International Journal of Disaster Risk Reduction 43 (2020) 101376

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: http://www.elsevier.com/locate/ijdrr

Facemask use for community protection from air pollution disasters: An ethical overview and framework to guide agency decision making

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ARTICLE INFO

Keywords:
Public health ethics
Air pollution
Air pollution disasters
Facemasks
Ethical Decision-making framework
Disaster response

ABSTRACT

Disasters involving severe air pollution episodes create a pressing public health issue. During such emergencies, there may be pressure on agencies to provide solutions to protect affected communities. One possible intervention to reduce exposure during such crises is facemasks. Ethical values need to be considered as part of any decision-making process to assess whether to provide advice on, recommend and/or distribute any public health intervention. In this paper, we use principles from public health ethics to analyse the critical ethical issues that relate to agencies providing advice on, recommending and/or distributing facemasks in air pollution disasters, given a lack of evidence of both the specific risk of some polluting events or the effectiveness of facemasks in community settings. The need for reflection on the ethical issues raised by the possible recommendation/use of facemasks to mitigate potential health issues arising from air pollution disasters is critical as communities progressively seek personal interventions to manage perceived and actual risks. This paper develops an ethical decision-making framework to assist agency deliberations. We argue that clarity around decision-making by agencies, after using this framework, may help increase trust about the intervention and solidarity within and between populations affected by these disasters and the agencies who support public health or provide assistance during disasters.

1. Introduction

Globally, ambient air pollution is the 5th highest ranked risk factor for mortality [1,2]. Particulate matter (PM) is a key airborne pollutant which derives from various sources, including natural (e.g., volcanic eruptions, dust storms, naturally occurring fires), geo-anthropogenic (dust storms caused by deforestation, fires of natural materials caused by human activity, quarry dust, land clearance, controlled burns) and anthropogenic (e.g., urban (vehicular) and industrial emissions). It has been estimated that the inhalation of $PM_{2.5}$ (particles $< 2.5\,\mu m$ in diameter) caused 8.9 million deaths in 2015 [3]. Recent research has also confirmed that the inhalation of $PM_{2.5}$ likely causes damage to every cell and organ in the body [4]. There is an urgent need to reduce polluting emissions globally, but also, in the meantime, to find ways to reduce personal exposure to PM, given that the World Health Organization (WHO) has warned that air pollution is a 'public health emergency' ([5] quoting WHO Director of Public Health). In this paper we focus on air pollution disasters (APDs). We define an APD as a singular (although sometimes prolonged), disaster where pollutant concentrations are significantly above the air quality standards expected in that jurisdiction, or a proximate jurisdiction, sufficient to create a significant risk to human health in an identifiable geographic area. This threshold

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https://doi.org/10.1016/j.ijdrr.2019.101376
Received 25 June 2019; Received in revised form 25 October 2019; Accepted 25 October 2019
Available online 31 October 2019

may be when AQ levels exceed hazardous or equivalent levels, as defined by the relevant air quality index in that country or region, and are expected to do so for a prolonged period of time resulting in attributable excess morbidity or mortality for the affected population. The Centre for Research on the Epidemiology of Disasters classifies disasters as natural (e.g., volcanic eruptions) and technological (e.g., industrial accidents) and APDs can draw from either of these categories [6].

There are many examples of disasters involving air pollution, some of the most obvious being large volcanic eruptions where volcanic ash can reduce visibility and blanket the environment for many months, as well as posing a major respiratory hazard, especially if crystalline silica is present in the ash [7]. One of the most serious APDs this century was the 2015 South East Asia 'haze' crisis where burning of vegetation and peat for land clearance in Sumatra and the province of Kalimantan, exacerbated by an El Niño climatic event, led to three months of severe air pollution (smoke) which is estimated to have resulted in over 100,000 excess deaths across Indonesia, Malaysia and Singapore [8].

Given the ubiquity of exposures in APDs, and the lack of options to reduce emissions and exposure, people will search for ways to protect themselves from inhaling the pollutants [9] and will expect agencies to provide advice or even to provide the protective interventions. One possible intervention for particulate exposures is the use of facemasks, but there is very limited evidence of efficacy for community use (e.g., [10–13]).

These uncertainties about efficacy raise a range of ethical questions about whether agencies, who may be under substantial pressure to act, should provide advice on, recommend or distribute facemasks during APDs and in what circumstances. It has long been recognised that, to quote Slim [14]: "… ethical analysis should always be an essential part of humanitarian practice". Similarly, the WHO has noted that epidemics, emergencies and disasters raise many ethical issues, noting particularly issues such as resource allocation, standard of care, effective communication and harms and benefits, which need to be addressed [15]. It is broadly recognised that the prioritisation of scarce resources in the context of overwhelming needs in an emergency situation can place practitioners and agencies in an 'ethical dilemma' in which one ethical principle can be contradicted by the reality of another. The issues associated with public protection during APDs have not been examined from an ethical perspective and, as Horner notes: "Every proposed new public health intervention should be carefully evaluated for this 'ethical dimension'." [16].

