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Public health challenges facing Environmental Health Officers during COVID-19: methamphetamine contamination of properties

Emma J. Kuhn, G. Stewart Walker, Jackie Whitey, Harriet Whiley, Kirstin E. Ross
1. College of Science and Engineering, Flinders University, South Australia
2. Environmental Risk Sciences, New South Wales

The World Health Organization announced the COVID-19 global pandemic to be a Public Health Emergency of International Concern on 30 January 2020. Many governments from around the world, including Australia, the US, China, and the UK, responded by implementing strict public health interventions. Globally, police, Army Reserves and other military services were used to enforce measures that included closing borders to overseas travellers, limiting group gatherings, and applying social distancing regulations. Despite adopting mitigation strategies, in some countries (e.g. China, Spain, Italy and Brazil), the spread of disease surpassed containment measures. Within countries, there have also been hotspots of infection, and even more stringent containment methods, such as lockdowns – which limited the movement of all residents – have been implemented in high-risk locations. Throughout 2020, social distancing regulations have changed the way people interact with each other and there has been a significant increase in public health messages for hand hygiene, sanitation and self-isolation. Every country has faced increased and, in some cases, overwhelming demands on healthcare, increased unemployment and economic uncertainty.

Environmental health workforce

Environmental health officers (EHOs) are frontline educators and enforcers of the public health sector. They have the multifaceted task of ensuring public safety through infection control, water quality, food safety, waste management, chemical exposure and climate change. It has already been determined the environmental health role is overlooked in Australia, the US, UK and South Africa, and that it is difficult to recruit and retain employees in this field. Tasks assigned to EHOs in response to the pandemic varied across countries. For example, a recent analysis of Australia, UK, US and Portugal EHOs showed that they were assigned with a range of COVID-19 tasks that varied between states and locations. Responsibilities included, but were not limited to, isolation and quarantine compliance checks, new food safety inspections for takeaway options, and advising social distancing restrictions for public spaces. As of December 2020, time delays in ‘normal’ activities are to be expected due to the increased workload, as EHOs are still assessing and investigating environmental health issues while working safely within current restrictions. As time and pressure mounts, we can expect the emergence of new environmental health challenges and exacerbation of existing challenges, such as food safety, healthy homes and climate change. It is critical that this workforce is adequately resourced to ensure public health regulation is enforced, and a risk-based approach is used to tackle these emerging issues. The response to COVID-19 has resulted in a sudden and single-minded shift in priorities. When faced with so many immediate issues associated with the worldwide pandemic, it can be difficult to maintain existing public health activities. This paper will use methamphetamine contamination of properties as an example of an emerging environmental health issue that has been exacerbated due to COVID-19. This highlights the need for an increased labour force to ensure that this overlooked but critical public health workforce is supported to ensure public health protection now and into the future.

Methamphetamine contamination of properties

Methamphetamine is a synthetic drug that is illegally used and manufactured all over the world. The ‘ice-like’ crystalline structure has become increasingly popular and is commonly injected or inhaled through smoking. The most common methods for manufacturing methamphetamine employ combinations of lithium from batteries, ammonia from household cleaner, phosphorus, iodine and acids, resulting in toxic by-products or volatile organic compound (VOC) contamination. This accounts for the harmful nature of the residues from the precursor chemicals and their by-products, as well as the drug itself. It has been well established there are health hazards involved with entering clandestine laboratories, especially for first responders. If the illegal drug activity is not discovered by law enforcement, it is likely the property will not be adequately cleaned prior to new residents moving in, posing a potential public health risk. Contamination from personal users or clandestine laboratories can become absorbed by structural components.
within a property such as walls, ceilings, and flooring. Smoke and VOCs can be deposited and re-released again when disturbed. A study of housing walls by Wright et al. found that methamphetamine had penetrated the outer paper, the inner gypsum wall and the inner paper layer in contact with the wooden structure. This dispersion could be attributed to vapour intrusion through the layers, or mobility via vapour movement or moisture in the roof space and down the cavity walls.

In a controlled methamphetamine cook performed by Van Dyke et al., airborne emissions moved from the manufacturing location and spread throughout other rooms in the property. Martyny et al. studied simulated smoking and found that residues can also travel by surface contact and air movement through air conditioner vents or foot traffic. Homes with ducted air conditioning have piping that distributes air throughout the home; therefore, potentially circulating residual methamphetamine and chemical by-products. These airborne emissions can be readily absorbed by porous items including toys, bedding and soft furnishings, which can be disturbed and redistributed. Wright et al. also demonstrated that residues persisted for at least five years after manufacturing had ceased, and new possessions introduced to the property became contaminated. Notably, this is an understudied area, and these estimates provide only a superficial assessment of the resilience of methamphetamine contamination.

