorpyrifos and to try to prevent a global ban under the Stockholm Convention whilst proposing to ban chlorpyrifos for use in India for the following reasons:

1. The product is an organophosphate, is neurotoxic, and has been banned for household use in the United States of America and 27 countries of European Union.
2. Data pertaining to the fixation of the waiting period for cotton, cabbage, ber, ground nut, citrus, and tobacco crops is not submitted.
3. The studies on air concentration, as recommended by Dr Ranjit Roy Choudhury Committee on Chlorpyriphos, have not been undertaken yet.
4. The product falls under category three under the European Union prioritisation of Endocrine Disrupting Chemicals and also figure in the Tier One screening final list of the Endocrine Disruption Screening Program (EDSP)
5. It is banned in 31 countries, approval not renewed in EU, details of country (as per PAN data): State of Palestine, Saudi Arabia, Sri Lanka, Vietnam, and European Union
6. Alternatives are available for use.
7. Incomplete data submitted for toxicity, bio-efficacy, eco-toxicity, and health hazards to children and infants, and product is an organophosphate and neurotoxic. India argued against incomplete data submitted during the Persistent Organic Pollutants Review Committee (POPRC) of Stockholm Convention. Also, there are reports on genotoxicity and health hazards. Therefore, import, manufacture, sale, transport, distribution, and its use shall be prohibited in agriculture except for use in desert locust.

Unless India is not taking stringent, science based regulatory measures on pesticides complying to the International Code of Conduct on Pesticides Management and global regulatory frameworks such as UN conventions ILO requirements and so on. India is likely to lead the world in the worst way with higher incidences of pesticide poisoning of its citizen including deaths of children, in addition to contributing to increased environmental contamination and food safety risks.

7.8.2 Implementation of the International Code of Conduct on Pesticide Management

Whilst India has implemented some aspects of the code, such as a regulatory system, there are other aspects that remain yet to be implemented, such as Article 3.6, which would prevent all or most UAPP.

India also has a problem with ensuring compliance with its regulations. There is widespread use of pesticides on crops other than for those which they are approved.[283] Pesticide retailers also decant highly toxic pesticides and sell them in a dangerous condition to small-scale farmers, such as, for instance, selling paraquat in plastic shopping bags.[284]

7.8.3 Availability of alternatives

283. Kumar D. 2022. State of Chlorpyrifos, Fipronil, Atrazine & Paraquat Dichloride Use in India. PAN India. https://pan-india.org/wp-content/uploads/2022/08/HHP_Chl-Fip-Atr-Pqt_Report-Final-web_PAN-India.pdf
284. Kumar D. 2017. Paraquat Dichloride Retailing in India: A Case Study in West Bengal. https://pan-india.org/wp-content/uploads/2017/04/Paraquat-retainiling-in-India_PAN-India-04.2017.pdf

According to Jaacks et al (2022),[285] 19 of India's 28 states have organic farming "policies, schemes, or missions", including one state that completely banned the use of synthetic pesticides and fertilisers since 2014. Their 2020 evaluation of Andhra Pradesh Community Managed Natural Farming (APCNF) showed that it is possible for farmers to reduce and abandon their use of highly toxic pesticides but that they need intensive training and support from extension workers, local retailers need to supply the necessary products, and the government needs to ban harmful pesticides. Andhra Pradesh has a target of 100% chemical-free farming by 2030. Their study found that, of those trained in the natural pest management methods, only 11% were still using monocrotophos compared with 29% not trained; similarly, for emamectin benzoate, the figures were 4% versus 24% and for imidacloprid, 7% versus 18%. These are three of the pesticides implicated in UAPP and they should be banned completely. The study also found that whilst 34% of the local pesticide retailers now stocked biopesticides, only 13% of them stocked sticky traps, pheromone traps, and other mechanical pest management tools. Retailers also need to be trained and supported to do away with the pesticides causing UAPP.

Perhaps, the pesticide industry also needs to be encouraged to divert their production from harmful pesticides to biopesticides and mechanical pest management tools, instead of bowing to their pressure to keep procuring the pesticides that kill people.