This paper introduces and articulates core relevant ethical values, from an organizational perspective, that could inform a decision of this nature and provides a framework to aid this decision-making process. Public health issues are complex and may not be amenable to simple solutions [17]. However, ethical analysis can help examine the difficult choices facing agencies, assess relevant options and facilitate decision making if there are tensions between core public health values.

2. Methods

This paper is an example of applied ethics as it applies general principles to real-world examples of decision making [18]. Here we draw on the authors' academic expertise in public health ethics, social work ethics and environmental and exposure sciences, together with practitioner experience in emergency response and public health and social care provision, to develop a set of questions which address the substantive ethical principles which agencies should consider during the decision-making process related to advising, recommending and/or distributing facemasks during APDs. The aim is to provide a framework for the development of ethically-robust policies for community protection, for enactment at the onset of an APD.

The ethical values were adopted from public health ethics, and selected on the basis of relevance to the decision-making process in the context of facemasks for use in APDs. Unlike other types of public health interventions, our working assumption is that wearing a facemask would not be mandatory. As such, we do not engage with questions in the framework about whether limitations on liberty are justifiable.

3. Results and discussion

Although people can choose to use an intervention, they may not have an entitlement or right to access it. Where there are scarce resources and, almost without exception, all countries, whether they are high, middle or low income, operate in an environment of scarcity, difficult decisions must be made about how to allocate resources. Science can often provide valuable information to help make these decisions, however, sometimes science has only incomplete information on both the health risk and the efficacy of the intervention, to inform decision making. Even when evidence is more determinative, science, alone, is insufficient as every decision about a health intervention has multiple dimensions, including science, ethics/morality, economics, legal, logistical, political, cultural and social factors. The importance of ethics in this context is "the application of value judgements to science" [19]. Ethics can contribute to discussions about what level of protection is acceptable when evidence is uncertain, for whom, and at what cost. A clearly articulated position can assist agencies in building trust and solidarity with communities at times of crisis [20]. We do acknowledge that, while this analysis focuses on ethics, politics, pragmatism and perception will also play a role in decision making.

Ideally, any decision-making process should occur prior to the APD onset. Some APDs will be predictable. It is generally known where natural APD-related hazards are situated, such as volcanoes. We suggest that agencies should use the framework set out here to decide how they will respond to APDs, in consultation or partnership with affected communities, to ensure that the communities' needs and expectations are considered. Such involvement will also ensure transparency about the decision and, importantly, that there are reasons behind it. Decisions about whether to distribute, recommend or provide advice about facemasks during APDs may be difficult and/or contentious but honesty about the decision could promote trust [21].

The framework consists of eight questions framed around ethical values (see also Table 1), and a decision-making tree (Fig. 1) which agencies can follow through the process from planning, to policy development and enactment and, finally, action in a crisis.

The setup and decision-making process, shown in Fig. 1, assumes an ethically accountable approach including inclusiveness, openness, reasonableness and responsiveness, as set out by Thomson et al. [21] (based on Daniels [22]; to maintain trust. After decisions have been made (grey boxes in Fig. 1), a series of processes should then ensue to enable enactment of the policy, as shown in the lower half of the decision-making tree.

The discussion below reviews eight ethical values which should inform decisions on the provision of advice, recommendation and/or distribution of facemasks during APDs. Table 1 also provides a guide to help decision makers address each ethical value.

3.1. Maximise benefit and minimise harm

A primary objective in both public health and humanitarian aid is to improve the health and well-being of communities, whilst protecting them from harm [23]. In order to assess whether action should be taken, the first question to ask is: *what are the potential health impacts of the identified hazards on local communities?* As discussed, there is evidence that both short and long-term exposure to ambient $PM_{2.5}$ (particulate matter sub-2.5 μm in diameter) can negatively impact both morbidity and mortality [24] and it is currently thought that there is no safe threshold below which effects would not occur [25]. A meta-analysis of air pollution health impact studies calculated that there is a 6.2% increased risk of mortality for every 10 $\mu g/m^3$ increase in annual average $PM_{2.5}$ concentrations [26]. Long-term exposure to $PM_{2.5}$ has

Table 1
Guide to decision making according to ethical values.

