COVID-19 vaccination and municipal waste management

TECHNICAL BRIEF

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1. Background

Effective as masks, hygiene, social distancing and other public health measures are in reducing the spread of COVID-19, vaccination of most of the world's population will be necessary to elevate immunity to the extent needed to stop circulation of the SARS CoV-2 virus and to protect against the severest outcomes in those infected[1] .

There are over twenty serious vaccine preventable diseases[2] with immunization estimated to save 4-5 million deaths annually[3]. Typically, individual vaccination campaigns in a single country target a million to tens of millions children[4,5,6] and during the last decade, 1 billion children are estimated to have undergone vaccinations[7]. In comparison, the vaccination campaigns for COVID-19 need to target at least the entire global adult population, approximately 6.5 billion individuals, far outstripping current rates of immunization. Presently only 60% of countries, home to almost 60% of the global adult population, are assessed to have adult immunization infrastructures[8]. If booster shots are required to extend immunity or counter emerging variants of concern, a high level of vaccination will need to be continued.

The effort will involve large scale vaccination campaigns in urban and rural locations. It will require attention to vaccine supply and cold storage, financing, logistics[9], and waste management[10] in addition to public outreach and sensitization.

In March 2020, the United Nations Environmental Programme (UNEP) declared waste management an essential service during the pandemic.[11] Additional quantities of waste have been generated since the start of COVID-19 and include both medical and hazardous waste and non-infected items[12].

Where healthcare waste systems operate well, vaccination waste is segregated into separate waste streams and managed as a matter of routine. Where the healthcare waste system is absent, weak or overwhelmed, there is a risk of cross-contamination between infectious and general waste generated in health-care facilities in general and in temporary sites from vaccination campaigns in particular. In such cases, all wastes including the infectious wastes may enter the urban waste stream, or, conversely, general municipal waste may be classified as infectious and overwhelm existing medical waste systems and facilities. As with every vaccination campaign, but especially given the magnitude of the current pandemic, careful planning is needed that incorporates waste minimization, segregation and handling, monitoring and control to ensure that all waste will be dealt with properly.

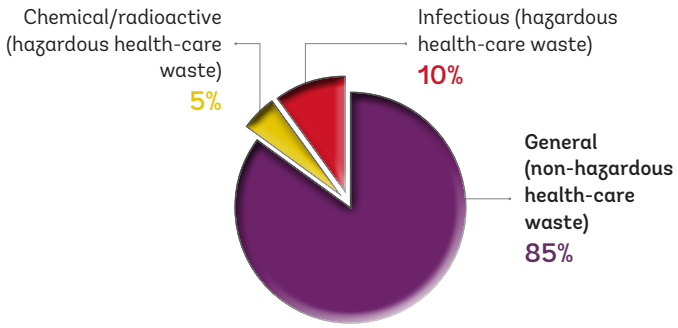
This briefing note provides a summary of existing guidance on managing COVID-19 vaccination waste as well as data points for further references. It is intended to benefit city and municipal officials as well as practitioners working on city and urban development projects with solid waste management components.

Photo: richard johnson

2. Type and quantities of waste from vaccination campaigns

Much of the waste generated in health-care facilities is general municipal waste (see Figure 1), though significant variations exist between types of facilities[13]. If waste is not segregated, all must be treated as infectious. Similarly, immunization activities generate waste that includes a general, non-hazardous fraction (such as packaging material and covers for syringes, boxes or papers) and hazardous ones (such as syringes with needles, broken vials, used PPE or dry ice)[14,15,16].

Figure 1 Typical waste composition in health-care facilities[17]



The types of waste generated by immunization campaigns and classification (hazard level) is summarized in Table 1 below. The World Health Organization (WHO) recommends that normal segregation and handling procedures for healthcare waste be used for COVID-related waste[18] and the guidance for preparing for COVID-19 vaccination campaigns[19,20] also refers back to established practices. WHO categorization for healthcare waste[21], including the used syringes that will be the waste of most concern for those responsible for vaccination campaigns, can be applied in the absence of national guidance.