7.8.4 Children and rights

There is no law or policy in India that addresses pesticide poisoning among children, and the lack of government action is violating the rights of children.[286] India also has the largest child population in the world, consisting of some 548 million under the age of 18, making up 40% of the population. And 73% of them live in rural areas.[287] The ongoing practice of storing pesticides in the kitchen is repeatedly resulting in the deaths of children and often their parents too. If these highly toxic pesticides were not available, these lives would be spared.

7.9 Conclusions

Despite being one of the largest producers and exporters of pesticides, India is only the thirteenth highest user of pesticides, reportedly using 58,720 metric tonnes technical grade in 2021-2022,[288] and one of the countries with the lowest use per area of cropland, with a rate of 0.3kg/ha – much lower than the U.S. (2.5), most countries in Europe (2.2-6.1), Malaysia (8.1), Japan (11.8), China (13.1), Mexico (1.8), Colombia (9.9), and others.[289] And yet, it has a much higher mortality and morbidity UAPP prevalence than any of these countries.

The most likely reasons are:

- Failure to adhere to Article 3.6 of the International Code of Conduct on Pesticide Management.
- Widespread use of toxic pesticides.
- Inability of farmers to use PPE due to cost, availability, heat/discomfort.
- Storage of pesticides in the home.
- A lack of support for the implementation of agroecological practices.

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285. Jaacks LM, Serupally R, Dabholkar S, Venkateshmurthy NS, Mohan S, Roy A, Prabhakan P, Smith B, Gathorne-Hardy A, Veluguri D, Eddleston M. 2022. Impact of large-scale, government legislates and funded organic framing training on pesticide use in Andhra Pradesh, India: a cross-sectional study. *Lancet Planet Health* 6:e310-19.
286. Utyasheva L, Bhullar L. 2021. Human rights perspective on pesticide exposure and children: A case study of India. *Health Hum Rights J* 23(2):49-61.
287. Utyasheva L, Bhullar L. 2021. Human rights perspective on pesticide exposure and children: A case study of India. *Health Hum Rights J* 23(2):49-61.
288. Government of India. Consumption of chemical pesticides in various states during 2017-2018 and 2021-2022. Directorate of Plant Protection, Quarantine and Storage. http://ppqs.gov.in/statistical-database. Accessed Dec 5, 2022.
289. Worldometer. Pesticide use by country. https://www.worldometers.info/food-agriculture/pesticides-by-country/ Accessed Dec 5, 2022.

7.10 Recommendations

1. Implement Article 3.6 of the International Code of Conduct on Pesticide Management, which means prohibiting the manufacture or importation of any pesticides that require PPE.
2. Phase out all pesticides on India's Short List (Table 7.7), beginning with the immediate ban of any pesticides in the priority list in Table 8.3, including any formulations containing the combination of chlorpyrifos and cypermethrin, which is emerging in a number of countries as being responsible for a number of poisonings including deaths.
3. Develop a national policy on replacing HHPs with agroecological practices and national and international assistance with training for farmers on their implementation, so as to remove farmers' perceived need for toxic pesticides.
4. All hospitalised cases should be data-segregated for occupational and accidental causation, and record the pesticides involved.
5. Intensify the monitoring of non-hospitalised occupational poisoning to more accurately identify the scale of the problem and to identify the pesticides causing the harm.

8. Summary of information on UAPP and the pesticides causing it

It is clear from the information obtained for this review that the four countries are continuing to experience a significant problem with unintentional acute pesticide poisoning. And the situation is not improving. In fact, in comparison with the earlier data used by Boedeker et al (2020), UAPP incidence has increased in all four countries.

Table 8.1: Estimates of UAPP in the four countries

Country	Population type	Year	Population size	Fatal	Non-fatal (estimated)	Incidence
Vietnam	agricultural	2019	20,805,540	?	12,127,549	59.29%
	children (rural)	2019	14,332,803	?	9,144,328	63.80%
Laos	agricultural	2019	2,302,905	?	1,672,600	72.63%
Bangladesh	agricultural	2019	26,515,004	?	16,227,182	61.20%
India	agricultural	2019	205,630,321	?	172,482,713	83.88%
	children	2019	363,716,740	155	?	?