Value	Decision makers should:
Benefit and harm	• Assess the scientific likelihood of the health risk and its seriousness for that community (refer to existing health impact assessments) • Consider suitability of type of facemask depending on the type of pollutants • Consider wearability of facemasks in that environment/climate/context
Effectiveness	• Consider evidence of relative effectiveness of different types of facemasks and whether the risk requires that only effective interventions be offered • Assess cultural factors that might impact on effectiveness
Precautionary principle	• Consider whether the risk associated with the APD indicates that facemasks should be recommended and/or distributed even in the absence of strong evidence of their efficacy • Assess the risk of wearing a poorly fitting mask • Consider the effectiveness of the mask in protecting against the range of hazardous pollutants • Assess whether other options (such as staying indoors) are more feasible and may offer the same or better protection
Harm of intervention	• Ensure individuals and communities know of the possible harms associated with facemask use including: - Risks associated with some types of masks to people with respiratory or cardiac conditions - Risk that ineffective mask use could generate a false sense of security where people might increase outdoor exposures assuming that masks are fully protective
Respect	• Ensure individuals and communities are aware of the limitations of current knowledge about the impact of specific APDs on human health and about the efficacy of facemasks for community protection during APDs • Ensure individuals and communities have the information they need to make informed decisions about whether and how to protect themselves and/or their families • Ensure that, if a person does choose to use a facemask or facemasks are distributed, information is provided about how to maximise any benefits and minimise any harms (including continuing to minimise exposure and how to wear a mask properly) • Ensure that people know that facemasks may only offer protection for limited periods during APDs as they may clog and replacement may be needed
Equity	• Preserve as much equity among different social groups as possible
Stewardship	• Analyse and assess collateral damage that may result from resource allocation decisions and try to minimise it • Maximise benefits when allocating resources • Consider good outcomes (i.e. benefits to the public good) and equity (i.e. fair distribution of benefits and burdens)
Trust	• Work collaboratively with stakeholders in advance of an APD to establish practice in relation to facemasks • Take steps to build trust with stakeholders before the APD, not once it has started • Ensure decision making processes are ethical and transparent to stakeholders • Ensure stakeholders are made aware of the scientific and moral reasons that inform the decision • Ensure that decisions made about who receives masks are transparent

been shown to cause cardiovascular mortality and morbidity (with links with atherosclerosis, adverse birth outcomes, childhood respiratory disease, neurodevelopment, cognitive function and possibly diabetes) [24]. Particulate matter is also classified as a carcinogen [27]. Such evidence confirms that APDs are a potential risk to public health.

However, it is also known that different types of PM are likely to have different toxicities (based upon specific particle compositions, sizes and sources) but the evidence base is not yet sufficiently strong to differentiate these for non-occupational exposures [24]. It should also be considered that air pollution may contain a cocktail of gases, in addition to particles. This means that there is uncertainty about the actual risk of inhalation of such airborne contaminants. For example, is the risk of inhaling volcanic ash or wildfire smoke the same as inhaling urban particulate (on which most of the above research has been based)? This question is yet to be fully answered, and also depends on effect modifiers (e.g., socio-economic factors, population and individual health etc.), genetic susceptibilities, and the levels of exposure experienced across a population, so the specific risk to an individual or population of inhaling particles in any given APD is often challenging to define at the time of exposure. In areas with good environmental monitoring, and access to modelling, it may be possible to estimate levels of exposure.

Nevertheless, there needs to be a reasonably objective air quality concentration threshold, beyond which there is a sufficient level of concern about the impact of APDs on human health, to justify intervention (see Fig. 1). There is no international consensus on this, however. Many countries have air quality indexes which combine the concentrations of a range of particulate and gaseous pollutants into a single number (or take the worst value) which can then be expressed within a banding system of air quality (usually from good/low to very poor/high) which are used for alerts. Such bands often come with accompanying actions, which do not usually incorporate facemask use. In some air quality banding systems, people with pre-existing conditions, such as asthma, are considered to be particularly at risk and are advised to take precautions at lower concentrations than healthy people. In other systems, everyone's risk is considered equally. In many countries, governments monitor concentrations of pollutants in the air. That information may or may not be available in real time. Air quality hazards may also be visible without explicit measurement, for example, ash plumes from volcanic eruptions, desert dust storms, or haze from large fires. Agencies need to determine which bands or standards they will use to guide decision-making. The bands are based on national or international air quality standards, which are set by each country or transnational group (e.g., the European Union). The WHO has its own guidelines for a range of pollutants [28]. Many countries do not yet have a 24-h mean standard for $PM_{2.5}$, but the WHO's guideline is that average $PM_{2.5}$ concentrations should not rise above 25 $\mu g/m^3$ over a 24-h period. Potentially, then, agencies may consider that interventions may be necessary in a disaster where air quality is consistently above, or may be predicted to be above, this value over a pre-defined period.