Table 1 Types of waste generated by immunization campaigns and classification

Type of waste	Classification/Hazard level
Sharps	Hazardous – Present high risk for vaccination workers
Vials and residual vaccine	Hazardous – Broken glass is classified as sharps. Vials may be classified as confidential waste because of counterfeiting concerns.
Syringes	Sharps, Infectious – Usually classified as infectious[22] (removing needles from syringes can reduce volume of sharps waste).
Shipping boxes, vaccine packaging	General waste (municipal solid waste) – Includes polystyrene, non-recyclable plastics. Vaccine packaging may be classified as confidential waste because of counterfeiting concerns.
Refrigeration packs	General waste (municipal solid waste) – contents of cold packs are non-toxic.
Dry ice	Hazardous – risk of burns and suffocation[23].
Other packaging	General waste (municipal solid waste).
Face masks, gloves, other PPE	Infectious – Additional concern on PPE includes the risk of illicit resale. Other ongoing work investigates the possibility of leaching of pollutants[24], and wildlife hazard[25].
Disinfectants	General waste (municipal solid waste) – These include non-recyclable packaging and wipes.

Variations in national regulations and handling practices will influence the amount of waste generated and the potential disposal route for each waste stream. For example, since the vaccinations are given to a healthy population, in the United Kingdom, the used syringes are not classified as infectious[26] although the needles mean that they are still hazardous. Conversely, India requires that needles be cut, and the waste is classified as infectious but can be recycled after disinfection[27].

Data on the amounts of waste from COVID-19 vaccination are not yet available and few data on vaccination waste in general exist. As well as weight, volume should be considered for logistic and transportation purposes. Weights and volumes of healthcare waste can vary considerably from location to location[28], with generally higher amounts being generated in high income countries. Some approaches on estimating quantities are listed below.

Waste audits assessing weight and volume[29] during the early stages of rollout can be valuable to fine tune planning for later operations. India's Central Pollution Control Board has created an application for stakeholders, including urban local bodies, to report COVID waste generation, collection and treatment via Android smartphone or the web[30]. This continuous data gathering allows authorities to track variations in waste generation, instead of having to repeat waste audits. In a published data summary[31], vaccination-related waste is not distinguished from other types of biomedical waste, but this information will be available to authorities if vaccination units report separately from providers of other aspects of healthcare. The largest waste stream of concern will be used syringes because of the danger of injuries from the needles. Syringes from curative care often contain blood which carries a risk of transmitting blood-borne disease, but the risk is lower from immunization syringes, especially intramuscular injections, as blood contamination will be minimal.

The WHO vaccine management handbook provides guidance on how to estimate the volume of vaccination-related materials[32]. In the absence of other information, authorities can use the amounts of commodities procured as an indication of the scale and quantities of waste that will require treatment through all routes. Experts in the United Kingdom (UK) estimate that for every million doses of COVID-19 vaccine delivered, approximately 11 tonnes of waste are produced, of which around half is sharps containers full of used syringes and the remaining half is packaging and other general waste[33].

WHO prequalification standards for UN procurement state that sharps containers must be able to hold at least 20 syringes per liter[34]. In practice, vaccinators often dispose of vials and other waste into the sharps container. Estimates from a measles vaccination campaign in the Philippines were that a 5-liter sharps container holding 100 syringes would weigh 619g, and 693g if the vials were added as well. Field data were somewhat higher: almost 500 sharps containers were weighed, with the average containing the 128 syringes (including diluent syringes) from vaccinating 118 children and weighing 790g[35]. In comparison, the Global Alliance for Vaccines and Immunizations (GAVI) estimates that a typical used 5-liter box will contain 80-100 syringes and weigh 1.2-1.4kg[36]. Based on the Philippine data, delivering one million doses of vaccine would generate 6.6 tonnes of waste, with a volume of 42.2 cubic meters, whereas the GAVI data predicts 12-17.5 metric tonnes of sharps containers with a volume of 50-62.5 cubic meters (m^3).

