Management of Solid Health-Care Waste at Primary Health-Care Centres

A Decision-Making Guide

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ABBREVIATIONS

HCW Health-care waste
HCWM Health-care waste management
PHC Primary Health Care centres

1. Introduction

The objective of this document is to provide guidance for selecting the most appropriate for option safely managing solid waste generated at Primary Health-Care centres (PHCs) in developing countries.

The main tool of this guide consists of six decision-trees aimed at assisting the user in identifying appropriate waste management methods. The guide takes into consideration the most relevant local conditions, the safety of workers and of the general public as well as of environmental criteria.

This guide is composed of the following parts:

i. Basic risks associated with poor management of heath care waste.
ii. Basic elements for safe health-care waste management (HCWM)
iii. Parameters to assess before selecting HCWM options
iv. Technical annexes describing HCWM options
v. Estimation of costs of the various options
vi. Decision-trees, assisting the selection of HCWM options

This guide may also be used to evaluate existing practices related to health-care waste management. More detailed sources of information on handling and storage practices, technical options for treatment and disposal of wastes, training and personal protection, and assessment of a country's situation, are presented in Annex A.

Audience

The audience for the guide includes the staff working in primary health-care centres and the technical staff working in the local, state or central administration.

Scope

The scope of the guide is to ensure a safer management of the solid wastes generated by PHCs in urban, peri-urban, and rural areas of developing countries. More specifically, the decision-making process helps selecting adequate options for the safe disposal of wastes at PHC level.

A PHC is a medical facility that delivers medical care to outpatients and, on occasion, may participate in large-scale immunization programmes. PHCs are generally relatively small and produce limited quantities of wastes.

The management of liquid wastes generated in PHCs is not addressed in this guide. Detailed information on handling, storage and transportation of waste, training and workers' protection can be found in WHO's publication *Safe management of wastes from health-care activities* (Ed. Prüss A et al, WHO, Geneva 1999) .

Scenarios used in this guide

This guide describes a total of six scenarios related to PHCs. They take into account the local characteristics of the PHC such as the population density and the proximity to legally approved modern waste treatment facilities. PHCs environments are characterized as **urban, peri-urban** or **rural**.

Definition of Health care waste

Health care waste (HCW) is defined as the total waste stream from a health care facility that includes both potential infectious waste and non-infectious waste materials.

Infectious wastes include infectious sharps and infectious non-sharp materials. Infectious *Sharps* consist of syringe or other needles, blades, infusion sets, broken glass or other items that can cause direct injury.

Infectious non-sharps include materials that have been in contact with human blood, or its derivatives, bandages, swabs or items soaked with blood, isolation wastes from highly infectious patients (including food residues), used and obsolete vaccine vials, bedding and other contaminated materials infected with human pathogens. Human excreta from patients are also included in this category.

Non-infectious wastes may include materials that have not been in contact with patients such as paper and plastic packaging, metal, glass or other wastes which are similar to household wastes.

Note: If no separation of wastes takes place, the whole mixed volume of health care waste needs to be considered as being infectious.

Table 1: Approximate percentage of waste type per total waste in PHC centres

Non-infectious waste	80%
Pathological waste and infectious waste	15%
Sharps waste	1%
Chemical or pharmaceutical waste	3%
Pressurises cylinders, broken thermometers...	less than 1%

2. Basic risks associated with the poor management of health-care waste

Poor management of health-care waste can cause serious disease to health-care personnel, to waste workers, patients and to the general public. The greatest risk posed by infectious waste are accidental needle stick injuries, which can cause hepatitis B and hepatitis C and HIV infection. There are however numerous other diseases which could be transmitted by contact with infectious health-care wastes.

Infectious sharps and Occupational Risk

During the handling of wastes, injuries occur when syringe-needles or other sharps have not been collected in rigid puncture proof containers. Inappropriate design and/or overflow of existing sharps container and moreover unprotected pits increase risk exposure of the health care workers, of waste handlers and of the community at large, to needle stick injuries.

Best practices in health care recommend the segregation of sharps at the point of use. In some countries, needle cutters are used to separate the needle from the syringe. Note that current WHO best infection control practices do not yet address the use of needle removal devices. While needle removals are a promising way to reduce the volume of sharps waste, evidence regarding the safety and effectiveness needs to be documented before they can be recommended.

Of particular concern is the need to assess the trade-off between the following paradigms:

- Adding a step in the collection of sharps waste that could increase handling of infectious needles and thus the risk for needle-stick injuries among health care workers.

- Decreasing the volume of infectious sharps waste through (a) disposing of syringe alone with less precautions than regular infectious waste and (b) handling needles only as infectious sharps waste. This may result in fewer needle-stick injuries among waste handlers and the community.

WHO recommends to conduct studies on risk associated with this device before introducing needle remover/cutter in immunization settings.

Risk to the general public

The reuse of infectious syringes represents a major threat to public health. Based on previous estimates (Kane et al, 2000) and recent updates, WHO estimated that, in 2000, worldwide, injections undertaken with contaminated syringes caused about 23 million infections of Hepatitis B and Hepatitis C and HIV.

Such situations are very likely to happen when health-care waste is dumped on un-controlled sites where it can be easily accessed by the public: children are particularly at risk to come in contact with infectious wastes. The contact with toxic chemicals, such as disinfectants may cause accidents when they are accessible to the public. In 2002, the results of a WHO assessment conducted in 22 developing countries showed that the proportion of health care facilities that do not use proper waste disposal methods range from 18% to 64% .

Risk for the environment

In addition to health risks derived from direct contact, health-care waste can adversely impact human health by contaminating water bodies during waste treatment and by polluting the air through emissions of highly toxic gases during incineration.

When wastes are disposed of in a pit which is not lined or too close to water sources, the water bodies may become contaminated.

If health-care waste is burned openly or in an incinerator with no emission control (which is the case with the majority of incinerators in developing countries), dioxins and furans and other toxics air pollutants may be produced. This, would cause serious illness in people who inhale this air. When selecting a treatment and or disposal method for HCW, the environmental viability is thus a crucial criteria.

WHO has established Tolerable intake limits for dioxins and furans, but not for emissions. The latter must be set within the national context. A number of countries have defined emission limits. They range from 0.1 ng TEQ/m^3 (Toxicity Equivalence) in Europe to 0.1 ng to 5 ng TEQ/m^3 in Japan, according to incinerator capacity.

3. Relative risk approach

Waste management treatment options should protect health-care workers and the community and minimize adverse impacts on the environment. Environmentally-friendly, safe and affordable options correctly used in high income countries may not always be affordable in developing countries. Health risks from environmental exposures should be weighed against the risks posed by accidental infection from poorly managed infectious sharps

4. Important issues for the safe management of health-care wastes

A robust national legislation and its efficient implementation are the base for planning a system for the sound management of HCW. Technical as well as organizational issues must be considered when developing plans for managing wastes from PHC centres. Training of concerned personnel, clear attribution of responsibilities, allocation of human and financial resources, thoughtful development and implementation of best practices regarding handling, storage, treatment and disposal, all need to be addressed.

The final selection of waste management options may not always be scientifically evaluated, especially when it comes to a combination of methods, the main criteria should be that their implementation will offer a level of health protection which eliminates as many risks as possible. See annex D.

The HCWM systems can subsequently be upgraded to reach higher safety standards. Basic elements of safe management of health-care wastes are summarized in Table 2.

It is crucial to acknowledge that it is only well trained and motivated personal who will take the necessary simple steps to increase the safety of health care waste management.

Table 2: Basic elements for the safe management of health-care waste for PHC centres

1 - Selection of options	2 - Awareness and training	3 - Implementation
• Choice of off site options :Identification of close by centralized waste management and disposal facilities that meet national regulations and are legally recognized as such • Choice of sustainable management and disposal options, according to: – Context and needs – Availability – Affordability – Environment-friendliness – Efficiency – Worker's safety – Prevention of the re-use of – disposable medical equipment (e.g. syringes) – Social acceptability • Process: Involve key stakeholders such as environmentalists, municipality and private sector.	• Awareness raising of all staff about risks related to sharps and other infectious wastes • Training of <u>all</u> health-care personnel regarding segregation practices • Training of waste workers regarding safe handling, storage and operation and maintenance of treatment technologies • Display of written instructions for personnel	• Assessment of the current HCW system in place • Joint development of a sound HCW system • Assignment of responsibilities for waste management • Allocation of sufficient resources • Waste minimization, including purchasing policies and stock management practices • Segregation of waste into sharps, non-sharps infectious waste and non-infectious waste (colour-coded system) • Implementation of safe handling, storage, transportation, treatment, practices and disposal options • Tracking of waste production and waste destination Evaluation of the HCW system

This guide assists in the selection of suitable options. The issues listed under "implementation" and "Awareness and training" in Table 2 also need to be addressed so as to ensure the safety and sustainability of a system. Resources documents that provide guidance on these issues are outlined in Annex A.

5. Key parameters to assess before selecting options

A number of local conditions should be assessed before choosing options for the treatment and disposal of health-care wastes including:

1. The quantities of waste produced daily at the PHC level
2. Availability of appropriate sites for waste treatment and disposal (e.g. space on PHC premises and distance to nearest residential areas).
3. Possibility of treatment in central facility or hospital with waste treatment facility within reasonable distance
4. Rainfall and level of groundwater (to take precautions against flooding of burial pits, or provide shelter for incinerators or other facilities)
5. Availability of reliable transportation
6. An overview of options used in the country (see if there is an existing mapping)
7. The availability of a national legislation
8. The availability of a national HCWM plan and policy for health care waste management
9. The availability of environmental regulations including those derived from the ratification of global legally binding Conventions.
10. The availability of equipment and manufacturers in the country or region
11. Social acceptance of treatment and disposal methods and sites
12. Availability of resources (human, financial, material)

The availability of resources requires additional attention.

- Availability of trained personnel, or possibility of training, for the more sophisticated treatment options.
- If incineration is considered, the availability of refractory bricks and concrete, sufficient paper/cardboard or wood/fuel should be considered, in particular for the more sophisticated models requiring pre-heating.
- Disinfection of syringes before transportation may require bleach (e.g., sodium hypochlorite solution) or other disinfectants.

The continuous availability of the required resources is a prerequisite for a waste treatment system to be sustainable and remain operational.

6. Scenarios considered

Six decision trees cover the seven scenarios considered in this guide. They are intended to assist in the selection of HCW treatment and disposal options:

- Urban area with access to a legally approved modern waste treatment facility or located within reasonable distance to a larger health-care facility with treatment facility
- Urban area without access to legally approved modern waste treatment facility
- Peri-urban area
- Rural area with access to a legally approved waste treatment facility or located within reasonable distance to a larger health-care facility with treatment facility
- Rural area without access to a legally approved modern waste treatment or disposal facility
- Mass immunization activities at PHC
- Outreach immunization activities

Definitions

An **urban area** is a densely populated geographical area with a substantial infrastructure of public services, having generally little space on/or around the premises.

A **peri-urban area** typically is a community composed of a large percentage of informal housing, which has been established on the periphery of an urban area.

A **rural area** is a small community or geographical area, having a population generally of less than 5,000, a low population density, and located in the countryside.

The decision-trees include the following basic elements of solid waste management as they apply to the management of waste generated at PHCs. These elements cover the "waste stream" from its generation to its final disposal.

1. ⬇ waste minimization
2. ⬇ segregation
3. ⬇ codification
4. ⬇ handling
5. ⬇ Transportation
6. ⬇ treatment
7. ⬇ disposal

Waste minimization

Waste minimization is defined as the prevention of waste production and/or its reduction. It involves specific strategies, changes in management and behavioural change. Methods of waste reduction include modification of purchasing procedures, control of inventory, and production of less toxic materials when discarded as wastes. No actions should however be taken that would impact on the quality and limit the access to health care.