3.2. *Effectiveness*

The second question to ask is: *is there an effective intervention available to protect the public from harm*? The ethical principle of effectiveness [29] suggests a public health intervention should not be offered unless it has been demonstrated to be effective in mitigating the risk. Borry et al. [30] have argued that "the use of the latest and best available medical research findings, is a moral imperative for ethical decision making" to avoid preventable harms. But evidence-informed decision making is difficult when there is no evidence, weak evidence, or incomplete evidence upon which to base decisions. A concern about effectiveness has been an important driver for several agencies. For example, WHO staff report reluctance to inform populations of preventive measures until all information is scientifically confirmed [31] and Public Health England (PHE) did not recommend that the public use facemasks during the Grenfell Tower fire tragedy "as it is not clear that they would be effective in reducing exposure." (See advice at: https://www.rbkc.gov.uk/newsroom/all-council-statements/public-health-advice-following-grenfell-tower-tragedy). Additionally, some argue that public health interventions that are not backed by evidence may undermine public trust in both the intervention and the agency(ies) that implement them [32].

So what does the evidence suggest? In many countries, dusty industries are regulated to protect workers from developing particle/fibre-related diseases. Respiratory protection must be certified against industrial standards (e.g. [33]), and workers must be individually

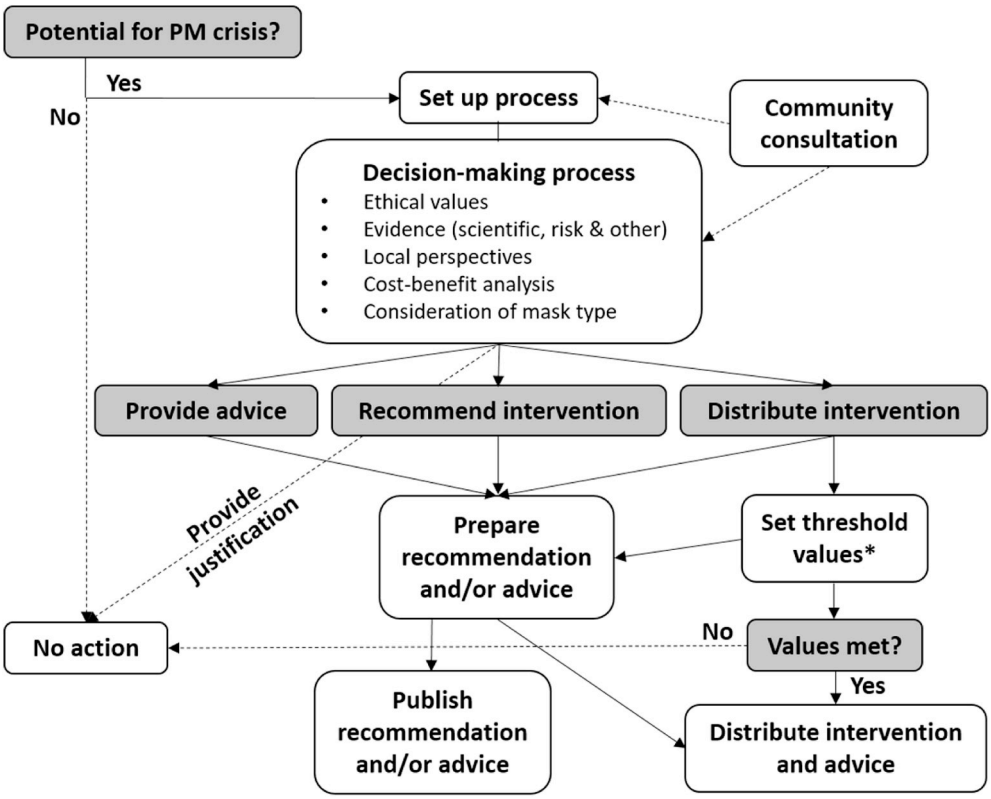

Fig. 1. Decision-making tree for ethical decision making for providing advice on/recommending and/or distributing facemasks during APDs. Grey boxes represent the decision to be made; white boxes represent actions. * Threshold values of air quality should be set both for level and duration of exposure.

fit-tested to find masks that prevent inward leakage of particles (e.g., [34]). Few studies have researched the efficacy of various types of respiratory protection as a preventive measure against the inhalation of PM outside of industrial settings (e.g., [10–13,35]). The limited research examines a continuum of options ranging from disposable, industry-certified masks, non-certified masks purporting to filter $PM_{2.5}$, surgical masks, nuisance dust masks, motorcycle masks, bandanas and other cloth-based masks and materials. The results of laboratory-based research suggest that different forms of respiratory protection offer substantially-varying protection based on: a) the effectiveness of the material at filtering particles; b) the size and possibly composition of the particulates; and c) the fit to the face (due to leaks around the edges). Poor fit may be attributed to poor design [36], design for adult usage (and lack of choice regarding size) [9], a lack of knowledge of how to properly wear respiratory protection, or the individual's characteristics, such as facial hair, facial shape, or glasses, that may inhibit a good fit [37]. There are specific challenges in demonstrating the effectiveness of facemasks for children as, until recently, facemasks designed for children were not available. No studies have been done on masks claiming to fit children's faces. Additionally, some APDs will contain gaseous pollutants which would not be captured by particulate facemasks, thereby leaving individuals unprotected against those gases. We know of no cases where gas masks have been distributed to communities outside of conflict settings. During the 2018 air pollution crisis at Kīlauea volcano, Hawaii, local agencies recommended against use of gas respirator masks (for protection against high concentrations of sulphur dioxide gas) because "safe use of respirators requires correct mask and/or filter cartridge selection, fit testing, physician screening, and training on correct use, maintenance and storage" [38]. Given the limited evidence, agencies must consider whether recommendation or provision of facemasks is ethical for community use during APDs and if so what mask(s) to distribute/recommend and why.