Using needle cutters (also referred to as hub cutters) can reduce sharps waste[37]. WHO research on waste generation during a yellow fever vaccination campaign in Ghana generated sharps containers at a rate of 41m^3 per million vaccinations where syringes were disposed whole, and 24m^3 for a million vaccinations when the needles had been cut using a needle cutter[38]. The volume of the needle cutters containing the sharps waste was 2.1m^3. Routine vaccinations in Bangladesh yielded 27.2m^3 of sharps containers per million vaccinations when the syringes were whole and 24.6m^3 when the needles were cut off[39].

Amounts of municipal waste generated from vaccination campaigns will not be large as a percentage of the overall municipal waste that is generated, so general municipal waste is unlikely to pose difficulties to local authorities due to its quantities. Worldwide, municipal waste generated per person per day averages 0.74 kilogram but ranges widely, from 0.11 to 4.54 kilograms with low-income countries and rural areas generating less[40]. Risks relate to the need to properly segregate the waste. Contaminated municipal waste with hazardous or infectious waste can negatively affect human health and the environment. Conversely, classifying general municipal waste as hazardous or infectious may overwhelm existing medical waste processes and systems. Proper wate classification, segregation and further handling are essential.

Photo: Radule Perisic

3. Waste segregation and handling

Management of healthcare waste follows the same hierarchy of principles as municipal solid waste, with prevention followed by segregation as a key requirement in minimizing the costs and difficulties of waste handling (see Figures 2 and 3).

According to WHO, segregation practices for COVID-related waste should not differ from normal segregation and handling procedures[41] and waste minimization should be exercised to the extent possible, in line with local regulations and WHO guidelines. For example, staff in vaccination centres will need masks, but other personal protective equipment (PPE) may not be recommended[42,43,44,45], providing opportunities for waste minimization. WHO recommends using soap and water and alcohol based hand rub, which can be manufactured locally[46], in refillable hand sanitizer stations, with can potentially reduce both waste and cost. Although hand hygiene is vital[47], cleaning the injection site with alcohol is indicated if local guidelines require it, otherwise water can be used[48]. These practices can reduce use of hazardous chemical disinfectants and individually packaged cleaning swabs.

Figure 2 The WHO waste hierarchy for healthcare waste management[49]

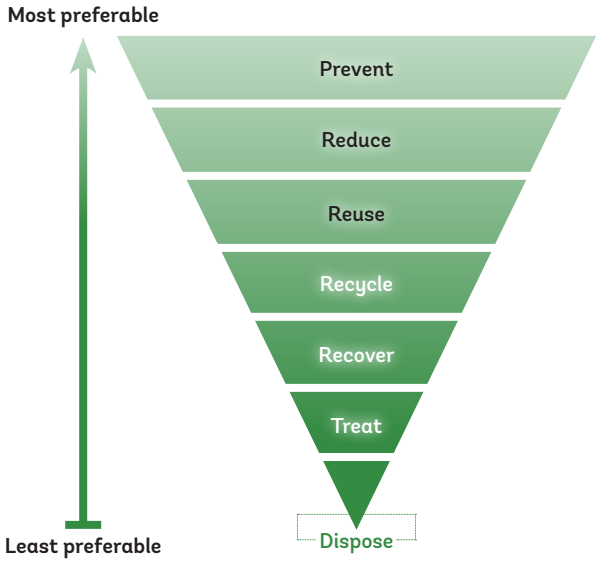
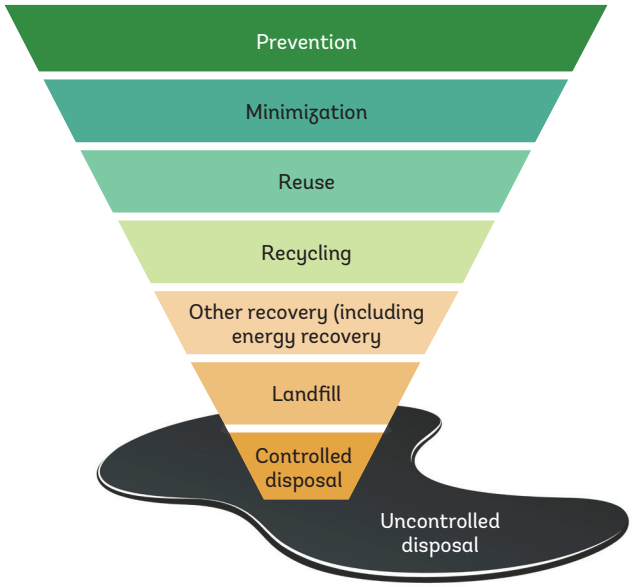