Because none of the four countries have implemented Article 3.6 of the International Code of Conduct on Pesticide Management, the pesticides that continue to poison children, women, and men remain widely available. Table 8.2 below summarises the pesticides most likely implicated in each country.

Table 8.2: Summary of pesticides potentially involved in UAPP in the four countries

Pesticide	Vietnam	Laos	Bangladesh	India
2,4-D	x	x	x	
abamectin/avermectin	x	x	x	
acephate			x	X
acetamaprid	x	x	x	
acetochlor	x			
alachlor				x
aldicarb				x
aluminium phosphide			X	X
atrazine	x	x		x
bifenthrin		x		x
bromadiolone	x			
buprofezin	x			x
butachlor	x			
captan				x
carbaryl	x	x		x
carbofuran		x	x	X
carbosulfan	x		x	x
cartap	x		x	x
chlorfenapyr	x			
chlorofenoxy acetic acid			x	
chlorpyrifos	x	x	X	X
copper hydroxide	x			
copper oxide				x
cymoxanil	x		x	x

cypermethrin	x	x	X	X
cypermethrin - alpha	x			X
cypermethrin - beta	x			
cyproconazole	x			
DDT				X
deltamethrin	x			
diafenthiuron	x			X
diazinon	x		X	
dichlorvos			X	x
dicofol				x
difenoconazole	x		x	x
dimethoate	x		X	X
diniconazole	x			
diquat dibromide	x			
dodine				x
edifenfos			x	
emamectin benzoate	x		x	x
endosulfan	x			x
ethion				x
etofenprox	x			
eugenol	x			
fenitrothion	x		X	
fenthion			X	x
fenbuconazole		x		
fenobucarb	x	x	x	
fenproparthrin		x		
fenvalerate			x	
fipronil	x		x	X
glyphosate	x	x		x
hexaconazole	x			
imidacloprid	x	x	x	X
indoxacarb	x			
iprobenfos	x			
iprodione	x	x		
isoprocarb	x		x	
isoprothiolane	x			
lambda-cyhalothrin	x		x	X
lindane				X
lufenuron	x			
malathion			X	X
metalaxyl	x		x	
metolachlor	x			
monocrotophos			X	X
myclobutanil	x			
nereistoxin	x			
nitenpyram	x			
nitrobenzene			x	
oxolinic acid	x			
paclobutrazol	x			
paraquat	x	x	X	X
parathion-methyl				x
permethrin	x			

phenthoate			x	x
phorate				X
phoxim	x			
profenofos	x			X
prochloraz		x		
propanil	x			
propiconazole	x		X	
propisochlor	x			
pyridaben		x		
quinalphos	x		X	x
quizalfop-p-ethyl	x		x	
spinosad				x
spirotetramat	x			x
sulphur	x		x	
tebuconazole	x	x		
terbuthylazine			x	
thiamethoxam	x	x	x	x
thiodicarb				x
thiosultap (Na and monosultap)	x			
thiram		x		
triazaphos				x
trichlorfon	x			
tricyclazole	x			
trifloxystrobin	x			
warfarin	x			
zinc phosphide	x		X	X
ziram	x			x

X = pesticides known to have caused poisoning in the country

All of these pesticides have the potential to be causing UAPP in all four countries and need to be phased out rapidly. Immediate attention should be given to banning the very worst of these, which are the pesticides known to be causing poisoning in one or more of the four countries and those with an LD_{50} <100 mg/kg because they are highly toxic and cannot be used safely in these countries.

Table 8.3: Pesticides for immediate ban in the four countries

Pesticide	Vietnam	Laos	Bangladesh	India	LD_{50}
abamectin/avermectin	x	x	x		8.7
acephate			x	X	945
aldicarb				x	0.93
aluminium phosphide			X	X	8.7
bromadiolone	x				0.56
carbofuran		x	x	X	7
carbosulfan	x		x	x	101
chlorfenapyr	x				45
chlorpyrifos	x	x	X	X	66
cypermethrin	x	x	X	X	287
cypermethrin – alpha	x			X	40
cypermethrin - beta	x				93
DDT				X	113
deltamethrin	x				87