We would also argue that effectiveness, as an ethical principle, should be considered to have more dimensions than a sole focus on questions of scientific efficacy. Effectiveness should also encompass broader concerns such as wearability. If people are less likely to wear a particular type of facemask, or to wear it inconsistently with advice, this influences its potential effectiveness as an intervention. There is no evidence of the wearability of various forms of facemasks for long periods in community settings. Steinle et al. [13] and Galea et al. [39] have shown that the most effective facemasks (i.e. those with excellent filtration efficiency and fit to the face) were rated as uncomfortable to wear both by volunteers in the laboratory and in community settings, whereas looser (and, therefore, more ineffective) masks were more comfortable, with an increased perception of 'breathability'. Individuals will balance decisions on whether to wear a mask, the type of mask, and under what circumstances to wear it based on their perception of the risk and their willingness to bear discomfort to mitigate it. If people will not wear a distributed facemask, this impacts on its effectiveness as an intervention and will be a factor in any decision-making process.

Cultural, spiritual and religious factors may also influence uptake of an intervention [40,41]. Specific belief structure may mean that some people will not use an intervention, such as facemasks, if it does not accord with their beliefs or the advice of local spiritual leaders.

3.3. *Precautionary principle*

The third question is: *are there circumstances in which action can be justified when there is no evidence or limited evidence on the effectiveness of the protective measure?* If decisions should only be made based on the availability of strong and compelling bodies of evidence about the effectiveness of an intervention, only a relatively small number of interventions would ever be approved. Bayer and Fairchild [23] argue that the ethical core of public health practice is to protect the common good and to intervene in the face of uncertainty. Tannahill notes:

> "the case for applying theory in the face of insufficient evidence is heightened where a large scale or severe threat to health makes action urgent … even in less immediately pressing situations, it may be that a decision to do nothing because of a lack of effectiveness evidence will be less desirable than to do something …" [42].

In public health, the precautionary principle suggests that, if an activity raises a possible threat to human health, precautionary measures should be undertaken, even in the face of limited scientific evidence [43]. Evidence may be limited due to a lack of robust longitudinal research and/or to simple limitations of scientific knowledge, as some natural processes may be too complex to fully understand or predict [44]. As discussed, there is clear evidence that APDs pose short and long term risks to human health even if there is uncertainty about risks of specific types of PM (or other pollutants), airborne concentrations and durations of exposure. There is also limited evidence of the efficacy of facemasks in protecting against exposure to PM in community settings (e.g., [10–13,35]).

The precautionary principle would also suggest that facemasks should not be provided if there are other, more effective and/or feasible protective mechanisms. In the absence of advice to evacuate, in general, common advice given by agencies during APDs, especially for susceptible groups (e.g., those with respiratory conditions), is to stay indoors with doors and windows closed [34,45]. Whilst this advice can be effective, it may not be appropriate for everyone, given that some people may not have access to well-constructed and enclosed indoor environments. In some circumstances indoor air quality may be as bad, or worse, than outdoor air quality, depending on building ventilation and indoor sources of pollution [34]; (household air pollution from solid fuels is the 2nd highest cause of morbidity, globally [46]. Other people will be homeless [9]. Some people must go outside for their employment (e.g., agricultural workers must tend stock and crops and workers must respond to the crisis and keep critical infrastructure going), or education, or to seek food and medical care, especially when APDs are prolonged. For example, an open cast coal mine fire in Morwell, Australia, burnt for 45 days [47] and the 2015 transboundary 'haze' crisis event in Central Kalimantan exceeded Indonesian air quality standards for nearly 60 days [48]. These factors indicate that, for many people, wearing facemasks may be the only viable precautionary measure that they could take. During volcanic eruptions, agencies now frequently take the decision to recommend and distribute facemasks for protection from inhaling volcanic ash, either from stockpiled reserves or by requesting philanthropic donations from major manufacturers [9]. In many locations, however, stockpiled masks may not be to industrial standards, more normally being of surgical design, or they may have deteriorated due to long periods in storage. Whether knowingly, or not, the agencies involved are adhering to the precautionary principle.