Figure 3 UNEP/ISWA waste hierarchy for general waste management[50]



The most basic segregation systems separate infectious, non-infectious and sharps waste, but separating pathological chemical/pharmaceutical and radioactive waste streams is recommended in addition[51]. Waste bags and bins should be color coded, and appropriately labelled for biological or chemical hazards.

Syringes can be disposed of immediately into a puncture proof sharps container, or needles can be cut before disposal. According to studies, using needle cutters does not increase the number of needle stick injuries to vaccinators or slow their work[52,53]. In these cases, the devices collected the needles in containers which were incinerated at high temperature and the syringe plastic was to be autoclaved, shredded or recycled[54], practices in line with previous WHO guidance[55].

Some vaccine manufacturers are requesting the return of shipping containers[56] that are equipped with valuable temperature monitors and location trackers. WHO guidance on planning for introducing vaccination against COVID-19 recommends creating a strategy and standard operating procedure to collect and return all vials and packing cartons to make sure that all vaccines are properly accounted for and disposed of[57]. Shredding by vetted waste handlers will be required for much of this waste, followed by recycling or disposal as ordinary municipal waste.

Dry ice will revert to gaseous form at above -78°C/-109°F and can pose a risk of suffocation in enclosed spaces. It should be left to dissipate at room temperature in the open or a well ventilated area and not disposed of to the drains. The contents of gel packs are non-toxic and can be disposed of as general waste[58] unless they can be reused. Used PPE should be treated as infectious waste. Cutting PPE before disposal can prevent reuse. Containers which held alcohol-based disinfectants and hand sanitizer are non-hazardous and can be returned or recycled.

Transporting waste, depending on the type of waste stream and its hazard classification, poses various levels of concern. If national regulations do not exist, the United Nations Economic Commission for Europe (UNECE) guidelines on transport of dangerous goods could be followed. Vehicles carrying more than 333kg are required to have warning signs indicating the nature of the waste that they carry[59,60].

Options for treatment of medical waste include steam disinfection, shredding and landfill, disposal in a protected pit, or high temperature incineration. The Stockholm Convention recommends that incineration only be used if it has the air pollution control to reduce emissions of unintentionally produced persistent organic pollutants[61]. WHO recognizes that incineration without air pollution control may be needed as an interim technology but supports the transition to technologies that meet the Stockholm Convention[62,63]. Criteria for selection of treatment methods can include environmental performance, occupational safety, social acceptance, capital and operating cost, institutional and regulatory requirements[64]; the process of arriving at treatment methods should also include consultation with stakeholders[65].

Disposal of general municipal solid waste created in the process of vaccination is also expected to follow existing practices and will likely not add additional challenges at the city-level, due to small overall quantities. However, extra diligence is required to monitor compliance with regulations on the composition of waste originating from vaccination sites to ensure that it is not contaminated with infectious and hazardous material.