Segregation

Segregation is in some ways a minimization of wastes. In fact, it reduces the quantity of wastes which are hazardous and therefore require special attention and treatment. Segregation is the separation of wastes into the following categories: sharps, infectious non-sharps and non-hazardous waste (similar to household waste). Segregation of PHC waste occurs on site at the time the waste is generated, for example, when an injection is given and the needle and syringe are placed in a waste container, or when packaging is removed from supplies and equipment.

Non-hazardous waste (e.g., paper) can be recycled. Non-infectious biodegradable organic wastes (e.g., food waste) can be composted and then used on-site or by the community. For additional information related to waste, reduction and storage see Annex B.

Infectious waste must never be mixed with non-infectious waste to keep the volume of infectious waste as low as possible.

Codification

Codification is a colour-coded system which define the containers in which waste must be stored once segregated – for example: yellow or red for infectious waste and black for non-infectious waste.

Handling

Handling concerns the collection, weighing and storing conditions. In general, the maximum time of storing should not exceed 24 hours.

Treatment

Treatment modifies the characteristics of the waste. Treatment of wastes mainly aims at reducing direct exposure less dangerous to humans, at recovering recyclable materials, and at protecting the environment. For wastes from PHC, the main aim is to disinfect infectious waste, to destroy disposable medical devices, in particular used syringe needles, which should not be reused, or at least to render them inaccessible or sterile prior to plastic reprocessing. For additional information related to treatment see Annex C.

Disposal

Disposal refers to the final placement of treated waste, using a sanitary landfill or any other environmentally acceptable method of final storage appropriate to the local conditions. For additional information related to land disposal see Annex E.

The practices of managing wastes from PHC centres described in this guide are mainly based on the following two criteria:

1. the minimisation of the occupational and public health risks associated with the management of PHC waste, and

2. the minimisation of volume and mass of infectious sharps and non-sharps.

The decision-trees describe the flow of PHC solid waste from the point of generation until final disposal of the waste. Decision points are represented in the diagrams by hexagons, and actions or operations (e.g. segregation, transportation) are represented by boxes. The flow of waste from one operation or decision point to the next is represented by arrows.

General Decision-Making Process

The steps below should be followed when using the decision-trees:

1. Determine the scenario which best reflects the situation of the PHC centre you want to analyse.
2. Commence the decision process at the top of the decision-tree diagram. Follow the initial flow arrow shown in diagram. When branching of the flow occurs, select the appropriate route based on the conditions that apply.
3. If needed, refer to the more detailed information in the Annexes concerning the specific types of waste management alternatives, or to one of the other sources mentioned in the list of references (Annex A).

Urban area with access to legally approved modern waste treatment facility

Scenario 1 describes the waste management decision-tree for a PHC centre in an urban area that has access to a legally approved modern waste treatment facility. Having access means that this treatment facility lays within reasonable distance from the PHC centre, and that it accepts treating its waste. The treatment facility may require the PHC facility to pay for the treatment of the waste, and that the packaging of the waste complies with certain conditions, generally aimed at protecting worker's safety and preventing waste spillage. Waste management service providers are generally accredited by a national regulatory body to ensure compliance with national standards. In growing urban areas the trend is to set up a central treatment plants that collect, segregate and process waste including medical waste. High capacity incinerators with pollution control device and/or more environmentally friendly alternative methods such as steam treatment and shredding are available in certain places. Other opportunities, such as incineration in kilns used for industrial purposes may also be explored. Finally, Scenario 1 should also be used when there is an opportunity to treat the waste in a nearby hospital which has a waste treatment facility.

Urban area without access to legally approved modern waste treatment facility

Scenario 2 describes the waste management decision tree for a PHC centre in an urban environment that does not have access to a modern treatment facility. This may well be the most difficult situation for a PHC centre wishing to safely dispose of its waste. Most of the possible options are not entirely satisfactory in terms of safety and better solutions need to be worked out. Although one

PHC centre alone has relatively limited possibilities to address HCW management issues outside their premises, action can be taken at central level to improve their situation.

Peri-urban area

Scenario 3 shows the decision tree for a PHC centre in a peri-urban area. In such an environment, the PHC centre may or may not have the opportunities of both urban and rural areas.

PHCs in rural area

PHCs located in rural area often receive substantive quantities of sharp waste from out-reach activities and health posts. These wastes may be carried in safety boxes (complete needle syringe) or contained in a sharp container (needle and the hub) when mutilated at the source. In that case the potentially infected plastic syringes can be carried in a bag but need further treatment before disposal.

Safety boxes can be transported to a defined and legally approved modern facility for treatment. Needles and safety containers can be disposed in a safe sharp pit. A study conducted in Eritrea - Eritrea needle removal devices pilot trials, the Ministry of Health of Eritrea (MOH) and the World Health Organization Africa Regional Office (WHO AFRO), September 2003, shows that a pit of one cubic meter can contain approximately 1 million needles. Plastic syringes can be disinfected in contact with a 0.5% hypochlorite solution, boiled or autoclaved if available and then shredded prior to recycling or land disposal**.**

Rural area with access to legally approved modern waste treatment within reasonable distance

This scenario is similar to the decision tree 1 or 3 and is for a rural PHC centre that is located within reasonable transportation distance to a district hospital that operates a legally approved modern waste treatment facility. Such scenarios are likely to be rare.

However, the judgement "within reasonable distance" also depends on the arrangements in place that could be explored for transporting the waste. For example, if supplies such as immunization goods are transported to the PHC centre from a district hospital, it could also be envisaged to transport the waste back to that district hospital for treatment. Often, countries do have legislation concerning transportation of HCW, this needs to be considered. Note that the use the same vehicle to transport supplies and waste should only happen after any risk for cross contamination is completely discarded.

Remote area without access to legally approved modern waste treatment or disposal facility

Scenario 4 illustrates the decision tree for a rural PHC centre that does not have access to legally approved modern waste treatment and disposal facilities. Consequently, the PHC centre must operate its own waste treatment system using multiple technical options for sharps, infectious and non-infectious wastes. Information on options applicable to rural PHC centres is included in Annexes C and E.

Immunization activities at PHC centre

Scenario 5 is the decision tree for a PHC involved in immunization activities.

Supplies can be safely collected on site and treated on site if the facility exists or transported to an existing or organised central facility for treatment.

Outreach immunization activities

Scenario 6 is the decision tree for outreach immunization activities. The waste produced should be collected in safety containers then brought back to a centralized facility for treatment.

7. Remarks

The recommended methods of managing PHC waste have been presented in the main body of the guidelines. The implementation of the methods given in the decision trees (Scenarios 1-6) may require certain policies and regulations to be put into place in the country in order to ensure safety in a sustainable way.

One example is the provision (or "bundling") of safety boxes together with syringes and/or vaccines as part of their supply. This approach requires that new policies be put into place or that the current procurement policies of PHC centres and governmental organisations be modified. If proper storage containers for sharps are lacking, simple technical options such as the needle removers are few for adequate protection and minimisation of the risks represented by the sharps.

8. Explanation of criteria and practices used in the decision trees

Safe transportation available

The basic criteria for safe transportation include segregation of infectious and non-infectious waste and the use of sharp containers to dispose needles right after injection. Infectious waste must be decontaminated before transportation to final disposal. If the health facility has a formal agreement with a public or private central treatment plant those must be certified by a regulatory body or endorsed by professional associations and the community. Transportation of HCW needs to conform with legal requirements. If such do not exist at national levels, international standards should be considered.

Disinfection with bleach

Household bleach, at the appropriate concentrations (0.5% chlorine solution), can be used to disinfect sharps and other wastes. Disinfecting procedures must be followed carefully to be effective [Favero and Bond, 1991, 1993; Shriniwas, 1992]. Such disinfection does certainly not render sharps safe for reuse and only serves to reduce the risk from accidental exposure to sharps prior to treatment or disposal.

Encapsulation of needles

Needles removed or cut from the syringes, take up very little space. Large quantities of needles can therefore be collected in hard puncture proof containers. When the container is three quarter full, wet concrete can be added to the container to permanently encapsulate the needles. Once the needles have been encapsulated, the block containing the needles can be disposed of in a burial pit or introduced into the municipal waste stream. Single use needle removers can also be disposed off in a similar manner.

Municipal waste stream

In the municipality or the area around the PHC centre there is usually a waste collection organized by the municipality, and a site where the waste is stored or buried. Wastes that are produced by the

PHC centre and which are not hazardous (i.e. wrapping, food scraps etc.) can be disposed of in the same way as other household waste produced by the community. Although the methods available in the community may not always be ideal, the major concern is always the safe management of the infectious waste. Once segregated at the source attention must be paid to ensure no mixing of infectious and non-infectious wastes along the waste stream.

Space available on premises

The available space refers to the possibility of building a waste treatment site or device and storage facilities on the premises of the PHC centre. If building a small incinerator, all national legal requirements need to be followed, especially those referring to space availability, and distance between the incinerator and the location where patients are treated or wait for their treatment, and the location of the nearest human settlement. If national legal standards are not existing, international standards should be applied.

Densely populated area

The distance between an incinerator on the premises of the PHC centre and housing refers to a minimal distance in order to avoid adverse health impacts of the emissions to the air on the population. The local situation should be investigated in terms of dominant wind directions, presence of agricultural fields, height of the chimney, proper operational practices and compliance with national (or in the absence of these, international) pollution control standards.

Acceptable operating conditions for incineration of non plastic wastes

Acceptable operating conditions for small-scale incinerators include the continuous supply of combustible required for the selected design, and availability of protective equipment for the operators, such as gloves, boots and aprons (which should be available for all workers collecting or handling such wastes, and not only for the operation of incinerators). To avoid the need of combustibles simpler, locally-built incinerators can be used. These can function without the need of combustibles, or just by adding other waste such as paper or cardboard. The available space on premises, a minimum distance to the community and the patients, the allocation of resources as well as staff training and most importantly respect of good practices are also prerequisites for incineration.

9. Costing Methodology

When identifying and recommending appropriate waste management systems to MOH or provincial and district health services, it is necessary to provide realistic estimates of the costs of the different treatment options. Moreover, when introducing systems for waste management, the costs of the activities should be monitored to facilitate budgeting and planning. In this chapter, a methodology for estimating and reporting the costs of waste management at primary health care facilities is outlined.

Waste generation

As seen in previous chapters, the most optimal solution for waste management varies between PHC centres, depending on the amount of waste generated and on the opportunities for transporting waste to a nearby treatment facility. The first step is therefore to define the amounts of waste generated in the facility. It is recommended to count the number of safety boxes and kilos of waste managed during a period of at least 1 month and if possible 3 months to ensure that any periodical variations are accounted for. The annual amount of waste managed should be estimated from the figures obtained during the monitoring phase.

System costing

The approach we are interested in is a "system approach", whereby focus is on defining the costs of the whole health care waste management (HCWM) system. All activities and equipment related to HCWM should be included in the cost analysis. They comprise direct costs of supplies and materials used for collection, transport, storage, treatment, disposal, decontamination and cleaning, as well as the cost of labour and material for training and maintenance costs. These costs will vary depending on the treatment method chosen, the capacity of the treatment facility and according to the waste quantity and quality. If revenue is being generated from recycling of waste, this amount should be subtracted from the cost of waste management to arrive at a "net cost" estimate.

A full description of the system is necessary to provide an appropriate cost estimate. The number and type of health facilities using each disposal site need to be stated and the system for collection, including frequency, mode of collection and itinerary, should be described. Specific data about the health care facility - size, services offered, average bed occupancy and, in the case of an outpatient facility, the catchment population - also need to be obtained. As a general indication, it would be interesting to know the percentage of the health care facility budget that is allocated to waste management.

Costs should be divided into capital and recurrent costs for all the options available. Capital costs are defined as resource items with a life time above one year, as opposed to recurrent costs that are items that are used on a regular basis and have a life time below one year. As all costs should be estimated on an annual basis, capital costs must be annualized. This is explained below.