diafenthiuron	x			**X**	2,068
diazinon	x		**X**		1,139
dichlorvos			**X**	x	80
dimethoate	x		**X**	**X**	245
emamectin benzoate	x		x	x	81.5
endosulfan	x			x	38
fenitrothion	x		**X**		330
fenthion			**X**	x	250
fipronil	x		x	**X**	92
hexaconazole	**X**				2,189
imidacloprid	x	x	x	**X**	131
lambda-cyhalothrin	x		x	**X**	56
lindane				**X**	**163**
malathion			**X**	**X**	**1,778**
monocrotophos			**X**	**X**	**14**
nereistoxin	x				92.6
paraquat	x	x	**X**	**X**	**110**
parathion-methyl				x	3
phorate				**X**	**2**
profenofos	x			**X**	**358**
propiconazole	x		**X**		550
quinalphos	x		**X**	x	71
thiodicarb				x	50
triazaphos				x	66
warfarin	x				10.4
zinc phosphide	x		**X**	**X**	**12**

9. Discussion

Despite the huge personal, financial, and societal costs, the issue of unintentional acute pesticide poising is still widely ignored globally, including in the four countries of focus in this review.

Since the publication of the WHO figures in 1990, the UN has focussed on mortality and largely ignored UAPP. With that focus on mortality, suicides became the target of WHO and a small number of researchers. Pesticides have been estimated to account for 14-20% of global suicides, leading to 110,00-167,000 deaths annually.[290] The extraordinarily high incidence of unintentional non-fatal pesticide poisoning has been over-looked and even accepted. Even the implementation of the Sustainable Development Goals[291] focuses only on reducing deaths, although Target 3.9 states that "*by 2030, the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution, and contamination will be substantially reduced*", the indicator for this target, 3.9.1, mentions only the "*mortality rate attributable to unintentional poisoning*".[292] On the other hand, Target 2 ("*End hunger, achieve food security and improved nutrition and promote sustainable agriculture*") fails to mention pesticides at all. But both mortality and illness should be addressed.

Much of the cause of the UAPP, both fatal and non-fatal, lies with the failure of governments to properly implement the International Code of Conduct on Pesticide Management and the failure of the pesticide industry to adhere to it voluntarily. Farmers are given access to lethal chemicals, which poverty drives them in many cases to store in their kitchen or other places in the house where they can be easily accessed by children. The fault lies not with the farmers but with those that provide them with the pesticides.

Annie Shattuck,[293] in her analysis of the issues embodied in safe use of pesticides, and noting the endemic under-reporting of pesticide poisoning, asked the question:

> *"If the primary mode of preventing harms to such users is safe use education, what accounts for the persistence of a model that is evidently failing to engender safety?"*

Shattuck, like so many others, reported that many farmers know what to do and what to wear, but they do not do so because it is too hot.

Based on many reports,[294, 295] it is clear that despite training, pesticide users continue to not wear the required PPE, and education has not and will not be enough to solve the poisoning problem. Telling farmers not to store pesticides in their house when they have nowhere else to store them also will not work. The only solution that will work is removing the pesticides that are causing the poisoning, as per Article 3.6 of the Code which stipulates that:

- ***Pesticides whose handling and application require the use of personal protective equipment that is uncomfortable, expensive, or not readily available should be avoided, especially in the case of small-scale users and farm workers in hot climates.***

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295. Joko T, Dewanti NA, Dangiran HL. 2020. Pesticide poisoning and the use of personal protective equipment (PPE) in Indonesian farmers. *J Environ Pub Health* 2020:5379619.

There is a "pattern of shifting blame to less powerful actors created by international pesticide governance … The focus on individual responsibility obscures the accountability or risk producers at larger scales, from wealthier farmers to governments and industry… hence, making it seem that safe use is all that can be done."[296] This leads to the blaming of the poor for their own poisoning, whilst those who are responsible wash their hands of the problem, including:

- the manufacturers who continue to produce highly toxic pesticides and promote these in countries where they know such substances will cause poisoning, and those who try to prevent governments from banning these.
- governments that register or approve pesticides that are poisoning their people.
- governments that ban pesticides for use in their own country but allow manufacturers to export them to others.
- dealers who deliver these pesticides to farmers.
- the international community that has failed to enact strict global regulation of pesticides and those countries that stand in the way of regulation.