Photo: Lubo Ivanko

4. Impacts of mishandled vaccination waste

Environmental and public health impacts of vaccination waste range from needle stick injuries and potential infection from used syringes (particularly infection with hepatitis B and C and HIV[66,67]), to air pollution from waste burning, and hazards to the public and wildlife[68,69] from discarded waste including mask and gloves.

WHO advises that there is no direct evidence of transmission of COVID-19 from waste[70] but recyclers and waste workers, including the informal sector, can suffer injury or infection through handling untreated waste without protection. Workers in insecure employment, especially women and minorities, are the most likely to suffer health or economic impacts from COVID-19[71]. These risks are exacerbated where waste handlers are not protected against hazardous waste co-mingled with municipal waste, for instance at separation lines or municipal disposal sites. All these risks can be ameliorated, and some eliminated altogether, with careful planning, adequate capacity and the right investment[72].

Healthcare workers are usually prioritized for immunization, but this is not always extended to waste workers[73]. Occupational health and safety elements to protect waste handlers are recommended to cover training, PPE, immunization against COVID-19, hepatitis B, and tetanus, and access to HIV post exposure prophylaxis.

It is of concern that fake vaccines are emerging, as noted in an alert issued by Interpol[74] and have been seized in several countries. Online scams selling fake vaccines have been anticipated[75]. Used gloves and masks may also be resold, potentially spreading infection. Resale of used syringes is less likely because per WHO guidelines[76], syringes used in vaccination campaigns should have reuse prevention mechanisms. As of the time of this briefing note, no harmful materials have been reported in fake vaccines, so it should be possible to dispose of them in the same manner as genuine vaccine waste. Secure shredding and crushing can be carried out either at the vaccination centre, or at trusted disposal sites, to minimize the chances of genuine vaccine vials, packaging and other materials being copied by counterfeiters.

Photo: Sekayu, Indonesia. © Riyan Pratama M | Dreamstime.com

5. Planning for large scale vaccination campaign

Many low- and middle-income countries do not have adequate capacity to meet WHO/ United Nations Children's Fund (UNICEF) basic standards of healthcare waste management[77]. Investment in capacity to handle waste from vaccinations can have long term benefits beyond the vaccination campaigns. Countries are encouraged to design waste management systems allowing safe segregation and disposal, secure sufficient funding (budgets) to hire and train waste handlers, provide waste containers and treatment technologies[78]. GAVI provides tools to help assess needs, including the maturity and level of development of the existing country system[79]. Low-tech options for vaccination waste management in remote or resource poor situations are addressed in guidance from WHO[80,81].

In 2020, the United Nations Development Programme (UNDP) conducted rapid assessments of healthcare waste management in the context of COVID-19 in seven low income countries (Ghana, Jordan, Kyrgyzstan, Panama, Serbia, Sudan, and Zimbabwe)[82,83], identifying similar gaps in systems likely also to impact vaccination waste management. Providers of waste management services identified funding and public awareness as their biggest challenges, whereas the surveyed governments identified process capacity, technologies and monitoring as areas requiring investment. Other potential systemic challenges were identified such as missing links between stakeholders or executing agencies in a healthcare waste management system; limited knowledge on the risks of healthcare waste; and the complications of change management, with new practices, equipment and technologies[84], which can be especially acute during a public health emergency. These key findings are shown in Figures 4 and 5.