Capital costs

The following items and activities are included in capital costs:

- incinerator, autoclave, microwave and needle removal devices, i.e. all equipment needed for the treatment technology, including transport to the site and installation
- security cage to store the incinerator in, if incineration is the treatment method chosen
- vehicles used for the transport of waste
- ventilators for storage areas so as to prevent a build-up of odours
- long-term training that needs to be provided to the staff to safely handle the treatment equipment.

Capital costs must be expressed on an annual equivalent basis in order to be combined with recurrent costs in a useful way. To do so, capital costs should be annualized as follows:

1. Identify the capital cost items of the waste management system
2. Determine the current value of each item (i.e. the purchase price). This can be collected from the supplier of the capital item or from available receipts.

3. Estimate the number of years for which the item can realistically be expected to function properly (from the time of purchase). Note that expected life largely depends on utilization rates as well as on the quality of maintenance of the item. The life of the equipment can be estimated either in number of years or in kg of waste treated, whichever is reached first. Expected life years are estimated by users and/or suppliers of the item for the particular setting. If the life expectancy is reported in kg of waste, it should be translated into time by using the estimate of annual waste generation.

4. Obtain the discount rate used by the economic planning office or ministry of finance (alternatively, calculate the real rate of interest, i.e. the rate of interest that could be obtained by depositing money in a bank, minus the inflation rate). In many international studies a discount rate of 3% is used

5. Estimate the annualization factor as follows:

   $$((1+r)^{t} - 1) / r(1 + r)^{t},$$

   where r is the discount rate and t is the number of years after year 0. This number can also be looked up in an annualization factor table for capital items with different expected lifetimes at different discount rates

6. Calculate the annual cost by dividing the purchase price of the item by the appropriate annualization factor.

Recurrent costs

Recurrent costs items consist of:

- fuel or electricity used by the treatment technology
- equipment maintenance
- safety boxes for sharps
- bags for non-sharp medical waste
- containers, closed bins, closed jars or puncture-resistant jars for collection, disinfection or transportation
- blades if needle cutters are used
- disinfectant if syringes and needles are disinfected manually
- puncture-proof and leak-proof containers and of material such as cement mortar, bituminous sand, etc. for encapsulation
- transport
- staff salaries for managing the waste, supervision and transport
- short-term training

Like capital items, the costs of the recurrent items should be estimated on an annual basis. Calculations are done as follows:

1. Identify the recurrent cost items used in the waste management system.
2. Estimate the annual quantities needed of each item.
3. Determine the unit costs of each item (the unit cost of each item is either collected from the supplier of the item or from past receipts).
4. Calculate the total, annual costs by multiplying the quantity with the respective unit costs.

Staff salaries can often be considered as an "opportunity cost", i.e. salaries are not directly related to waste management and are not directly budgeted for. Additional staff is rarely recruited to manage medical waste. However, time spent on waste management (as opposed to any other task) represents a cost. A monetary value is determined based on the salary of the person in charge and the time spent on activities related to waste management (operating, maintenance, etc.). Time of the treatment process and capacity of the treatment option have to be incorporated into the costing model.

Similarly, transport items include direct and indirect (or opportunity) costs. Direct costs are the fuel needed, whereas indirect costs consist of the time spent on transport, and not on any other activity. Direct transport costs are calculated by multiplying the quantity of fuel needed, based on the distance in kilometres to be driven, by the unit price of the fuel. Indirect transport costs are estimated by adding the time necessary to go to and from the treatment site (incinerator or landfill) to the time of loading and unloading the trucks. A correction factor could be applied to the total time estimated, based on the fact that some of the trips made to the treatment facility or landfill could have been carried out anyway (trip to collect drugs, etc.). The adjusted transport time would be multiplied by the salary of the person in charge. The same criteria or methodology apply for the final disposal of residues. If waste is to be transported to a centralized final disposal unit, direct and indirect transportation costs are to be calculated as explained above.

Estimating costs per ---kilogram of waste managed

Costs per kilogram of waste managed should be estimated by dividing total, annual costs by the estimated number of kilograms of waste managed per year (generated in their own or other facilities). For planning of waste management of immunization services, it might be of interest to estimate the costs per syringe. An estimate of the costs per syringe will be generated by dividing the annual costs of waste management by the approximate number of syringes treated, or by dividing the cost per kilogram of waste managed by the number of syringes per kg. The total number of syringes per kg is approx.200.

10. Health care waste management training (see reference document in Annexe A)

- Principles of health care waste management
- Employees' responsibilities
- Employees' poles in management program

11. Introduction to treatment options

Today there are no systems without disadvantages and the final choice of the best available alternative is dependent on local conditions rather than global policy.

<u>Working / Decision tool</u>

<u>Parameters to assess before selecting options</u>

- Need at PHC: Quantity of waste Kg / day / category
- PHC resources available (human, budget, material)
- Availability of a national HCWM legislation: yes / no
- Availability of a national HCWM plan: yes / no
- Overview of options used in the country
- Equipment available in the country or region
- Treatment in central facility possible: yes / no
- Availability of reliable transportation: yes / no
- Power supply on site: yes / no
- Space available at PHC
- Estimate of running cost and total cost

SELECTION OF FEASIBLE OPTIONS

Overview of disposal and treatment methods suitable for different categories of health-care waste

Technical options	Non Plastic Infectious waste	Anatomical waste	Sharps	Pharmaceutical waste	Chemical waste
ON SITE					
Waste Burial	Yes	Yes	Yes	Small quantities	Small quantities
Sharp pit	No	No	Yes	Small quantities	No
Encapsulation	No	No	Yes	Yes	Small quantities
Inertization	No	No	No	Yes	No
Low T° burning (. < 800°C)	Yes	Yes	No	No	No
Med T° burning (800 – 1000°C)	Yes	Yes	Yes	No	No
High T° burning (.> 1000C°)	Yes	Yes	Yes	Small quantities	Small quantities
Steam autoclave	Yes	No	Yes	No	No
Microwave	Yes	No	Yes	No	No
Chemical	Yes	No	Yes	No	No
Discharge to Sewer	No	No	No	Small quantities	No
OFF SITE					
Sanitary landfill	Yes	No	No	Small quantities	No
Other methods				Return expired drugs to supplier	Return unused chemicals to supplier

Characteristics of different options for treatment and final disposal of infectious sharp health care wastes

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Waste Burial Pit sides covered with a low permeability material, covered and fenced. The pit should be sealed with cement once it is full or at least the last 50cm should be filled with compacted soil and the area identified.	▪ Low tech ▪ Simple ▪ Adequate for small quantities of waste ▪ No atmospheric pollution (non burn technique)	▪ Requires space available ▪ Does not disinfect waste ▪ Might be a risk to community if not properly buried ▪ Potentially easy access to non-authorized personnel ▪ No volume reduction ▪ May fill up quickly ▪ Potential soil and water pollution	▪ Correct segregation of waste ▪ Depth of ground water ▪ Size ▪ Lining of pit ▪ Impact of rainy season	▪ According to pit size	Low construction cost Low cost of cement
Cemented sharp pit Pit well covered with a narrow access for sharps. Should be filled with cement once full.	▪ Low cost ▪ Simple ▪ Adequate for large quantities of needles ▪ No atmospheric pollution (non burn technique)	▪ Space availability ▪ Does not disinfect waste ▪ No volume reduction ▪ Potential soil and water pollution	▪ Correct segregation of waste ▪ Depth to ground water ▪ Depth, size ▪ Design	▪ Needles: 1 million in $1m^3$ ▪ Needle + syringes: 30 000 in $1m^3$	Construction cost: approximately US$50 /$1m^3$ Low cost of sealing material

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
<u>Encapsulation</u> A process in which full safety boxes or disinfected needles are placed within high-density plastic containers or metal drums. When the containers are full, an immobilizing material such as plastic foam, sand, cement or clay is added. Once dry the containers are sealed and disposed of in landfill sites or waste burial pits.	▪ Low tech ▪ Simple ▪ Prevents needle reuse ▪ Prevents sharp related infections / injuries to waste handlers / scavengers ▪ No atmospheric pollution (non burn technique)	▪ Requires space availability ▪ No volume reduction ▪ Does not disinfect waste ▪ Potential soil and water pollution	▪ Correct segregation of waste ▪ Sealing method	▪ About 3000 needle-syringes in a 200 l drum.	▪ Low cost of equipment: plastic containers or metal drums ▪ Low cost of immobilizing material
<u>Inertization</u> Mixing of waste with cement before disposal in order to minimize the risk of leakage of toxic substances contained in the waste	▪ Simple ▪ Safe ▪ May be used for pharmaceutical waste ▪ No atmospheric pollution (non burn technique)	▪ Not applicable to infectious health care waste.			Cost of cement only

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Low Temperature burning (< 400°C) Open air burning of waste in pits, drums, open - brick enclosures on the ground, single chamber incinerator. Waste residues and ashes are buried.	▪ Reduction in waste volume and weight ▪ No need for highly trained operators ▪ Relative high disinfection efficiency	▪ May require fuel, dry waste to start burning ▪ Incomplete combustion ▪ May not completely sterilize ▪ Potential for needle stick injuries since needle are not destroyed ▪ Toxic emissions (i.e. heavy metals, dioxins, furans, fly ash) poses a threat to health and violate environmental health regulations ▪ Emits heavy smoke and has potential fire hazard ▪ Production of hazardous ash containing leachable metals, dioxins and furans may pollute soil and water ▪ Produces secondary waste	▪ Correct segregation of waste ▪ Waste moisture content ▪ Combustion chamber filling ▪ Temperature / residence time ▪ Maintenance & repairs	▪ 100 to 200 kg / day ▪ Drum: ▪ 5 to 10kg/day	Purchase price of single chamber incinerator: up to US$1,000

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Medium Temperature burning (800 – 1000°C) Relatively high-temperature burning (i.e. above 800°) reduces combustible waste to incombustible matter and results in a very significant reduction of waste volume and weight. The high temperatures attained via incineration ensure full combustion and sterilization of used needles. Incineration produces a small amount of ash and waste material that must be buried.	▪ Reduction in waste volume and weight ▪ Reduction in infectious material ▪ Prevents needle reuse ▪ Achieves complete sterilization of contaminated wastes	▪ May require fuel or dry waste for start up and maintenance or high temperatures ▪ Possible emission of toxic emissions (i.e. heavy metals, dioxins, furans, fly ash) poses a threat to health and violate environmental health regulations ▪ Potential heavy smoke ▪ Production of hazardous ash containing leachable metals, dioxins and furans may pollute soil and water ▪ Requires trained personnel to operate ▪ Potential for needle stick injuries since some needles may not be destroyed	▪ Correct segregation of waste ▪ Moisture content in wastes ▪ Filling of the combustion chamber ▪ Achieving Temperature / residence time ▪ Maintenance & repairs ▪ May require fuel ▪ Population density in the nearby community ▪ Requires trained staff for operation and maintenance	▪ 10 kg to 50kg / hour	Purchase price of incinerator: US$1,000-15,000

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
High Temperature burning (> 1000C°)	▪ Complete combustion and sterilization of used injection equipment ▪ Reduced toxic emissions ▪ Greatly reduces volume of waste	▪ Expensive to build, operate and maintain ▪ Requires electricity, fuel and trained personnel to operate ▪ Possible emission of toxic emissions (i.e. heavy metals, dioxins, furans, fly ash) poses a threat to health and violate environmental health regulations unless pollution control devices are installed ▪ Production of hazardous ash containing leachable metals, dioxins and furans may pollute soil and water	▪ Correct segregation of waste ▪ Moisture content in wastes ▪ Filling of the combustion chamber ▪ Achieving Temperature / residence time ▪ Maintenance & repairs ▪ May require fuel ▪ Requires trained staff for operation and maintenance	▪ 50 kg to 500 kg / hour	Purchase price of incinerator: US$50,000-100,000 Running costs: Fuel