Acting according to the precautionary principle raises the question of what an 'acceptable level' of protection should be, whether some level of protection is better than no protection, and who decides this. The limited evidence suggests that facemasks certified as highly protective in industry (e.g., N95, FFP2, P2, D2 masks, as they are called in different parts of the world) will also work relatively well where no training is provided [10,13] but are expensive and may be uncomfortable to wear [39]. Some disposable surgical masks could also provide a high level of protection, if somehow secured to the face to prevent inward leakage [10,12,13]. Improvised masks made of cloth, and basic dust masks will often provide very little filtration [12,35]. Although exposure may be reduced by even very-poorly constructed/worn interventions, it is difficult to discern whether a small reduction in exposure would be sufficient to prevent or limit adverse health impacts, although it is known that relative risk decreases as exposure to PM is reduced [25].

3.4. Harm caused by interventions

Whether the precautionary principle should be used will also be mediated through concerns about the intervention, itself, causing harm [49]. A fourth question is: *will the intervention, itself, cause more harm than good?* Some people may be unable to tolerate high-efficiency (usually industry-certified) facemasks for long periods of time. Tight contact with the face, increased breathing resistance (especially for people with respiratory and cardiovascular diseases), thermal discomfort, humidity and anxiety due to feelings associated with claustrophobia [13,34,39] are all potential causes of harm. There do not appear to be similar concerns associated with disposable surgical masks, probably because they are not designed to form a tight seal around the face.

There also could be harms associated with not providing information or training about masks. In Indonesia, over a million surgical masks were distributed by agencies in Yogyakarta during a volcanic ashfall event, including to street children, without accompanying advice on efficacy or effective use, including fit [9].

There may also be harms associated with facemask use if such use creates a situation of moral hazard. This could occur if mask use leads wearers to have a false sense of security due to the belief that they are well-protected, potentially leading to an increase in exposure, or increased physical exertion, when, without a mask, they may choose to reduce exposure by staying indoors or moving to a lesser-exposed area. If we look at other public health interventions, there has been an argument that the moral hazard posed by seatbelts may have caused some risk compensation by drivers (i.e. they feel safer so may take more risks when driving). However, analysis suggests that there has not been a net increase in harm associated with seat belt use but rather a smaller net reduction in harm than would have been expected [50]. While most APDs of natural origin are not preventable by human action, others, such as the Indonesian transboundary haze crisis, could potentially be prevented. Another moral hazard argument is that adaptive measures, such as facemask use, may distract from the need to effectively manage the cause of the APD. Accordingly, there may be a socially inefficient increase in, or maintenance of, risky actions by one party after another party (or another intervention) absorbs some of the potentially negative consequences of that action [50].

3.5. Respect

A fifth question is: *how can agencies best respect individuals in the communities that they serve?* People may make autonomous decisions to use facemasks during APDs in the absence of evidence and/or action or advice by agencies. A small study of facemask use in Indonesia during a volcanic eruption found that, of 125 participants, 77% wore various forms of facemasks as a protective mechanism against ash on their own initiative [9]. People make decisions based on a range of factors, including evidence, but also their intuition or common sense, and their social, cultural, religious and economic circumstances and values [51,52]. Individual autonomy can be respected through providing information to enable individuals, families, or communities to decide whether they can or will adopt a precautionary approach, what risks they are willing to tolerate, what preventive mechanisms to use [53] and how any potential benefits could be maximised.

Whether or not an agency chooses to recommend and/or distribute facemasks, respect for autonomy would suggest that relevant information about the risks associated with the APDs and possible interventions, including facemasks, should be made available to the public [54]. The WHO has noted that improving public health information is important and it should be factually accurate, easily understood and accessible [55,56]. In this context, it would include information about the probability that some types of facemasks may offer limited protection and that any stated level of protection will be reduced if the facemask is not worn correctly or fitted appropriately. They may also be able to provide training and/or advice on how to wear the masks correctly and, thereby, enhance the degree of protection afforded by a 'good' fit. Agencies are likely to be in a better position than a member of the public to assess the available evidence and to identify better-quality facemasks based on

design and materials. As O'Malley, Rainford and Thompson [31] note: "Transparency […] about what is *not* known is just as important to the promotion of public trust as transparency about what *is* known".

This approach has been adopted by the Oregon (US) Health Authority who, in a FAQ leaflet on wildfire smoke and health [57], state:

> "Most people will find it difficult to correctly use N95 respirators. It is important that the respirator fits properly and air does not leak around the sides. If it does not fit properly, the respirator will provide little if any protection, and may offer a false sense of security. Proper fit testing requires special equipment and training. […] Dust masks and surgical masks that are not … certified are not tested for filtration effectiveness and may not offer a consistent level of protection from particles. This means that they may offer little protection. […] A wet towel or bandana may stop large particles, but not the fine, small ones that can get down into the lungs. They will likely provide little protection."