Figure 4 Major investment areas for COVID-19 waste identified by governments[85]

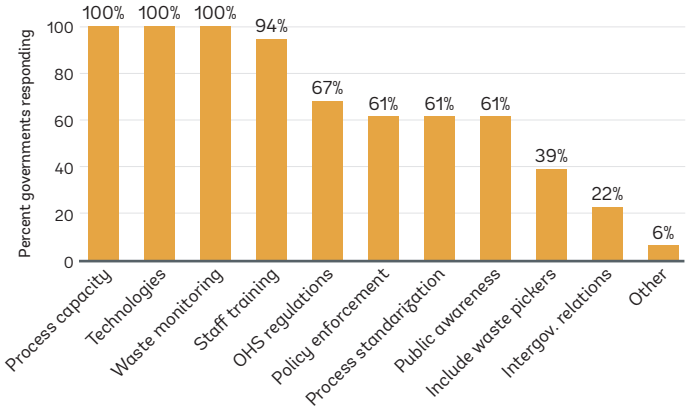
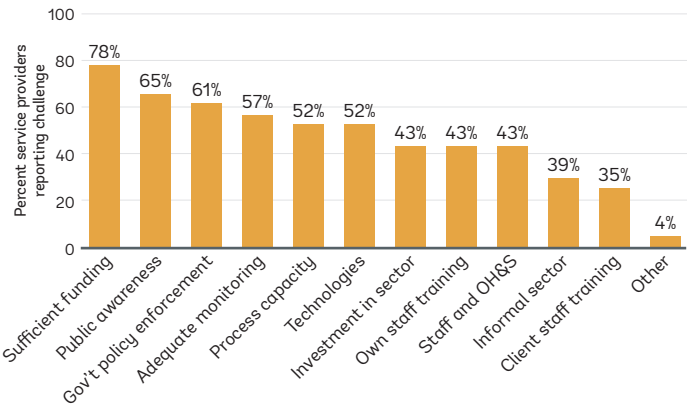


Figure 5 Challenges reported by providers of waste management services[86]



Detailed planning guides for immunization waste have been issued by UNICEF[87] and GAVI[88]. The key steps in the process are to:

1. Review national legislation on collection and disposal of healthcare waste;
2. Assess the maturity of the waste management system and identify gaps, including in human capacity;
3. Estimate the total amount of waste that each vaccination site will generate based on the size of the population to be vaccinated;
4. Map current waste treatment and disposal facilities which are compliant with regulations for disposal of hazardous waste. Include private sector and recycling facilities;
5. Cluster vaccination sites around selected waste disposal facilities;
6. Plan the collection and transportation of the waste to the disposal sites identified:
    a. Select routes for collection;
    b. Determine the types of transportation for each route;
    c. Assign responsibilities and supervision and reporting roles at all steps; and
7. Formulate a detailed plan for the waste collection, transport, and disposal and use the plan to obtain financing and other resources for the implementation of the plan.

It can be valuable to plan for contingencies in case the healthcare waste management system cannot cope. None of the waste from vaccinations is offensive or liable to become more hazardous with time, so it may be sufficient to arrange safe storage until existing services are able to treat it. If is it necessary to make arrangements for changes in normal practices and create or reinforce procedures for ensuring compliance, it may be preferable that wastes that need to be treated outside the normal healthcare waste management system are treated in facilities that are already processing hazardous materials[89].

Photo: © Irina Borsuchenko | Dreamstime.com

6. Cost and financing

Vaccination waste management costs will depend on the type of waste, technology used and factors such as collection and transportation. WHO and UNEP provide detailed guidance on how to cost healthcare waste management[90,91], district level costs of waste from vaccinations[92] and costing the introduction of new vaccines[93]. They have developed costing tools for healthcare waste management in high[94], medium[95] and low[96] income countries. These tools contain default cost estimates for each element and allow users to add local data.

In addition, WHO and UNICEF are conducting cost analyses for providing water, sanitation, hygiene and healthcare waste management (WASH) in healthcare facilities in low income countries, which are expected to be published in 2021. Preliminary estimates indicate that providing basic services in the 47 least developed countries will require US$3.6 billion between 2020 and 2030. One third (US$1.2 billion) will be needed for investment and two thirds (US$2.4 billion) for operations and maintenance. This is equivalent to US$0.30 per person per annum, and since governmental health spending in these countries averages US$10 per capita per annum, these amounts are equivalent to 1% of healthcare spending on investment and 2% on operations and management[97]. WHO recommends that a specific budget line be assigned to healthcare waste management at the facility level[98] and including it in tracking helps guide future management decisions.

