Evidence check

7 October 2020

Rapid evidence checks are based on a simplified review method and may not be entirely exhaustive, but aim to provide a balanced assessment of what is already known about a specific problem or issue. This brief has not been peer-reviewed and should not be a substitute for individual clinical judgement, nor is it an endorsed position of NSW Health.

Waste from personal protective equipment

Evidence check question

Is there any evidence or data about the amount of waste produced from personal protective equipment (PPE) during the COVID-19 pandemic?

In brief

- There are widespread concerns that the requirements for use of PPE during COVID-19 have resulted in a significant increase in plastic pollution.
- A recent study estimated a global monthly use of 129 billion face masks and 65 billion gloves.(1)
- A pre-peer review article reported an estimated carbon footprint of the PPE supplied during the first six months of the pandemic in England of 158,838 tonnes of carbon dioxide equivalent, with greatest contributions from gloves, aprons, face shields, and Type IIR surgical masks. The consequences of this pollution included a loss of 314 disability adjusted life years, a 0.67 loss of local species per year, and resource depletion equivalent to US$20.4 million.(2)
- Local studies focused on estimating medical waste during the pandemic have been undertaken in China, South Korea and Italy.(3-7)
- As well as concerns about the volume of waste generated, is the question of safe disposal. The United Nations Environment Program reviewed practices for managing waste from healthcare facilities, households and quarantine locations accommodating people with confirmed or suspected cases of COVID-19 and provides recommendations for policy makers and practitioners to improve waste management.(14)

Limitations

Searches focused on PubMed and evidence published in environmental science or waste management data bases may contain additional evidence.

Background

Environmentally sound management of medical waste is one of the key challenges during normal times in many countries. During emergencies such as the COVID-19 pandemic, this challenge is magnified.(1, 3, 7-9)

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There are some papers that discuss waste management practices but do not specifically analyse the waste from masks.(4, 5, 10-13)

The United Nations Environment Programme states there is a lack of sufficient data on medical waste amounts likely to be generated, a lack of geographical identification of 'hot spots' for medical waste generation, and lack of knowledge or capacity to conduct assessments.(14) Healthcare waste, particularly COVID-19 waste, needs to be treated following local guidelines and regulations. The United Nations Environment Programme has summarised healthcare waste treatment options, which includes incineration, autoclaving, and microwave treatment (refer to Appendix 2), after which recycling or landfill disposal may be options.

Methods (Appendix)

PubMed, Google, and selected grey literature searches were conducted. Key United Kingdom and Australian experts in environmental sustainability in healthcare were also contacted. These sources were searched to 28 September 2020.

Results

Table 1: Peer reviewed sources

Source	Summary
Peer reviewed sources	
Emergency response to the explosive growth of health care wastes during COVID-19 pandemic in Wuhan, China Yang, et al. 2020 (3)	The study period was from 23 January 2020 (city lockdown) to 24 April 2020 (on-care cases were less than 30), and was divided into three stages, including the first stage (23 Jan - 12 Feb), the second stage (13 Feb - 22 Mar), and the third stage (23 Mar - 24 Apr). The peak value of daily treatment amount of healthcare waste was 291 tons on 1 Mar, which was nearly six times greater than the routine amount of 50 tons on 23 Jan. The average production of healthcare waste per 1000 persons in Wuhan varied from 3.64 kg/day to 27.32 kg/day after the pandemic. Comment: This analysis does not pull out data for waste from PPE.
Management of used personal protective equipment and wastes related to COVID-19 in South Korea Rhee, et al. 2020 (4)	According to the Ministry of Environment, South Korea, about 295 tons of medical waste related to COVID-19 was generated from early February to early March 2020. This medical waste was generated from general hospitals (61%), temporary isolation facilities for overseas groups of South Koreans (21%), isolated life treatment centres for patients with COVID-19 (13%), and community treatment centres (5%). In April the Ministry of Environment reported that 20 tons of waste related to COVID-19 was generated daily. Comment: This analysis does not pull out data for waste from PPE.
Municipal solid waste management during the SARS-COV-2 outbreak	Applying estimates for single-use mask wearing in China, it was estimated that the Chinese population during the COVID-19 pandemic might be wearing about 900 million single use masks per day i.e. two thirds of the whole population. By adopting the same assumption for the Italy, with population of 60 million people, the whole population would