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
<u>Rotary Kiln</u> A rotating oven with a post-combustion chamber. High T° burning (1200 – 1600 °C)	▪ Adequate for infectious waste, most chemical waste and pharmaceutical waste. ▪ Very effective at high temperatures ▪ Reduces significantly volume and weight	▪ Not for pressurized containers, waste with high heavy metal content ▪ Require skilled staff to operate	▪ Correct segregation of waste ▪ Moisture content in wastes ▪ Achieving Temperature / residence time ▪ Maintenance & repairs ▪ Operation and equipment cost are high ▪ Energy intensive ▪ Requires trained staff	▪ 0.5 to 3 tonnes/hour	Purchase price: approximately US$350,000 Running costs: approximately US$15,000 per year for energy and maintenance
<u>Needle remover</u> The used needle is inserted into a device which cuts or pulls the needle off from the syringe. Various designs available ranging from manual pliers (not recommended) to manually enclosed boxes (needle poppers).	▪ Prevents needle re-use ▪ Inexpensive models available (some can be made locally) ▪ Drastically reduces volume of most dangerous types of waste, i.e. contaminated needles ▪ Plastic syringes can be recycled after disinfection ▪ Easy to operate	▪ Splash back of bodily fluids may pose a significant risk to operator and contaminate working areas ▪ Some models require electricity ▪ Needles and syringes are still infectious ▪ Breaks down ▪ Needles may point out of the receiver underneath ▪ Safety profile not established	▪ Correct segregation of waste ▪ Needle cutter should be designed in such a way that they do not allow "splash back" of bodily fluids ▪ Should be easy to operate ▪ Reduces occupational risks to waste handlers and scavengers ▪ Need to be used in conjunction with another waster disposal technique (e.g. burial pit)	▪ Blade life: 200 000 cuts	Purchase price: US$2-80
Technical options on	**Strengths**	**Weaknesses**	**Decisive factors**	**Performance**	**Cost information**

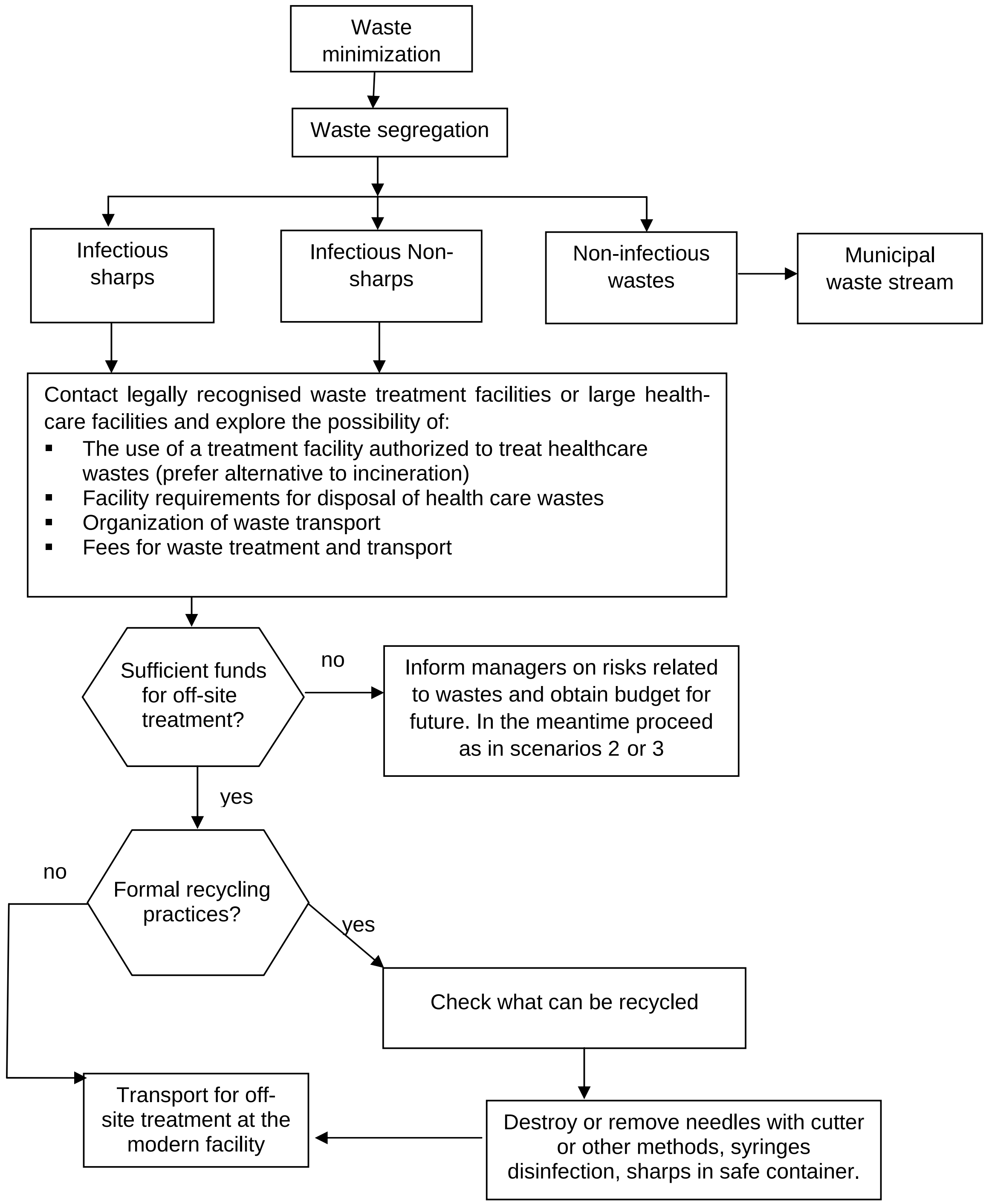
site					
<u>Needle destroyer</u> The needle is inserted into a closed box and makes contact with an electrical device that destroys it. Ashes are stored in an attached container. Various models are available commercially.	▪ Almost completely destroys the needle ▪ Plastic syringes can be recycled after disinfection ▪ Small ▪ Complete disinfection of the entire needle	▪ Requires electricity ▪ A sterile piece of the needle remains attached to the syringe	▪ Correct segregation of waste ▪ Requires electricity ▪ Maintenance of the electrical contacts	▪ Results It takes 2 seconds to destroy one needle	Purchase price: US$100-150
<u>Steam autoclave</u> Waste is added to a large autoclave where a combination of heat and pressure sterilizes the waste. Various commercial models are available. In some countries locally made autoclaves are available.	▪ Sterilizes many types of waste such as used injection equipment ▪ Low adverse environmental impact ▪ Facilitates plastic recycling ▪ When combined with shredding reduces waste volume and can safely be handled as municipal solid waste ▪ Low operating cost	▪ Requires electricity ▪ Medium to high capital cost ▪ Requires well-trained staff for operation and maintenance ▪ May emit volatile organics in steam during depressurisation and opening of chamber ▪ Not suitable for all waste types ▪ Waste appearance unchanged ▪ Waste weight unchanged ▪ Requires further treatment to avoid reuse (e.g. shredding) Resulting sterile waste still needs to be disposed off	▪ Correct segregation of waste ▪ Temperature / pressure ▪ Requires electricity ▪ Steam penetration ▪ Waste load size ▪ Treatment cycle length ▪ Chamber air removal	▪ 12kg / day to 90kg / hour	Purchase price: US$500-50,000 Running costs: Electricity

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
<u>Microwave</u> Micro organisms are destroyed by the action of microwaves that rapidly heat the water contained within the wastes.	▪ Significant volume reduction ▪ Waste made unrecognizable ▪ No liquid discharge	▪ High investment cost ▪ Increased waste weight ▪ Not suitable for all waste types ▪ Potential contamination of shredder, exposure to pathogens ▪ Uncharacterised air emissions	▪ Correct segregation of waste ▪ Waste characteristics ▪ Moisture content of wastes ▪ microwave source strength ▪ Duration of microwave exposure ▪ Extent of waste mixture	▪ 40 kg/day to. 250 kg/h	Purchase price: US$70,000-500,000 Running costs: Electricity
<u>Chemical treatment</u> Treatment of wastes with chemical disinfectants e.g. bleach (sodium hypochlorite 1% solution)	▪ Simple ▪ Relatively inexpensive ▪ Disinfectants widely available	▪ Disinfectants may be corrosive and need to be handled safely ▪ Proper concentrations must be used for specific lengths of time to ensure adequate disinfection ▪ No waste volume reduction ▪ Environmental health concerns when disinfectants are disposed of ▪ Uncharacterised air emissions	▪ Correct segregation of waste ▪ Chemical concentration ▪ Temperature and pH ▪ Chemical contact time ▪ Waste/chemical mixing ▪ Requires availability of disinfectants ▪ Requires further treatment / disposal e.g. encapsulation, burial, etc.	▪ High performance	Cost of disinfectant only

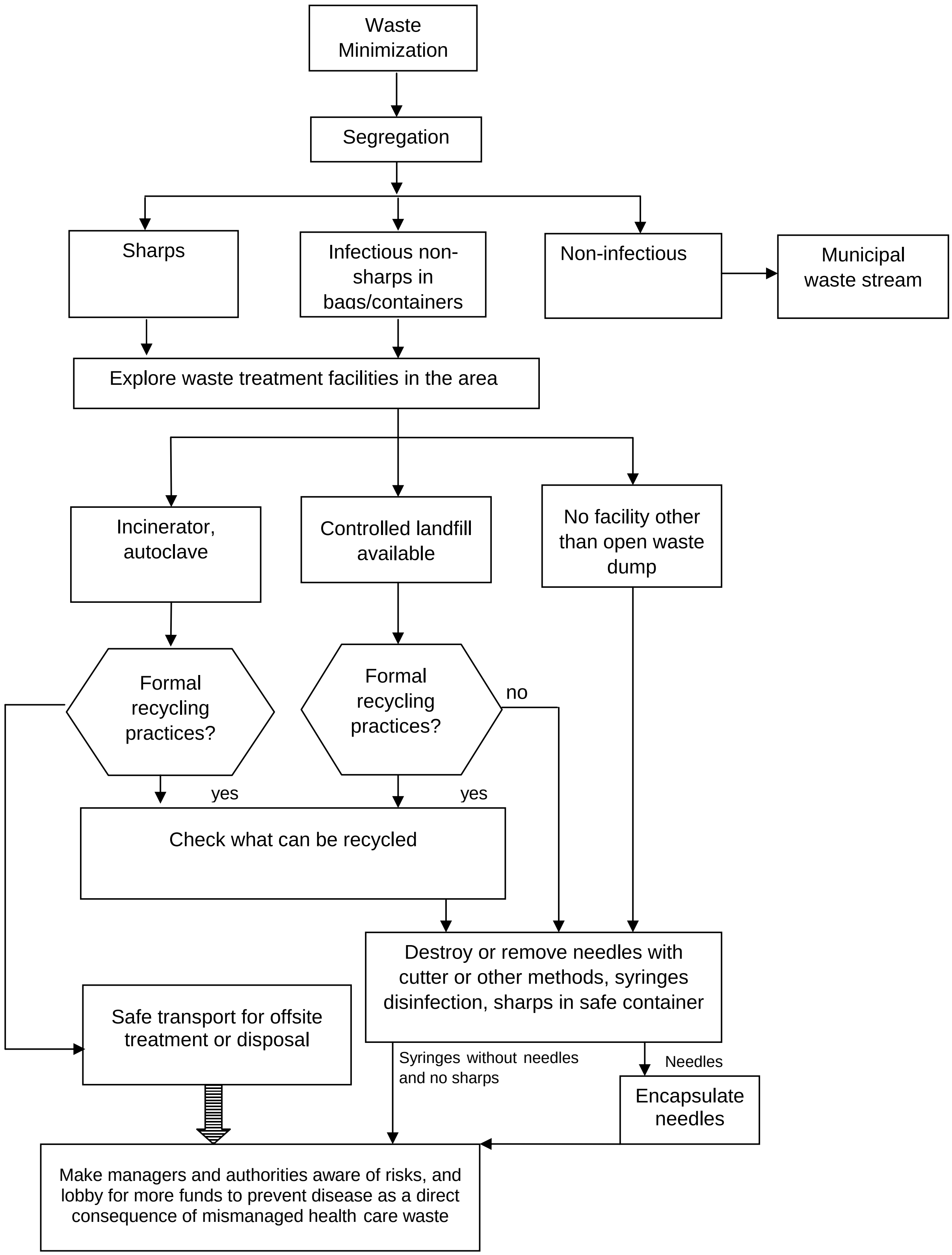
Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Shredding After autoclaving, the wastes are often added to a mechanical shredder to reduce their volume. Various commercial locally-made models are available	▪ Reduces waste volume ▪ Facilitates plastic recycling ▪ After autoclaving the waste can be safely handled as solid municipal waste	▪ Requires electricity	▪ Correct segregation of waste ▪ Requires electricity	▪ 50kg to X tonnes /hour	Cost of shredder: If locally made grain mill, then low cost; Up to US$100,000 for a 4t/hour-capacity shredder
Syringe melter Used syringe needles are placed inside a metal pot which is heated in a specially designed oven. The syringes melt and form a cake that can be disposed of as solid waste. Commercial models are not widely available	▪ Prevents needle reuse / scavenging ▪ Sterilizes the used syringes and needles ▪ Treated waste handled as solid waste ▪ Greatly reduces volume wastes	▪ High electricity consumption ▪ May emit localized air pollutants (needs a well-ventilated working area) ▪ Scarce availability of commercial models	▪ Correct segregation of waste ▪ Requires electricity		High use of electricity