Once costs for HCWM are established, they can be incorporated into the WHO COVID-19 Vaccine Introduction and Deployment Costing Tool (CVIC tool), which is aligned with the national deployment and vaccination plan[99].

A systematic review of the literature[100] in 2021 pertaining to low and middle income countries did not reveal any costs specific to vaccination waste. An earlier study of the Philippines Measles Eradication Campaign which targeted 18 million children compared several non-combustion methods provides local cost-estimates, according to which simple burial in a clay-lined pit was lowest cost, followed by centralized steam disinfection via microwave or autoclave.

Values of recyclable materials will vary from location to location, but can offset the overall disposal costs, including through the reduction in the volume of waste requiring disposal. Syringes are almost entirely composed of polyethylene and polypropylene, which are widely recycled. Values in Nepal have been reported in the order of 25 US$ cents per kg; paper and card from packaging are worth around 3-4 US$ cents per kilo; glass around 1.5 US$ cents per kg[101].

Figure 6 Comparative costs of disposing of sharps containers in the Philippines[102]

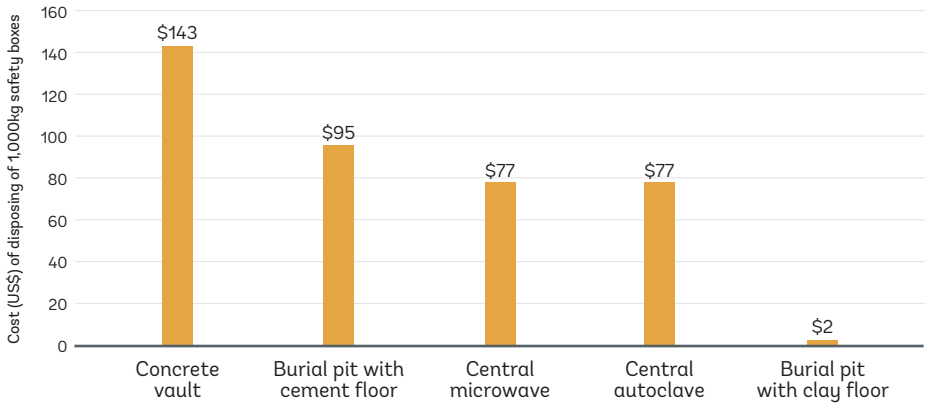


Photo: Arequipa, Peru. Edson Flores Silloca

7. Education and publicity campaigns

Dealing with outbreaks and COVID-19 require adequate capacity among health, vaccination and waste workers along with improved overall environmental awareness of the population.

Workers may not be aware of the dangers posed by healthcare wastes[103]. Moreover, research in Bangladesh found a tendency in both medical workers and supervisors to attribute accidents to fate rather than failures of safety procedures that needed rectification[104]. It is important that vaccinators and waste handlers receive training on safe waste management before starting work, with on-the-job reinforcements as appropriate. The focus should be on best practice and occupational health and safety. Managers and supervisors' training need to cover how to ensure the availability and proper use of materials including safety boxes, needle cutters and other supplies. They should know the appropriate regulations, and track changes in practice that may affect their staff, as staff may need support to keep up with changing rules[105].

Today the internet is the default means of providing information for many governments and organizations, but this can miss out significant sectors of society who do not have access to it. Education and publicity campaigns are advisable to facilitate waste management and counter both overconfidence and fear, along with providing guidance and advice to the general public, and should address all sectors of the society through a variety of routes.

Training resources on COVID waste management are available from WHO[106], UNDP[107]; and can provide additional detail to the guidance in vaccine deployment toolkits[108] and injection safety[109].

Endnotes

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