The proffering of advice about how to wear a mask does not require an agency to recommend the intervention, but does provide people with information to make their own decisions. If members of the public decide to use a facemask, they can maximise any protection that that particular type of facemask may offer and be alerted to any issues that could harm them.

3.6. Equity

The sixth question is: *what are the implications of the intervention for equity?* The assumption is that, with information, individuals and communities can make decisions that are right for their circumstances, values, and needs about whether or not to use facemasks during APDs. However, this rests on another assumption; that people can access and/or afford facemasks. Blake et al. [58] noted that disaster preparedness is situated within a social-political context which privileges agency to some while denying it to others. If only the affluent can afford to adopt a recommended public health intervention, such as purchasing facemasks that are the most likely to offer excellent protection during an APD, the effectiveness of any protection afforded may be determined based on one's socio-economic status [44]. This may worsen already existing health and social inequalities, including those based on gender, age and disability. A further issue arising from any decision to distribute facemasks during APDs is how to equitably allocate them, but this question is outside the scope of this paper as we focus on *whether* to provide advice on, recommend and/or distribute facemasks during APDs.

3.7. Stewardship

A seventh question is: *what are the implications for resources*? The ethical principle of stewardship encompasses the imperative to effectively and efficiently use finite resources to further certain social goals, such as benefiting public health [59]. A decision to provide advice will involve the costs of formulating and distributing the advice and keeping it current as the evidence evolves. A decision to distribute facemasks will involve additional costs of staff training, procurement and distribution. Even if there is a special responsibility to place a greater moral weight on health-related concerns and the needs of vulnerable groups, agencies may have other conflicting responsibilities, including the management of other health–related concerns. As all agencies have finite budgets, they may have to prioritise one over the other using a cost-benefit analysis. The decision to fund one intervention may mean another is not funded [60] or involves an opportunity cost if using an existing resource (for example, facemasks stored for pandemics) for a different purpose, rendering them unavailable for use in a concurrent pandemic. This requires consideration of which is the greatest risk. However, a cost-benefit analysis may privilege the majority over the needs of minority groups. Logistics will also need to be considered: can the masks be distributed in a safe manner which will protect the staff carrying out the distribution, and will all this be done in a timely manner? Additionally, does the agency have appropriate storage for the stock, preserving it in good condition until distribution?

The most effective facemasks for particulate exposures are expensive and may only be affordable for mass distribution in high-income countries, unless crowd-funding is used (as was done by NGOs in Indonesia during the 2017 Agung eruption: https://kopernik.info/en/donate/mount-agung-emergency-response-phase-three) or major mask manufacturers donate them, which can be requested by non-governmental organizations during APDs such as eruptions or wildfires (for example, see: https://news.3m.com/press-release/company-english/3m-responding-california-wildfires-n95-respirator-donations-supplies). As discussed above, wearability is a concern, especially for the more expensive respirator type facemasks [39]. Disposable surgical masks (which, as discussed above, appear less effective but more wearable) are much more affordable, especially for low and middle income countries (LMICs). They are mass-manufactured, lightweight, flat-packed, are often stockpiled for pandemics, and so are available for shipping in bulk quantities. If an intervention aims to protect the health of a population, especially where alternative exposure reduction measures are unavailable or not practical, the choice to recommend and/or distribute surgical masks seems logical to protect against exposure to PM. However, this raises the question of whether it is morally justifiable for people in LMICs to be offered a lesser standard of protection than that which may be offered in high-income countries. Some moral distress may be experienced by those distributing masks when they are aware that they are not offering the 'best' protection, at least from a scientific perspective.

Additionally, a one-off distribution of facemasks may be insufficient in prolonged APDs, which creates on-going resource allocation questions. As masks filter particles, they gradually become clogged but the amount of time until a mask becomes unusable due to particle overload will depend, primarily, on the airborne concentration of particles, which cannot be predicted in advance. Therefore, there is no set duration of wear beyond which a mask should be discarded. However, disposable masks, in general, are designed for single use in an occupational environment (i.e. one shift), so the materials (e.g., straps and nose clips) may not stand up to sustained usage. The fit and efficacy of the mask may deteriorate over time, especially if it is stored in a pocket or around a person's neck. Environmental factors, such as temperature and humidity, may also impact on shelf life as the parts of the mask which relate to fit (e.g., elastic straps and foam around the mask edge) may degrade. These factors affect total cost, as ongoing replacement will need to be factored in.