Technical options off site	Strengths	Weaknesses	Decisive factors	Performance	Cost informatio n
<u>Sanitary landfill</u> Wastes are disposed of in the ground at a landfill site. Landfills are specifically designed to prevent wastes from contaminating the environment. Public access to the landfill is restricted. Trained staff manages the wastes at the site. Landfill is a supervised facility as opposed to as open / unregulated dumping of wastes.	▪ Controlled adverse environment al impact ▪ Final disposal wastes away from the healthcare facility	▪ Requires organized transportation ▪ Requires good operation and maintenance to prevent environmental health risks	▪ Correct segregation of waste ▪ Needs a secured transport to landfill site, especially if the waste is still infectious or not encapsulated / mutilated ▪ Landfills must be properly designed to prevent environmenta l health risks	▪ Depends on space availability	Costs vary between settings
<u>Plastic recycling</u> Plastic syringes are reprocessed for the production of other plastic products (buckets, benches, etc.)	▪ Creates income generating opportunities Environment ally friendly ▪ Used syringes are turned into useful products	▪ Needles or needles parts need to be removed ▪ Contaminated syringes need to be disinfected prior to recycling ▪ Requires sustained demand for recycled plastics ▪ Requires established infrastructure for recycling plastic products	▪ Requires established recycling industry willing to acquire recycled plastics ▪ Requires markets for products made from recycled plastics		Purchase price of thermoplast: approximately US$15,000

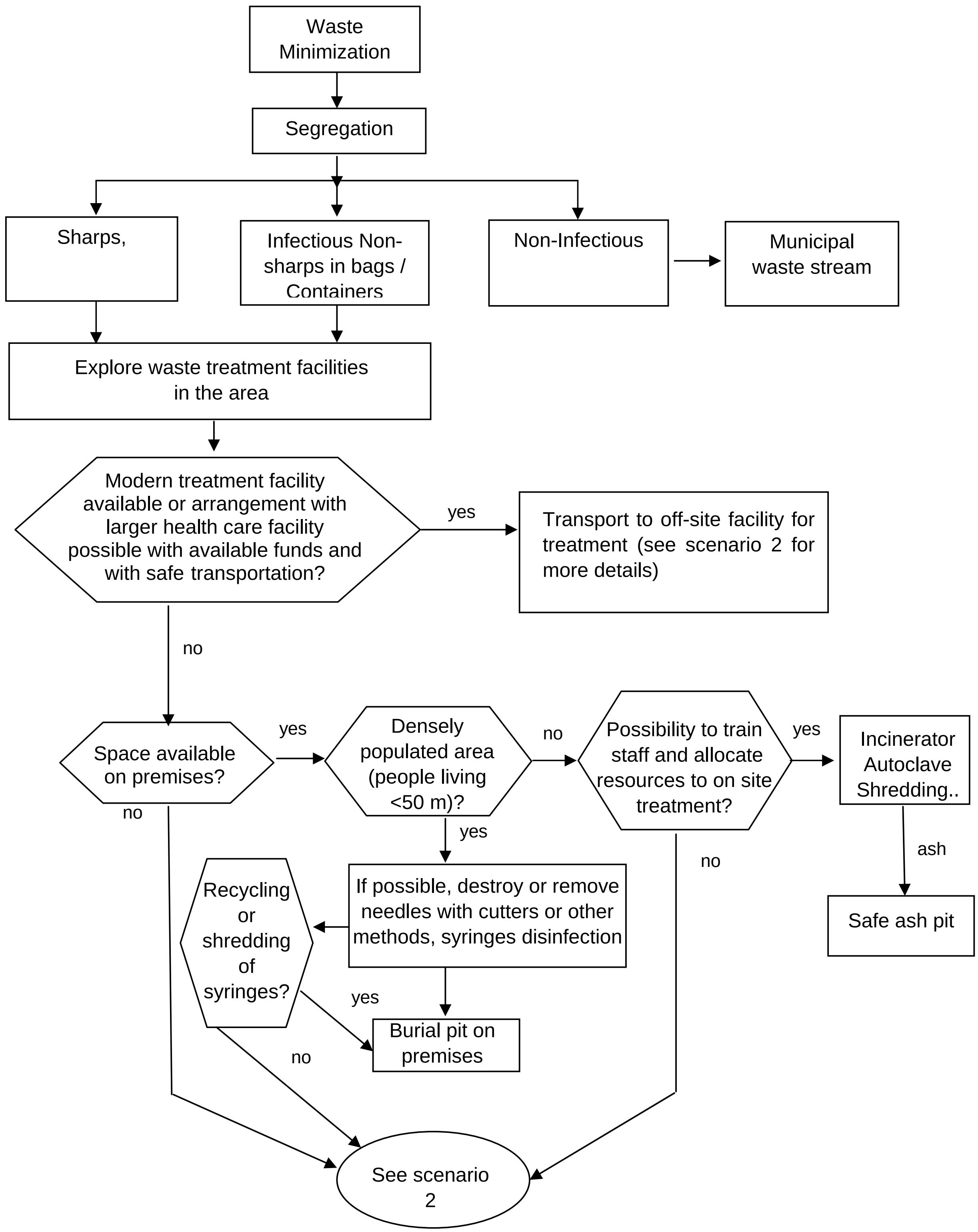
Scenario 1: Urban area with access to a legally approved modern waste treatment facility



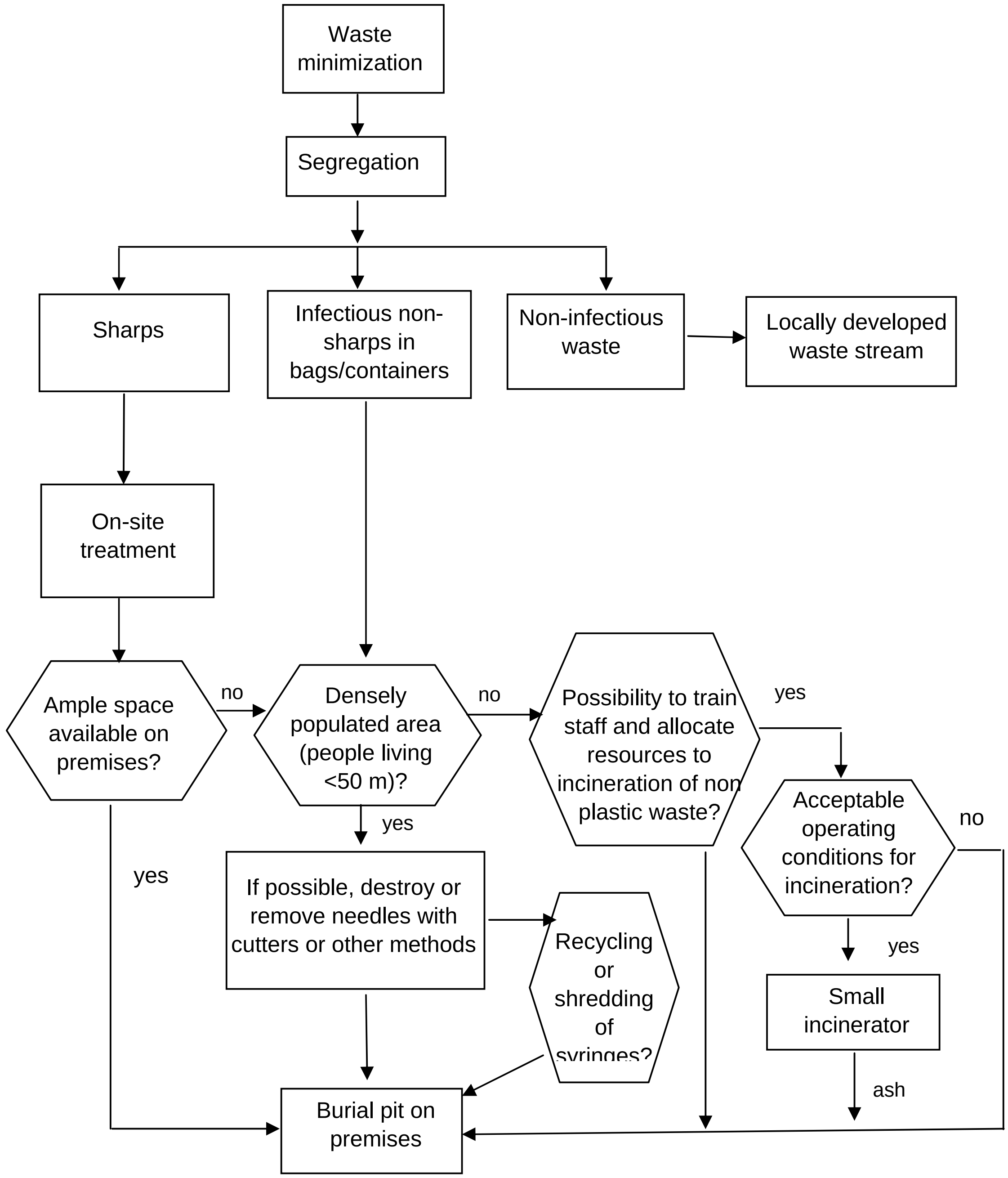
Scenario 2: Urban area without access to a legally approved modern waste treatment facility