Source	Summary
Peer reviewed sources	
and lockdown ease: Lessons from Italy Ragazzi, et al. 2020 (5)	dispose of about 40 million masks daily. Considering that a surgical mask weighs about 3g, the total amount of masks used annually would correspond to about 44,000 tons, i.e. 0.14% of the national total municipal solid waste production in 2018 and 0.35% of the national residual municipal solid waste production of the same year. Including 40 million pairs of nitrile or latex single-use gloves would increase the mass percentage of PPE used by citizens in terms of national municipal solid waste and residual municipal solid waste production to 0.59% and 1.39%. Comment: This analysis for Italy is only a rough estimate of waste from PPE. It is also not specific for waste from healthcare facilities.
Minimising the present and future plastic waste, energy and environmental footprints related to COVID-19 Klemes, et al. 2020 (6)	According to the 11 March press releases of the State Council's Joint Prevention and Control Mechanism in China, the amount of municipal solid waste in large and medium cities was reduced by 30% during the disease outbreak. However, the generation of medical waste increased sharply (+370%) in Hubei Province, with a high proportion of plastics. From 20 January to 31 March 2020, the accumulated medical waste in all of China was estimated as 207kt. In Wuhan, medical waste increased from the normal level of 40t/day to about a peak of 240t/day, exceeding the maximum incineration capacity of 49t/day. The incineration cost of hazardous medical waste in China is estimated at 281.7-422.6 US$/t as compared to 14.1 US$/t for municipal solid waste. Comments: This analysis does not pull out data for waste from PPE.
COVID-19 pandemic repercussions on the use and management of plastics Prata, et al. 2020 (1)	Mismanagement of PPE during the COVID-19 pandemic, with a monthly estimated use of 129 billion face masks and 65 billion gloves globally, is resulting in widespread environmental contamination.

Table 2: Government and non-government organisations reports

Source	Summary
Government and non-government organisations reports	
Waste management during the COVID-19 pandemic - from response to recovery United Nations Environment Program, International Environmental	Table: Estimated additional amount of healthcare waste in each city due to COVID-19 pandemic. Source: Asian Development Bank, 2020.

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<table>
<tr><th>Source</th><th>Summary</th></tr>
<tr><td colspan="2">Government and non-government organisations reports</td></tr>
<tr><td>Technology Centre, 2020 (14)</td><td>
<table>
<tr><th>City</th><th>Population (World Population Review)</th><th>healthcare waste generated (tonnes/day before COVID-19)</th><th>Estimated additional healthcare waste generation (tonnes/day during COVID-19)</th><th>Percentage of increase due to COVID-19</th></tr>
<tr><td>Manila</td><td>14 million</td><td>47</td><td>280</td><td>496</td></tr>
<tr><td>Jakarta</td><td>10.6 million</td><td>35</td><td>212</td><td>506</td></tr>
<tr><td>Kuala Lampur</td><td>10.5 million</td><td>35</td><td>210</td><td>500</td></tr>
<tr><td>Bangkok</td><td>8 million</td><td>27</td><td>160</td><td>493</td></tr>
<tr><td>Ha Noi</td><td>7.7 million</td><td>26</td><td>154</td><td>492</td></tr>
</table>
The Asian Development Bank report also estimated that the increase of healthcare waste from healthcare facilities associated with COVID-19 is 3.4kg/person/day.
Approximately 2.5kg/bed/day of COVID-19 healthcare waste is being generated in developing countries based on the findings of 2.85kg/bed/day in Thailand, 2.23kg/bed/day in Indonesia and 2.0-2.2kg/bed/day in Mexico.
Estimate that healthcare waste treatment capacity was required from 50 tons/day to 106.9t/day, during the active pandemic in Wuhan, China.
A rapid increase of healthcare waste generation in West Java, Indonesia during the COVID-19 epidemic, including about 10,903, 11,646 and 14,606 tonnes of healthcare waste generation in the months of January, March, and April 2020 respectively, with an increase of about 30% between January and April.
Comments: This report did not pull out data for PPE waste. It is all combined data.
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Table 3: Pre-peer review publications

Source	Summary
Pre-peer review publications	
Environmental impact of personal protective equipment supplied to health and social care services in England in the first six months of the COVID-19 pandemic Rizan, et al. 2020 (2)	The carbon footprint of PPE supplied during the study period totalled 158,838 tonnes carbon dioxide equivalent, with greatest contributions from gloves, aprons, face shields, and Type IIR surgical masks. The estimated damage to human health was 314 disability adjusted life years, impact on ecosystems was 0.67 species/year (loss of local species per year), and impact on resource depletion costing US$20.4 million. Method: Life cycle assessment was used to determine environmental impacts of PPE supplied to health and social care in England during the first six months of the COVID-19 pandemic. The base scenario assumed

Source	Summary
Pre-peer review publications	
	all products were single-use, air freighted, and disposed via clinical waste. Comments: This paper analysed the estimated environmental impact life cycle costs of PPE. It did not provide data specifically on the waste generated from PPE after use, e.g. PPE that goes to landfill.