### Adverse health effects of methamphetamine-contaminated properties

Adverse health effects due to methamphetamine contamination can be experienced by anyone in contact with the residues. However, the health problems are non-specific and can be attributed to a range of other causes before contamination of a property is considered and investigated. Children are most at risk of increased exposure to methamphetamine and health impacts due to their body size, developmental stages, inhalation exposure and physical contact with surfaces. In a recent case study of 63 individuals by Wright et al., adults, adolescents and children experienced adverse health effects after being unknowingly exposed to methamphetamine through third-hand use and manufacture of the drug. The amount of time family members spent living at the contaminated property varied from several days to 10 years. Common health issues experienced by children and adolescents included but were not limited to behavioural and cognitive effects (79%); sleeping issues (72%); respiratory effects (62%); and eye and skin irritation (55%). Brewer et al. demonstrated that between 0.056 and 0.34 ng/mL methamphetamine was absorbed by three racehorses transported for six hours in a contaminated float. Therefore, higher quantities of methamphetamine could be expected to be absorbed with long-term exposure. During the COVID-19 global pandemic, there has been increased time spent in isolation. This means that people unknowingly living in methamphetamine-contaminated properties will have experienced significantly higher levels of exposure. The increased amount of time spent inside the home may increase the number or severity of health effects experienced. There are also people aware that their home is contaminated but who are unable to leave or remediate due to their financial situation. This is exacerbated as the capacity to investigate methamphetamine-contaminated houses has been impeded by social distancing measures, the imminent heath concern of SARS-CoV-2, and increased workload of EHOs. The ability for owners to undertake assessment and remediation has also been impacted by economic hardship.

The health issues detailed above highlight the importance of remediating methamphetamine contamination. Australia has the National Clandestine Drug Lab Remediation Guidelines, New Zealand has the standard (NZS 8510:2017), and the US has the Voluntary Guidelines for Methamphetamine Laboratory Cleanup available for guidance. However, to date, there is no legislation or regulatory organisation in these countries to ensure compliance. The Australian Voluntary Code of Practice for methamphetamine-contaminated properties released in November 2019 provided clarification and

| Environmental health issue | Normal process | Current concern | References |
|----------------------------|---------------|----------------|------------|
| Take away food options     | ETHs visit premises and assess the take-away food handling procedure | Many businesses that have not previously offered take away options are now using it as a lifestyle to save their businesses. | (25, 26) |
|                            |               | There are delays in assessing food premises due to the increased workload, so some businesses may be offering take-away prematurely. |            |
| Main wastewater treatment  | Only toilet paper should be flushed through wastewater | Many people have resorted to using unflushable products due to the lack of access to toilet paper. | (27, 28) |
|                            |               | This means the sewer system is under pressure from blockages. |            |
| Onsite wastewater treatment | Limited amount of time spent at home and only toilet paper is flushed into the septic tank. Only toilet paper should be flushed with wastewater | Residents are spending more time at home therefore their septic tanks are being used more. | (27, 29) |
|                            |               | The system is having inadequate time to process and separate the particles that can cause overflow and blockages. |            |
|                            |               | As above, many people have resorted to using unflushable products due to the lack of access to toilet paper. This means the sewer system is under pressure from blockages. |            |
| Methamphetamine contamination in properties | Contamination testing would be conducted before contacting a remediation specialist to remediate the property | People are less likely to bring contractors into their home due to home isolation measures and uncertain employment | (30, 31) |
|                            |               | Residents are spending more time at home which increases exposure in a contaminated property |            |
| Mould or dampness in properties | Depending on the severity of the situation, some can be treated by the resident otherwise, it a remediation specialist is required | Due to the increased amount of time in the home, health effects of mould or dampness issues could also increase. | (32, 33) |
|                            |               | Depending on the location, the country could be in lockdown, and it may be difficult finding a remediation specialist. |            |
| Overcrowding or squalor    | This would normally be investigated based on a complaint | The increased close contact with people in the same home would increase the risk of transmitting other infectious diseases. | (34) |
insight into the specific details recommended for remediation,5,4
In Australia, when a suspected clandestine laboratory has been detected, police and forensic services investigate the property and then notify the local council. EHOs will contact the property owner and work with them to ensure they understand the ramifications of this investigation and risks to public health. EHOs enforce remediation under the relevant state or territory Public Health Act. EHOs are also able to use their powers as an authorised officer of their state or territory to issue a notice that prohibits entry onto the property until the site has been remediated and the success of the remediation validated.4,9 To avoid bias towards businesses, most states and territories require property owners to independently seek a remediation company. However, the Western Australian Department of Health has a different approach and issues a list of approved forensic testing, cleaning companies and laboratories that EHOs can recommend to owners.5 Engagement with property owners and validation experts is a time-intensive and challenging process, as financial and inadequate remediation problems often arise. It is recommended that EHOs are involved in the assessment, remediation process and validation to ensure appropriate measures are taken before notices are removed.5,9 This process is time-consuming and costly; as such, it is a significant burden and risk to public health, especially for those of a lower socioeconomic demographic.