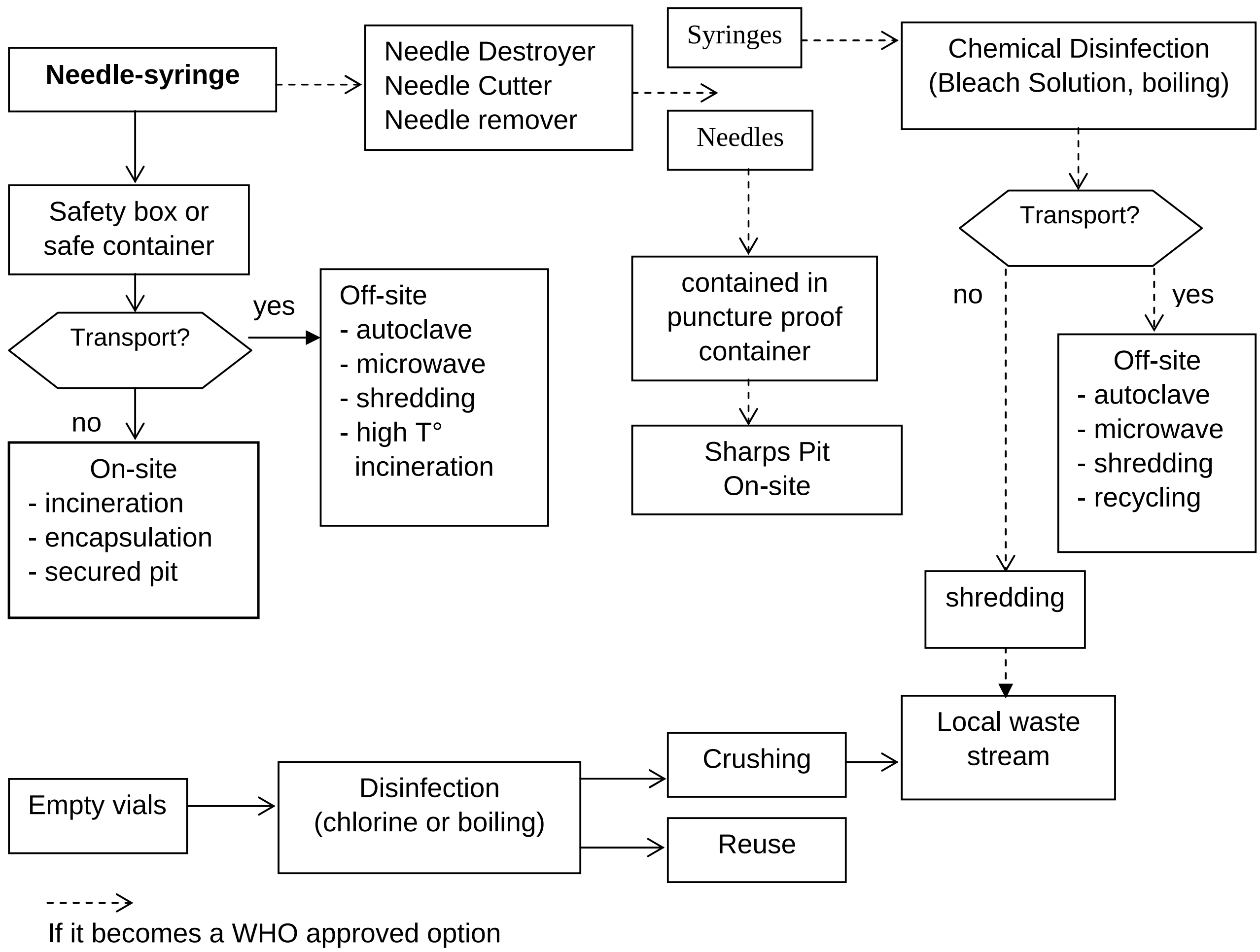
Scenario 3: Peri-urban area



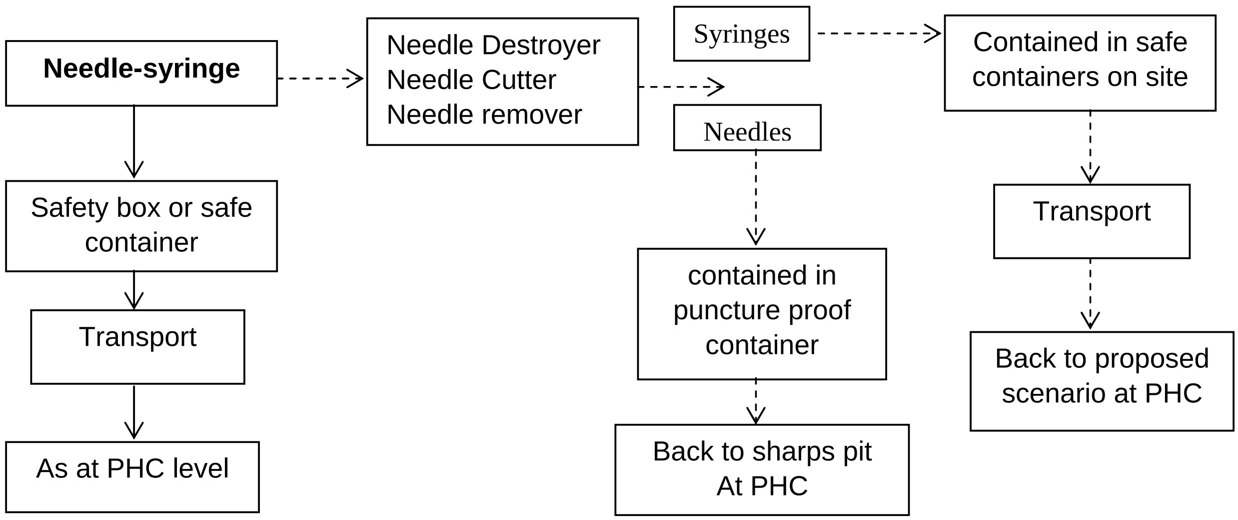
Scenario 4: Rural area without access to a legally approved modern waste treatment or disposal facility



Scenario 5: Needle-syringes waste management - immunization at PHC



Scenario 6: Needle-syringes waste management - outreach immunisation activities.



- - - - -> If it becomes a WHO approved option

Empty vials back to PHC

Annex A

Further sources of information on the management of health-care wastes

1. Web sites containing resource material and additional information:

www.healthcarewaste.org and www.who.int/water_sanitation_health

- Database with management options of HCWM for developing countries
  This compilation aims at improving access to technologies and promoting practical, safe and sustainable solutions by making available practical information on HCWM options that are potentially suitable for developing country situations.
- Country information
- News
- On-line documents

www.injectionsafety.org

For related information on safety of injection

2. Addresses:

WHO Regional Office for Africa, P.O. Box BE 773, Harare, Zimbabwe
WHO Regional Office for the Americas, 525, 23rd Street, N.W.- Washington, D.C. 20037, USA
WHO Regional Office for the Eastern Mediterranean, WHO Post Office, Abdul Razzak Al Sanhouri Street, Naser City, Cairo 11371, Egypt
WHO Regional Office for Europe, 8, Scherfigsvej, DK-2100 Copenhagen 0, Denmark
WHO Regional Office for SouthEast Asia, World Health House, Indraprastha Estate, Mahatma Gandhi Road, New Delhi 110002, India
WHO Regional Office for the Western Pacific, P.O. Box 2932, 1099 Manila, Philippines
PATH, 1455 N.W.Leary Way, Seattle, WA 98107, USA; Tel: +1 206 285-3500; Fax: +1 206 285-6619; www.path.org ; E-mail: info@path.org
Additional contact addresses are available from www.healthcarewaste.org.

3. Available materials

Aide-mémoire for a national strategy for health-care waste management
This aide-mémoire summarizes basic activities to be undertaken at national and local levels to ensure safe management of health-care waste.
2 pages, available on www.who.int/water_sanitation_health, *under health-care waste or* www.healthcarewaste.org

Health-care Waste Management - Policy Paper and fact Sheet.
These documents provide information on the dangers of unsafe health-care waste management and the need to evaluate the risks and benefits when establishing an appropriate strategy. It outlines the guiding policy principle directing WHO activities in this area. In addition, short, medium and long-term strategies for improving health-care waste management are described.
Available on www.who.int/water_sanitation_health, *under health-care waste or* www.healthcarewaste.org

Safe Management of wastes from health-care activities

This comprehensive handbook covers various theoretical and practical issues related to health-care wastes, including an outline of related risks, organizational issues within the health-care facility and at national level, examples of regulatory frameworks, handling, storage and treatment options of wastes. Although it addresses both simple and more sophisticated options, its emphasis lies on developing countries. The handbook also contains a section on minimal programmes for health-care waste management.
230 pages; full text available on www.who.int/water_sanitation_health, *under health-care waste* or www.healthcarewaste.org*; 1999, paper copy Sw.fr. 72.- or 50.40 in developing countries from the World Health Organization.*

Teacher's Guide: Safe management of wastes from health-care activities
The teacher's guide accompanies the forthcoming WHO publication on management of wastes from health care activities. It provides teaching materials (ready-to-copy texts for overhead transparencies, lecture notes, handouts, exercises and course evaluation forms) and recommendations for a three-day training course. It is designed mainly for managers of health care establishments, public health professionals and policy makers.
227 pages; full text available on www.who.int/water_sanitation_health, *under health-care waste* or www.healthcarewaste.org*; World Health Organization, 1998.*

Rapid assessment tool for national level assessment
This tool has been designed by WHO to assess the management of wastes from health-care activities at the level of a country. It allows drawing a picture of current practices, understanding the level of awareness regarding risks associated with unsafe health-care waste management, and evaluating the existing regulatory framework. In addition, it provides the necessary information to design an action plan on the basis of the information collected so that information can be actively followed with action.
Tool available in Excel format on www.who.int/water_sanitation_health, *under health-care waste or* www.healthcarewaste.org.

Preparation of national health-care waste management plans in Sub-Saharan countries - a guidance manual
This manual is the product of experiences gathered over the last few years (2000 - 2004) in conducting technical assistance projects in several countries in the sub-Saharan region and aims at identifying appropriate practices for health care waste management by providing useful assessment and planning tools applicable in most sub-Saharan countries of Africa. The document is divided in fours sections. Section 1 contains fundamental information, section 2 presents actions, section 3 provides guidance and section 4 cover strategy to implement health care waste management plans.
Manual available on www.who.int/water_sanitation_health, *under health-care waste or* www.healthcarewaste.org.

Management of wastes from immunization activities - practical guidelines for planners and managers

This document provides practical guidelines for planners, managers of health -care facilities or mobile team leaders to improve planning and coordination at the central level as well as waste management practices at the local level where immunization activities are conducted. It is divided into 4 parts: Elements of strategy, chronological management plan, recommendations for practical waste management procedures and tool boxes and last, a glossary of terms.

Tool available on www.who.int/water_sanitation_health, *under health-care waste or* www.healthcarewaste.org.

Findings on the assessment of small-scale incinerators for health care waste.

This report provides analysis of low cost small-scale incinerators used to dispose of health care waste in developing countries, specifically sharps waste. The report includes a situation analysis, a best practices guide to small-scale incineration, a screening level health risk assessment for ingestion and inhalation exposure to dioxin-like compounds, and other information related to the operation and evaluation of the incineration option for health care waste.

Document available on www.who.int/water_sanitation_health, *under health-care waste or* www.healthcarewaste.org

Health-care waste management - Guidance manual for the development of national action plans.

This guidance document is part of an overall WHO strategy which aims at reducing the disease burden caused by poor health-care waste management through the promotion of best practices and the development of safety standards.

Document available on www.who.int/water_sanitation_health, *under health-care waste or* www.healthcarewaste.org.

Annex B

Waste prevention, reduction and storage

Waste prevention and reduction

The design and implementation of waste prevention and reduction programmes for health-care facilities involve a number of activities. The activities include characterisation of the waste, identification of waste prevention and reduction opportunities, implementation, and education and training. Examples of waste prevention and source reduction methods applicable to PHC centres include modification of purchasing procedures that result in less packaging materials requiring eventual discard, control of inventory so that the shelf-lives of materials (e.g. drugs, sterilised supplies) do not expire before use, the substitution of less toxic materials than those currently in use, and onsite use of discarded materials so that they do not require collection and disposal beyond the PHC site. Some suggestions are provided in the following box.

Box 1. Examples of practices that encourage waste minimization

Source reduction

- Purchasing reductions: selection of supplies that are less wasteful or less hazardous
- Use of physical rather than chemical cleaning methods (e.g. steam disinfection instead of chemical disinfection)
- Prevention of wastage of products, e.g. in nursing and cleaning activities

Stock management of chemical and pharmaceutical products

- Frequent ordering of relatively small quantities rather than large amounts at one time (applicable in particular to unstable products)
- Use of the oldest batch of a product first
- Use of all the contents of each container
- Checking of the expiry date of all products at the time of delivery

Storage of waste

PHC waste includes sharps, infectious non-sharps and non-infectious waste.