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Appendices

Appendix 1: Method

PubMed search terms

((2019-nCoV[title/abstract] or nCoV*[title/abstract] or covid-19[title/abstract] or covid19[title/abstract] OR "covid 19"[title/abstract] OR "coronavirus"[MeSH Terms] OR "coronavirus"[title/abstract] OR sars-cov-2[title/abstract] OR "severe acute respiratory syndrome coronavirus 2"[Supplementary Concept]) AND (2019:2021[pdat])) AND (("personal protective equipment"[MeSH Terms] OR "personal protective equipment"[title/abstract] OR "PPE"[title/abstract] OR "mask"[title/abstract]) AND (("waste management"[MeSH Terms] OR ("waste products"[MeSH Terms] OR "waste"[title/abstract] OR "nursing home*"[title/abstract]))

PubMed was last searched on 28 September 2020.

Grey literature search terms

Keywords: medical waste, environmental waste, mask, personal protective equipment, PPE, COVID.

Grey literature searches: Australian and state Environment Protection Authority, United Nations Environment Program, World Health Organization, United Nations Development Programme, World Bank and the United States Centers for Disease Control and Prevention websites.

Other sources: We contacted key United Kingdom and Australian experts in environmental sustainability in healthcare for information. Also searched the Econlit Database.

These sources were searched between 7 to 28 September 2020.

Waste management and regulator websites were searched on 30 September 2020. Sources included: NSW Environment Protection Authority, Australian Therapeutic Goods Administration, Australian Department of Agriculture Water and the Environment, United States Centers for Disease Control and Prevention, and commercial waste management companies that process medical waste, such as Veolia, Cleanaway, Initial, All Medical Waste Australia Pty Ltd, and Suez.

Inclusion and exclusion criteria

Inclusion	Exclusion
• Articles published from 2020 onwards. • Articles with data about, or evaluation of, medical and/or environmental waste due to PPE.	• Articles about procurement or rationing of PPE. • Articles about re-usable PPE, re-use or recycling of PPE. • Articles about the biohazards or infectivity of discarded PPE.

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Appendix 2: Summary of healthcare waste treatment options

Note: Healthcare waste, particularly COVID-19 waste, needs to be treated following local guidelines and regulations.

Source: Waste Management during the COVID-19 Pandemic - From Response to Recovery. United Nations Environment Program, International Environmental Technology Centre, 2020.(14) Content in the below table has been copied from the source material.

Methods	Pros	Cons
Incineration	• Significant reduction of waste volume and weight. • Ensure decontamination (combustion at minimum 800-degree Celsius temperature). • No post treatment needed for final disposal.	• High energy requirement. • The combustion of healthcare waste produces mainly gaseous emissions, including steam, carbon dioxide. • Nitrogen oxides, a range of volatile substances, e.g. metals, halogenic acids, products of incomplete combustion. • Potential emissions of carcinogens. • Particulate matter, plus solid residues in the form of ashes, which are to be treated as toxic.
Autoclave	• Suitable for soiled wastes, bedding and PPE, clinical laboratory waste, reusable instruments, waste sharps, and glassware. • Low-heat thermal processes produce significantly less air pollution emissions than high-heat thermal processes. • No specific pollutant emissions limits for autoclaves and other steam treatment systems. • Waste does not require further processing, it can be disposed of in a municipal landfill, as it is disinfected and not hazardous anymore. However, some countries request to render the waste unrecognizable then it is shredded afterwards, but this depends on the legal regulation. • Available in various sizes from lab autoclaves to large autoclaves used in large waste treatment facilities.	• Cannot treat volatile and semi-volatile organic compounds, chemotherapeutic waste, mercury, other hazardous chemical and radiological waste, large and bulky bedding material, large animal carcasses, sealed heat-resistant containers. • Odours can be a problem around autoclaves if there is insufficient ventilation. • Poorly segregated waste may emit low levels of alcohols, phenols, formaldehyde, and other organic compounds into the air. • Treated waste from an autoclave retains its physical appearance. • Waste requires further processing for final disposal.
Microwave treatment	• Suitable for soiled wastes, bedding and PPE, clinical laboratory waste, reusable instruments, waste sharps, and glassware.	• Volatile and semi- volatile organic compounds, chemotherapeutic waste, mercury, other hazardous chemical waste and radiological

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Methods	Pros	Cons
	• A fully enclosed microwave unit can be installed in an open area and used with a high-efficiency particulate air filter to prevent the release of aerosols during the feed process. • Odour is somewhat reduced, except in the immediate vicinity of the microwave unit. • A large-scale, semi-continuous microwave unit is capable of treating about 250kg/hour (3,000 tonnes per year). • Waste does not require further processing, it can be disposed of in a municipal landfill, as it is disinfected and not hazardous anymore. However, some countries request to render the waste unrecognizable, then it is shredded afterwards, but this depends on the legal regulation.	waste should not be treated in a microwave. • Treated waste from an autoclave microwave unit retains its physical appearance. • Waste requires further processing for final disposal. • Very limited volume reduction, no weight reduction.

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