**Methamphetamine manufacturing, usage, and increased exposure during COVID-19**

During 2020, drug shipments hidden and imported among legal products were restricted by the reduction in international air and sea cargo.5,6 Similarly, border closures restricted the movement of drugs and precursors. The closure of entertainment venues and restrictions on public gatherings will have reduced the usual supply routes. While it is difficult to predict, it is reasonable to presume other tactics may have been adopted to combat these accessibility issues.5,5 Anticipated changes include altered chemical composition of the drug,6 increased street prices, increased local manufacture and inventive ways to smuggle

**drugs internationally, such as in hand sanitizer bottles.5,9**

**Conclusion**

EHOs continue to be overlooked and under-resourced despite the invaluable role they have played in response to COVID-19.1,1,2 To expedite and support society’s recovery, it is essential that we minimise the burden of other controllable health risks; this includes the identification of emerging environmental health challenges. While EHOs have been prioritising the implementation, education and regulation of social distancing measures, it is essential that exacerbated and emerging threats such as methamphetamine contamination of properties are not overlooked. Sufficient resources, support and recognition of the EHO workforce will enable them to identify and mitigate risks early to minimise long-term public health consequences.14,16,61

**References**

1. World Health Organisation. Statement on the Second Meeting of the International Health Regulations (2005) Emergency Committee Regarding the Outbreak of Novel Coronavirus (2019-nCoV) (Press release). Geneva (CHE): WHO; 2020 January 30.
2. Leece D. Recent provision of military assistance to civil authorities in Australia. United Service. 2020;71(No. 2, Winter 2020):5-8.
3. Walensky R, del Rio C. From mitigation to containment of the COVID-19 pandemic: Putting the SARS-CoV-2 genie back in the bottle. JAMA. 2020;323(19):1889-90.
4. Garfin DR, Silver RC, Holman EA. The novel coronavirus (COVID-19) outbreak: Amplification of public health consequences by media exposure. Health Psychol. 2020;39(5):355-7.
5. Mheidly N, Fares J. Leveraging media and health communication strategies to overcome the COVID-19 infodemic. J Public Health Policy. 2020;41(4):140-20.
6. Islam MS, Sarker T, Khan SH, Mostofa Kamal A-H, Hasan SMM, Kabir A, et al. COVID-19-related infodemic and its impact on public health: A global social media analysis. Am J Top Med Hyg. 2020;10(3):1621-9.
7. Ferguson NM, Laydon D, Nedjati-Gilani G, Imai N, Anslie K, Baguelin M, et al. Report 9 - Impact of Non-pharmaceutical Interventions (npi) to Reduce COVID-19 Mortality and Healthcare Demand. London (UK): Imperial College London; 2020.
8. Morrow-Howell N, Galaciu N, Swinford E. Recovering from the COVID-19 pandemic: A focus on older adults. J Aging Soc Policy. 2020;32(4):S26-S35.
9. Mamun MA, Ullah I. COVID-19 suicides in Pakistan, dying off not COVID-19 fear but poverty? - The forthcoming economic challenges for a developing country. Brain Behav Immun. 2020;87(1):163-5.
10. Coates B, Cowgill M, Chen T, Mackey W. Shutdown: Estimating the COVID-19 Employment Shock. Melbourne (AUS): Grattan Institute; 2020.
11. Dietrich A, Kuester K, Müller G, Schoene R. News and Uncertainty about COVID-19: Survey Evidence and Short-Run Economic Impact. Cleveland (OH): Federal Reserve Bank of Cleveland; 2020.
12. Whiley H, Willis E, Smith J, Ross K. Environmental health in Australia: Overlooked and underrated. J Public Health. 2018;41(3):235-5.
13. National Environmental Health Association. Environmental Health Workforce Needs Assessment in Response to COVID-19. Denver (CO): NEHA; 2020.
14. U.S.A. H.R.2262 - Environmental Health Workforce Act of 2019, 116th Congress(2019).
15. Lowry S. Housing and health: Sanitation. BMJ. 1990;300(6718):177.
16. Bartosak C. Environmental Health Workforce Attraction and Retention [Research paper]. Adelaide (AUST): Environmental Health Australia; 2012.