3.8. Trust

The eighth question is: *what are the implications for trust?* Trust is essential to the relationship between agencies and the public, especially to any specific communities that agency serves. It is important in terms of process, as discussed at the beginning of section 3. However, it is also important more generally. If the public perceives a risk to their or their community's health and well-being, action by agencies, for example by providing facemasks, even without evidence of efficacy, may be expected. This may arise from a perception that those agencies have a duty of care to that community to provide health-focused interventions in a public health crisis. Any failure to act may be seen as betraying that trust and as abandonment at the time of greatest need [21]. It is noted, certainly in high income nations, that there is an increasing mistrust of science (see, for example, vaccination) [61]. Some members of the public may be less concerned about evidence of efficacy and more concerned about action to support them to manage something they intuitively see as a risk, like highly polluted air. In this sense, the perception that action is being taken (even if solely through the provision of advice) may support trust more than inaction on the basis of a lack of evidence (see discussion in Effectiveness section 3.2).

4. Conclusion

The impact of high levels of exposure to PM associated with APDs is a significant public health issue. Agencies with health-related responsibilities need to determine their responses during APDs in the face of public concerns about the health implications of APDs and the public's desire to protect themselves from potential harm. Whatever the evidence of effectiveness, some people will choose to use facemasks as a protective mechanism during APDs. Agencies need to reflect on how they will respond to a recognised public health issue where there is limited evidence to inform decision making as to the degree of risk and effectiveness of interventions.

There are a number of ethical and other considerations that will inform a decision about whether or not to provide advice, recommend and/or distribute facemasks during APDs and of what kind. There will be a range of health-related obligations that an agency will be responsible for. For some agencies these will include public health interventions more generally, as well as those emerging from the disaster. Even during a disaster, health-related concerns are likely not to be limited to air quality issues. Difficult decisions will need to be made about which may be the most pressing priorities from a public health and community perspective, in terms of whether to provide facemasks or to provide advice (which could include a recommendation to use or not to use a facemask). Other interventions, such as evacuation or staying indoors, may be considered to be more appropriate given the predicted nature of the risk or a set of recommendations around a number of possible measures could be made.

If a decision is made to distribute facemasks during APDs, careful prior consideration of the air quality concentrations that will trigger the provision should be made so that it is clear to those who will be tasked with their distribution and to the community. Additionally, there needs to be careful consideration of type of facemask that will be provided or recommended. This is not just a question of what type offers the best protection, but what type is most likely to be worn, is most cost-effective and/or affordable, and is most practical from a logistical perspective, amongst other factors. In a disaster situation, where there is considerable uncertainty about risk and the effectiveness of the intervention, an intervention (such as a surgical mask) that may offer some protection may be more justifiable than an intervention that offers more protection (such as an industry-certified mask) if that mask is more expensive, difficult to wear correctly, logistically more difficult to distribute and less likely to be worn. Such determinations will be situationally specific, influenced by the nature of the disaster and where it occurs.

If autonomy is to be respected then it is important for agencies to communicate information so that people can make their own assessment of any potential risk, understand the limitations of the proposed intervention, and understand how to wear it to maximise any potential benefit. However, we have noted the limitations or influences on autonomous decision making, associated with poorer socio-economic status, culture, and other factors.

Ultimately, these decisions will be contingent on a number of factors specific to the particular type of APD, the culture, norms, values and expectations of the agency and the society within which they are working, and resource availability. A decision in one community or by one agency may not concur with the decisions made by another agency. As Thompson et al. [21] note:

> "Within pluralistic societies, there are many different ethical perspectives that exist simultaneously on issues about global, public and individual health. An ethical framework to guide decision-making is robust to the extent that it reflects the values and beliefs of the decision-makers who refer to it and the values and beliefs of those affected by the decisions being taken."

The emphasis placed on the relative importance of each of these values may differ among countries and/or agencies. There may be other important ethical values in specific countries that have not been analysed in this paper.

Many of the issues discussed in this paper require pre-disaster discussion by agencies and communities about whether they want/need protection, who should be protected, and what level of protection, if any, is justifiable in their particular circumstances, given other health-related concerns that may be considered to be as important or more important. But these decisions also require internal dialogue within agencies about their values, the relative importance of this issue in the context of the other health related issues that the agency is managing, and what the public expects of them. It also highlights the importance, for trusting relationships, of transparent and inclusive decision-making processes and effective communication with the public. As Slim has noted:

> "A moral position which does not gloss over difficulties but sets out a clear and acceptable moral vision within such difficulties, can make a great contribution to the morale of helpers and the helped in any situation" [14].

Funding

Fiona McDonald's research was supported by Durham University and the European Union through a Durham COFUND International Senior Research Fellowship. Claire Horwell and Lena Dominelli's time was supported by the Research for Health in Humanitarian Crises programme (ELRHA) via the Health Interventions in Volcanic Eruptions project.

Declaration of competing interest

This paper was co-authored by Richard Wecker, Robie Kamanyire, and Ciro Ugarte in their personal capacity. The opinions expressed in this article are the authors' and do not reflect the view of UNICEF, Public Health England, or PAHO.

Acknowledgements

We thank Djoni Ferdiwijaya (TATTs Programme, Mercy Corps Indonesia) and Gordon Walker (Lancaster University).

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