Improperly handled and stored sharps represent a significant hazard to healthcare staff charged with managing PHC wastes. Special, dedicated containers made of plastic or cardboard are available in some locations for storing used sharps. If such safety boxes are not available, other types of containers that can serve as containers for sharps are cardboard boxes and used plastic bottles. Another type of safety boxes is designed to remove used hypodermic needles from their syringes without risk to the user, and to serve as a safe storage vessel. Needle removers extract, cut or burn needles. Removed needles are safely contained within the device or an attached container which can be emptied or disposed in a sharp pit once three quarter full. The mutilated syringe can then be treated as an infectious waste. Some examples of containers that can be used for collecting sharps are displayed in Figure B-1.

Non-sharps should be stored in closed containers. Appropriate types of containers for their collection include plastic bags with closures or plastic bags placed in metal or plastic containers with lids. A larger container can then be used to store the waste bags when they are full.

Figure B-1. Examples of safety boxes or hard plastic containers for storing used syringes and needles

Annex C

Waste treatment technologies

The following options could be applied to PHC waste, according to the situation:

- Shredding or removal of needles from the syringes (after disinfection)
- Encapsulation (or solidification) of sharps
- Disinfection
  - Steam/thermal
  - Microwave
  - Chemical
- Incineration
  - Uncontrolled (to be avoided)
    - Open pit
    - Burning
  - Controlled
    - Small incinerator
    - Large incinerator

These waste treatment technologies are described below, and more detail can be found in the resource material described in Annex A.

Removal of needles from syringes

Needle removal of used syringes and needles can render them unfit for reuse and safe for disposal after disinfection. Various types of removal of needles or size reduction technologies are available. Some types require a source of electrical power (needle burner) and their wide application in developing countries is limited, particularly in remote areas. Additionally, these burning devices must be regularly maintained and operated carefully.

Needles can also be removed from the syringe just after the injection by small manually operated devices. The mutilated syringe needs to be disinfected prior to disposal with communal waste. Additional information about needle removers can be found by contacting PATH (see Annex A) and at www.healthcarewaste.org.

Shredding.

Shredders cut sharps into small pieces. This technology requires a worker skilled in the operation and maintenance of sometimes heavy-duty, rotating equipment. Simple shredders can be made from a manually operated grain mill. Due to the risk to workers during operation, only disinfected needles and syringes should be processed. Shredding leading to plastic and needle recycling technologies in developing countries can be considered when large quantities of used needles and syringes are available, implying a centralized system involving collection and transportation from various settings.

Encapsulation

Encapsulation (or solidification) refers to the containment of a small number of hazardous or dangerous items or materials in a mass of inert material. The purpose of the treatment is to isolate the dangerous items or materials from humans and the environment by encapsulating them in an impervious mass. Encapsulation involves filling containers with waste, adding an immobilizing material, and sealing the containers. The process uses either cubic boxes made of high-density polyethylene or metallic drums, which are three-quarters filled with sharps and chemical or pharmaceutical residues. The containers or boxes are then filled up with a medium such as plastic foam, bituminous sand, cement mortar, or clay material. After the medium has dried, the containers are sealed and disposed of in landfill sites. The main advantage of the process is that it is very effective in reducing the risk of scavengers gaining access to the hazardous health-care waste. Encapsulation of used sharps is generally not practised and not a long term solution. Encapsulation of sharps or unwanted vaccines could, however, be envisaged in temporary settings, such as camps, or mass campaign, provided that raw materials are available. For more information see the HCW database at www.healthcarewaste.org and WHO, 1998.

Disinfection

Disinfection is aimed at reducing the pathogenic risk of infectious health-care wastes.

Chemical disinfection

Chemical disinfection is generally done by adding bleach or other disinfectants to syringes or other types of infectious wastes. It is uncertain whether or how harmful the syringes still are after such treatment, but in case no more satisfying option is available, such disinfection certainly reduces the risk of infection in case of accidental needle stick before transportation for further treatment.

Disinfection of infectious PHC waste can serve as a pre-treatment step and may be required prior to employing subsequent treatment technologies, e.g. size reduction by shredding. However, little information exists on how safe such methods are.

Steam disinfection

Microwave

Microwave disinfection is essentially a steam-based process, since disinfection occurs through the action of moist heat and steam generated microwave energy. This facility needs electrical power so that their application is very limited in remote areas.

Autoclave

Autoclaving is a low heat thermal process and is designed to bring steam into direct contact with the waste for sufficient duration to disinfect the waste.
Environmentally safe, autoclaving requires in most cases electrical power and for this reason is not always suitable to treat waste at PHC centres.

Controlled Incineration

The benefits of controlled incineration of PHC wastes include volume reduction and the removal of pathogenic risk, as long as the system operates correctly. The drawbacks to incineration include the large capital and operating costs for modern technologies, the need for skilled labour to operate and maintain the system, the potential lack of local access to materials for incinerator construction, the required supplies (e.g. fuels) and the potential for toxic emissions to the air where there is no emission control equipment. Open burning (uncontrolled incineration) of PHC waste should be avoided in nay case, because of risks to workers, not only from uncontrolled toxic gas emissions to the air, but as well from infectious wastes that are only partially burned.

Large modern treatment facilities such as high temperature incinerators are not an option for PHCs, but for a centralized solution. These incinerators would be suitable for some urban or peri-urban areas that require incineration capacity for PHC waste.

In the case of rural PHCs, some simple types of waste incinerators are available. These units are designed to process the small quantities of PHC waste that are generated at rural health-care facilities. Several types of incinerators are on the market or can be locally built with local materials following a relatively simple design. See the construction, operation and maintenance - Waste Disposal Unit (WDU) - WHO AFRO, contact Dr Modibo Dicko - dickom@afro.who.int. Their basic design consists of a simple combustion chamber, or dual combustion chambers (i.e. primary and secondary), and a flue. Combustion and air emission control are minimal or lacking in these units.

Annex D

Local solutions for managing health-care waste

Process	Local solutions
Awareness and training	- Handmade posters and instructional sheets in local languages contests - Contests (at facilities or schools) to develop best posters, brochures etc. - SIGN toolbox (http://www.injectionsafety.org). General awareness raising materials can be downloaded and modified to suit local conditions
Initial containment (safety boxes)	- Cardboard safety boxes made to WHO/UNICEF standards manufacture locally - Safety boxes made from available cardboard, folded and taped at Site - Reusable plastic bucket with round hole cut in plastic lid (work best with sharps disposal in cement-lined pits - Various reusable plastic containers (medicine jars, empty detergent/disinfectant containers, empty cooking oil containers, etc.) with holes cut in them (works best with sharps disposal in cement-lined pit) - Locally manufactured metal box with a hole in top for syringe disposal and pull away bottom for emptying box in purpose build pit - Empty metal cans
Disposal / treatment options:	
Burying	- Purpose-built cement lined burial pits with cement covers - Pit latrines (emergency use) - Old underground tanks
Incineration	- Locally built incinerators
Other options	- Encapsulation with cement - Melting ovens - Needle cutting / destruction - Steam sterilization / shredding of syringes - Chemical disinfection / needle cutting / shredding / plastic recycling
Access control	- Chain-link fence - Scrap metal fence (corrugated iron sheets) - Wood fence - Living fence (trees, cactus…) - Thorn fence - grass or sisal fences

Annex E

Land disposal

The two basic forms of land disposal in developing countries are uncontrolled and controlled. As its name implies, uncontrolled land disposal (i.e. open dumping) is not managed and is not acceptable. Open dumps have no controls over access of unauthorized persons or environmental pollutions. PHC waste should never be disposed in open dumps.

A variety of controlled land disposal options are available to PHC waste. The alternatives range from small pits to a modern sanitary landfill (which is a central facility). These alternatives have improved controls and site security. Methods of land disposal are described by Pruess et al., 1999; Diaz et al., 1996; and Savage et al., 1998.

Examples of disposal pit designs for sharps and for organic wastes are presented in Figures E-1 and E-2.