17. Rodrigues MA, Silva MV, Ernest NA, Davis G, Lynch Z, Dhesi S, et al. How can Environmental Health Practitioners contribute to ensure population safety and health during the COVID-19 pandemic? 2020. [Unpublished observations]
18. Brooks BW, Gerding JA, Landeen E, Bradley E, Callahan T, Cushing S, et al. Environmental health practice challenges and research needs for U.S. Health Departments. Environ Health Perspect. 2019;127(12):12501.
19. Shezal MB, Mathew A, Szabai W, Street RA, Naicker N, Kunene Z, et al. Environmental health practitioners potentially play a key role in helping communities adapt to climate change. BMC Public Health. 2019;19(1):54.
20. Smith J, Whiley H, Ross KE. The new environmental health in Australia: failure to launch. 2020. [Unpublished observations]
21. Al-Khatteeb BP. Changing agendas and priorities of public health associations across the globe following in the era of COVID-19 pandemic: A mini-review. J Family Med Prim Care. 2020;9(8):3388-42.
22. Ryan BJ, Swienton R, Harris C, James JJ. Environmental health workforce–essential for interdisciplinary solutions to the COVID-19 pandemic. Disaster Med Public Health Prep. 2020. doi: 10.1017/dmp.2020.242.
23. Pfefferbaum B, North CS. Mental Health and the Covid-19 Pandemic. N Engl J Med. 2020;383(5):10-12.
24. Mesa Vieira C, Franco OH, Gómez Restrepo C, Abel T. COVID-19: The forgotten priorities of the pandemic. Maturitas. 2020;136:63-81.
25. Yapp C, Fairman R. Factors affecting food safety compliance within small and medium-sized enterprises: Implications for regulatory and enforcement strategies. Food Control. 2020;120:106576.
26. U.S. Food & Drug Administration. Best Practices for Retail Food Stores, Restaurants, and Food Pick-Up/Delivery Services During the COVID-19 Pandemic. Silver Spring (MD): FDA; 2020.
27. Gosselin J. COVID-19: Implications for the Water and Wastewater Industry New England. Woburn (MA): New England Water Environment Association; 2020.
28. Smart Water Magazine. Unflushable Wipes Lead to Rise in Sewer Main Blockages. Smart Water Magazine. 2020;May 18.
29. O’Dowd P. Increased Use of Septic Tanks Raises Concerns for Environment. WBUR Public Radio Station. 2020;May 15.
30. Dzekic NC, Allen JG, Schepers PT, Levy J. The COVID-19 Pandemic: A moment for exposure science. J Expo Sci Environ Epidemiol. 2020;30(4):591-3.
31. Wright J, Kenneally ME, Edwards JW, Walker GS. Adverse health effects associated with living in a former methamphetamine drug laboratory—Victoria, Australia, 2015. Med Sci Monit. 2020;26:1723.
32. Davies M, Ucci M, McCarthy M, Oreszczyn T, Ridley I, Mumovic D, et al. A review of evidence linking ventilation rates in dwellings and respiratory health—a focus on house dust mites and mould. Int J Vent. 2004;3(2):155-68.
33. Hope AP, Simon RA. Excess dampness and mold growth in homes: An evidence-based review of the aetiological effect and its potential causes. Allergy Asthma Proc. 2007(28):3-26.
34. Favas C. Guidance for the Prevention of COVID-19 Infections among High-risk Individual/Urban Settings. London (UK): London School of Hygiene and Tropical Medicine; 2020.
35. Owens CV. Remediation of manufactured methamphetamine in clandestine laboratories. A literature review. J Chem Health Saf. 2017;24(5):23-37.
36. Thrasher DL, Von Derau K, Burgess J. Health effects from reported exposure to methamphetamine labs: A poisons center-based study. J Med Toxicol. 2009;5(4):200-4.
Abdullah AF, Miskelly GM. Recoveries of trace pseudoephedrine and methamphetamine residues from impermeable household surfaces: Implications for sampling methods used during remediation of clandestine methamphetamine laboratories. Talanta. 2010;81(1-2):455-61.

Van Dyke M, Martyny JW, Serrano KA. Methamphetamine residue dermal transfer efficiencies from household surfaces. J Occup Environ Hyg. 2014;11(5):249-58.

Wright J, Walker GS, Ross KE. Is wipe sampling adequate to determine risk? Int J Environ Res Public Health. 2019;16(9):3568.