One set of data used to help identify which pesticides are most likely to be causing UAPP in the four countries is the European Union approvals database, specifically the pesticides that have had their approval removed. The EU was chosen to determine which pesticides are most likely to be causing UAPP because of the sophistication of their hazard and risk assessment processes, their transparency, and the availability of data. This is not to say that the EU bans all pesticides that are likely causing problems in Asia, but because, in the author's opinion, the region has the best available processes resulting in the best available data and the most health-protective outcomes. There may be pesticides that are not yet banned in the EU that need to be banned in Asia, in order to protect human health and the environment. The assessments by the EU, for example, are based on the use of PPE, whilst there is a significant lack of use of proper PPE in Asia.

However, not all pesticides still approved by EU should be regarded as safe. For example, lambda-cyhalothrin is not yet banned by the EU but is known to have caused numerous poisonings around the world, including in Africa, Canada, Europe, Latin America, and USA.[297] Recently, an accidental burst pipe in a spray during spraying operations with lambda-cyhalothrin resulted in the death of a farmer in India.[298] Cypermethrin, also still approved in the EU, is implicated in a number of poisonings, especially when it is used in combination with chlorpyrifos.[299]

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296. Shattuck A. 2021. Risky subjects: Embodiment and partial knowledges in the safe use of pesticide. *Geoform* 123:153-61.
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10. Overall Recommendations for Vietnam, Laos, Bangladesh and India

A number of steps need to be taken at the regulatory level to ensure that pesticides which are causing poisoning, or are likely to cause UAPP, are removed from the market. Some of these steps will also help protect against chronic pesticide poisoning and environmental impacts, such as loss of biodiversity, but it must be emphasised that that is not the purpose of this review; rather, it is solely focussed on acute unintentional poisoning. More analysis is needed to identify the pesticides causing the most damage in those categories. The recommended steps are the following:

1. Implement Article 3.6 of the International Code of Conduct on Pesticide Management, which means prohibiting the manufacture, importation, or use of any pesticides that require PPE.
2. Immediately ban all pesticides on the priority List (Table 8.3), including any formulations containing the combination of chlorpyrifos and cypermethrin, which is emerging in a number of countries as being responsible for significant poisonings, including deaths.
3. Phase out all pesticides on each country's Short List.
4. Cease the import of pesticides banned by the EU, as these have been found to be either too damaging to human health or the environment, or to have insufficient information to support their use.
5. Cease the import of pesticides banned in their country of origin because that country has identified them as too hazardous for use.
6. Countries that have banned pesticides for use but still allow their manufacture for export should cease this discriminatory practice.

There are a number of non-regulatory areas where measures can be taken to reduce UAPP:

1. Governments work together and with other countries in the region and international organisations to prevent illegal trade in pesticides, particularly into Laos, which has huge land borders and inadequate resources to enforce compliance with bans and other regulatory measures.
2. Governments should develop a national policy on replacing the pesticides implicated in UAPP with agroecological practices, and scale up national and international assistance with training for farmers on their implementation, so as to remove farmers' perceived need for toxic pesticides.
3. All cases of hospitalisation should be data-segregated for occupational and accidental causation, including recording the pesticides involved, and the data made publicly available. Moreover, all cases should be collated at a national level and the information made publicly available to assist in the elimination of UAPP.
4. The monitoring of cases involving non-hospitalised occupational poisoning should be intensified to more accurately identify the scale of the problem and to identify the pesticides causing the harm.
5. Greater monitoring of the impacts on children should be enforced.

Vietnam, Laos, Bangladesh, and India are all suffering from very high levels of poisoning of their farmers, farmworkers, and in some cases, children. Implementing the above recommendations will drastically reduce the problem and will not only improve the health and wellbeing of rural people but also their economic situation and food security. Critical to the success of these recommendations is assisting farmers in the implementation of agroecological practices, aimed at improving their productivity, resilience to climate change and natural disasters, and relief from pests and plant diseases.

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