Van Dyke M, Erb N, Arbuckle S, Martyny J. A 24-hour study to investigate persistent chemical exposures associated with clandestine methamphetamine laboratories. J Occup Environ Hyg. 2009;2(2):82-9.

Martyny JW, New Zealand SL, McCammon CS, Erb N, Van Dyke M. Methamphetamine contamination on environmental surfaces caused by simulated smoking of methamphetamine. J Chem Health Saf. 2008;15(5):25-31.

Wright J, Edwards J, Walker GS. Methamphetamine contamination in homes - Contamination and risk levels. Proceedings of the 7th International Conference on Energy and Environment of Residential Buildings; 2016 Nov 20-24; Brisbane, Australia, 2016.

Martyny JW, Arbuckle SL, McCammon CS, Esswein EJ, Erb N, Van Dyke M. Chemical concentrations and contamination associated with clandestine methamphetamine laboratories. J Chem Health Saf. 2007;14(4):40-52.

Morrison G, Shakila NV, Parker K. Accumulation of gas-phase methamphetamine on clothing, toy fabrics, and skin oil. Indoor Air. 2015;25(4):405-14.

The Environmental Health Standing Committee. envHealth Guidance On: Clandestine Drug Laboratories and Public Health Risks. Canberra (AUST): Australian Department of Health; 2017.

Mesora N, Jeter K, Marinelli-Casey P, West K, Rawson R. Children exposed to methamphetamine use and manufacture. Child Abuse Negl. 2014;38(11):1872-83.

Wright J, Symons B, Angell J, Ross KE, Walker S. Current practices underestimate environmental exposures to methamphetamine: Inhalation exposures are important. J Expo Sci Environ Epidemiol. 2020. doi: 10.1038/s41370-020-00260-x

Wright J, Kenneally M, Ross K, Walker S. Environmental methamphetamine exposures and health effects in 25 case studies. Toxics. 2020(8):3(1-61).

Brewer K, Shultz TF, Machin J, Kudrimoti S, Eisenberg RL, Hartman E et al. A cluster of trace-concentration methamphetamine identifications in racehorses associated with a methamphetamine-contaminated horse trailer: A report and analysis. Can Vet J. 2016;57(8):860-4.

Australasian Crime Commission. Clandestine Drug Laboratory Remediation Guidelines. Canberra (AUST): Government of Australia; 2011.

Standards New Zealand. NZS 8510:2017 - Testing and Decontamination of Methamphetamine Contaminated Properties. Wellington (NZ): Standards New Zealand; 2017.

United States Environmental Protection Agency. Voluntary Guidelines for Methamphetamine Laboratory Cleanup. Washington (DC): US EPA; 2013. p. 44.

Kuhn EJ, Walker GS, Whiley H, Wright J, Ross KE. Household contamination with methamphetamine: knowledge and uncertainties. Int J Environ Res Public Health. 2019;16(23):4676.

Wright J. Australian Voluntary Code of Practice Assessment, Remediation and Validation: Former Clandestine Drug Laboratories and Other Methamphetamine Contaminated Properties. Sydney (AUST): Environmental Health, Australia, Australian Land and Groundwater Association; 2019.

Western Australian Department of Health. Companies Qualified for Testing and Remediating Chemical Residues. Perth (AUST): State Government of Western Australia; 2020.

Interviews with Liliana Wester Kuhn EJ, Walker GS, Whiley H, Wright J, Ross KE. A cluster of trace-concentration methamphetamine identifications in racehorses associated with a methamphetamine-contaminated horse trailer: A report and analysis. Can Vet J. 2016;57(8):860-4.

Australasian Crime Commission. Clandestine Drug Laboratory Remediation Guidelines. Canberra (AUST): Government of Australia; 2011.

Standards New Zealand. NZS 8510:2017 - Testing and Decontamination of Methamphetamine Contaminated Properties. Wellington (NZ): Standards New Zealand; 2017.

United States Environmental Protection Agency. Voluntary Guidelines for Methamphetamine Laboratory Cleanup. Washington (DC): US EPA; 2013. p. 44.

Kuhn EJ, Walker GS, Whiley H, Wright J, Ross KE. Household contamination with methamphetamine: knowledge and uncertainties. Int J Environ Res Public Health. 2019;16(23):4676.

Wright J. Australian Voluntary Code of Practice Assessment, Remediation and Validation: Former Clandestine Drug Laboratories and Other Methamphetamine Contaminated Properties. Sydney (AUST): Environmental Health, Australia, Australian Land and Groundwater Association; 2019.

Western Australian Department of Health. Companies Qualified for Testing and Remediating Chemical Residues. Perth (AUST): State Government of Western Australia; 2020.