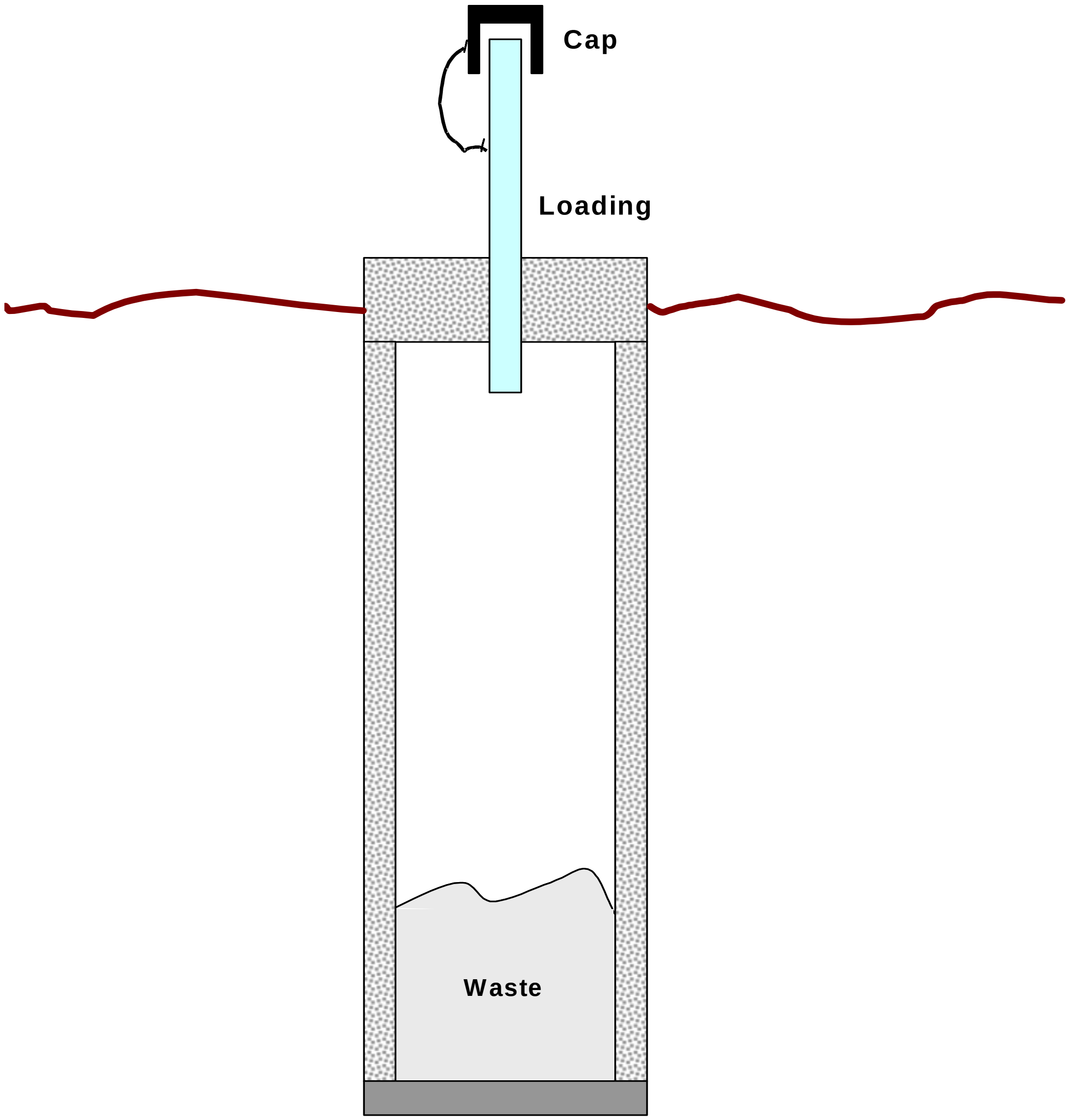


Figure E1. Cross - sectional view of secured disposal pit for sharps

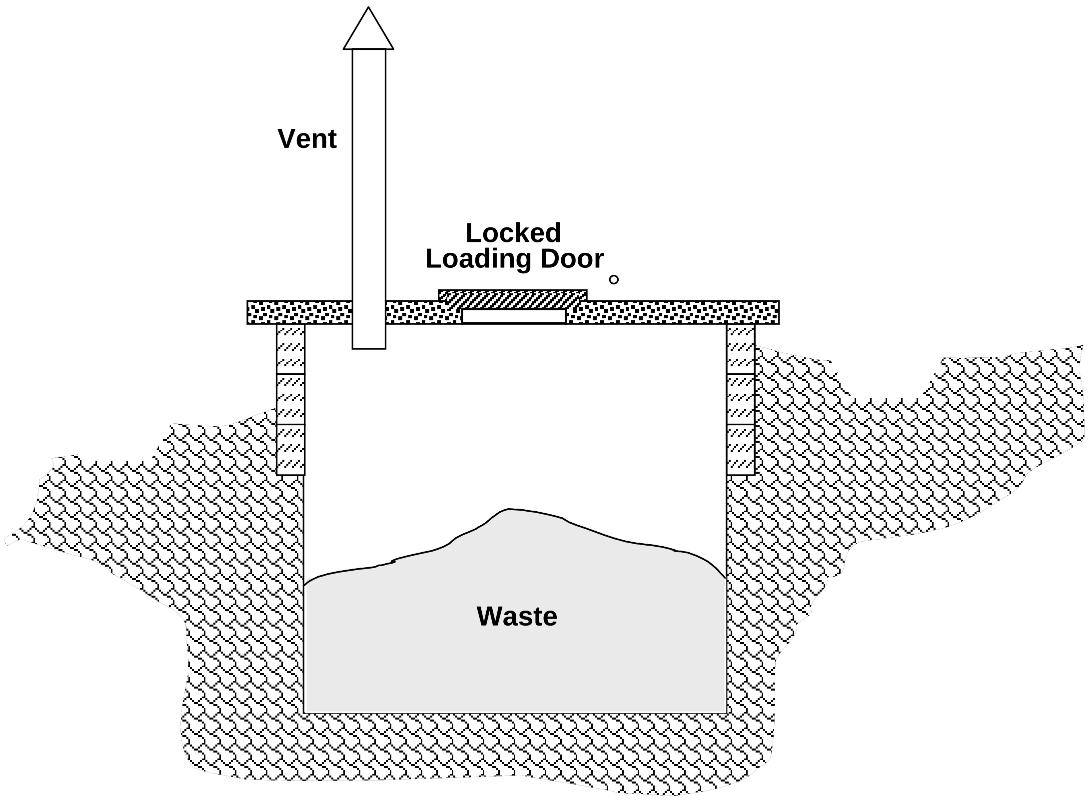


Figure E 2. Cross - Sectional view of secured disposal pit for PHC organic waste

Annex F -

Management of specific wastes

Management of contaminated and infectious AD syringe

- The sharp being removed (needle remover) the syringe is considered as a potential infectious waste and should be treated in that respect.

Options

1 Rural area	Collected in container ⇩ Straight to protected pit or encapsulated in concrete ⇩ Pit or other use	Do not require disinfection May be relatively cheap Requires space Environment friendliness?
2 Small to medium health-care units	Collected in container ⇩ Chemical disinfection (chlorine) or boiling[1] ⇩ Municipal waste or landfill	Involve disinfection Requires chemical or fuel for boiling Relatively cheap Relative disinfection effectiveness
3 Small to medium health-care units	Collected in container ⇩ Chemical disinfection (chlorine) or boiling ⇩ Shredded or not ⇩ Municipal waste, landfill, plastic recycling	Involve disinfection Requires chemical or fuel for boiling Relatively cheap Relative disinfection effectiveness Reduce volume Risk through plastic sharp handling if shredded
4 Urban contexts	Collected in container ⇩ Autoclave or microwave on-site or off-site central facility ⇩ Shredded or not ⇩ Send to municipal waste, landfill, plastic recycling	Involve sterilization Requires high tech equipment Might be expensive at central facility Need transport Good disinfection level Reduce volume Risk through plastic sharp handling if shredded

Managements of vials

- Proper stock management is the key issue to minimize wastages of unused vaccines.
- In presence of a large stock of expired unused vaccines, it must be investigated whether they can be returned to the supplier.

[1] Boiling time - 5 minutes
Chemical disinfection - 0.5% chlorine solution

Disposal of vials

- Vials should not be incinerated or burned. If capped they explode and if uncapped they melt and could block the incinerator grate.

There are two options - no reuse or reuse of vials.

<u>No reuse</u>

A

Dispose of them capped or uncapped into a protected pit.
To reduce the volume, crush them once into the pit.

B

Boil or steam sterilize them capped, then send them to the municipal waste stream or land fill

C

Uncap them all, rinse them with water and a 0.5% chlorine solution - send them to municipal waste stream or land fill.

<u>Reuse</u>

Uncap the expired ones, clean them with water and a 0.5% chlorine solution or boil or steam sterilize according to the existing facilities on site.

- The clean empty vials can be used to contain, e.g. ointment or GV…, or even sold.
- The reuse or recycling as the advantage of controlling the quantity of waste produced.

Management of single use glass syringes

- Do not burn or incinerate as they may explode
- Do not use needle remover as the glass may break

2 options

<u>2 - The simplest with minimum handling risks</u>

Collect the glass syringes in puncture and leak proof and covered containers

⇩

Once 3/4 full - empty the container into a protected sharp pit

⇩

From time to time crush the syringe contained into the pit to reduce the volume.

Note: disinfect the container with a 0.5% chlorine solution then rinse with water.

<u>1 -Where facilities or/and means of transport exists</u>

Collect the glass syringes in puncture proof and covered containers

⇩

Once 2/3 full - autoclave or microwave

⇩

Shredder

⇩

Organized site for sharp wastes at municipal landfill

Disinfection of needle removers

Why?

- Presence of blood or vaccine on and around the blade (splashing).
- On outreach clinic the needle remover needs disinfection.

How?

- Clean the surface with a clothe or brush and a 0.5% chlorine solution or alcohol
- Then rinse with water as the chlorine will corrode the blade.

Annex G

Case study: Estimating the costs of recycling the plastic of AD syringes
(The whole study can be found with WHO/FCH/IVB/VAM)

Introduction
In order to prevent unauthorized reuse of disposable syringes and limit the spread of infections due to malpractices, Ukraine has followed the WHO recommendation to introduce auto-disable (AD) syringes for all immunization activities and has, in April 2003, launched a pilot project aiming to assess the overall safety and viability of recycling the plastic of AD syringes in Khmelnytsky oblast and Kiev city with the support of WHO European Region. While the system used previously consisted of chemically disinfecting syringes and needles and manually separating the needles from the syringes before recycling the syringes, the pilot project introduced needle cutting and autoclaving for the decontamination process. The objective of this case study is to estimate the costs of waste management of AD syringes as carried out in the pilot project and compare these with the costs of the previous system. The costs are assessed from the viewpoint of all partners involved, including the public health sector and the recycling companies, and are reported as the costs per syringe and per kilo of waste managed. The official US dollar exchange rate (on 6.10.2004) of US$1 for UAH5.3 is used for all cost estimates.

Methodology
Data collection took place between 5th and 15th October 2004 in Khmelnytsky oblast and Kiev city. Interviews were conducted with key individuals at MOH and SES in Kiev and Khmelnytsky and with health workers involved in the project. In addition, a questionnaire was sent to all the facilities that could not be visited due to a lack of time and the too long distances to be driven between each of the facilities. Unit costs and quantities of all resource items used in the waste management process were assessed by reviewing expenditure records and interviewing relevant staff about their workload with respect to waste management. All activities and equipment related to waste management are included in the cost analysis. If revenue is being generated by the recycling companies from recycling of waste or by health facilities from selling used syringes to recycling companies, this amount is subtracted from the cost estimates to generate a "net cost" estimate. With the old system, the used syringes were sold at a price of UAH0.65-1.5 (US$0.12-0.29) per kg. It is expected that a slightly lower price can be charged for AD syringes (as not dissembled). In our analysis, we assume a price of UAH0.5 (US$0.1) per kg of syringes.

Costs from the perspective of the health care facilities

This analysis has illustrated that the total cost per syringe treated from the perspective of the health facilities ranges from US$0.020 to US$0.036 with the new system (40%-72% of the price of an AD syringe), depending on whether health facilities are responsible for waste delivery to recycling companies or whether waste is collected by recycling companies directly. The cost greatly varies with the amount of waste generated and level of utilization: the more waste managed the lower the cost per syringe. With the old system, the cost per syringe ranged from US$0.018 to US$0.035, without and with transportation costs respectively (see table below).

Table 1: **Comparison of total costs of previous and current systems per health facility**

	OLD SYSTEM			NEW SYSTEM		
Items	Unit costs	Monthly quantity	Annual costs	Unit costs	Monthly quantity	Annual costs
Disinfectant	12	0.66	95			
Autoclave. Bag				0.4	2	9.6
Safety box				2.0	1	24
Electricity				0.12	1.35	19
Maintenance				44		44
Total items			**95**			**96.6**
Nurse	0.23	44	120	0.23	1.5	4
Head nurse				0.4	1.5	5.4
Driver		2	5.5		2	5.5
Total salaries			**125.5**			**15**
Fuel	0.5	15	180	0.5	15	180
Total transport			**180**			**180**
Capital				Value from new	Useful life years	Annual costs
Needle cutter				15	15	1.3
Autoclave				2,000	25	115
Installation				100	25	5.7
Total capital costs			**0**			**122**
GRAND TOTAL			**400.5**			**413.6**
Revenue generated*			**12**			**6**
NET COSTS			**388.5**			**407.6**
COST PER SYRINGE			**0.035**			**0.036**
Cost per syringe (excl. transport)			**0.018**			**0.020**
Recurrent cost per syringe (current prices, without transport)			**0.0074**			**0.0081**
Recurrent cost per syringe (potential local prices, without transport)			**0.0074**			**0.0057**

* with the following assumptions: 11100 injections a year in each facility, 200 syringes in 1 kg and a selling price of US$0.2 per kg
of used syringes for the old system and of US$0.1 per kg with the current system.

If we, however, only consider recurrent costs, the cost per syringe with the new system varies from US$0.0057 to US$0.0081 (11.4%-16.2% of the price of an AD syringe), depending on whether the recurrent items - autoclaving bags and safety containers - are manufactured locally or not. The recurrent cost per syringe with the old system is US$0.0074. Recurrent cost items included in this estimate are the items that are or should be borne by health facilities, i.e. disinfectant, autoclaving bags, boxes, electricity and maintenance. Salaries are excluded as they are paid by the Ministry of Health. Transport is not included either as we assume transportation costs associated with the new system are similar to the costs that incurred with the old system.

Costs from the perspective of the recycling companies

One of the two recycling companies involved in the pilot project estimated that the recycling of 130kg of syringes from the pilot project had taken fourteen hours. Recurrent costs range between US$51.3-58.8, depending on whether transport is incumbent upon the recycling company or not. Based on the assumption that recycled plastic can be sold at a price that is five times higher than the price paid for the used syringes, our estimates indicate tentative revenue of US$71.5 generated by the sale of syringes recycled within the pilot project, i.e. a profit of US$12.7- 20.2.

Table 2: Cost of recycling 130kg of syringes for the pilot project

Recurrent costs						
	Unit	Quantity/h	Unit costs	Costs / hour	Hours spent on the pilot project	Costs of the pilot project
Electricity						
Shredder	KW	11	0.05	0.55	2	1.1
Metal detector	KW	0.1	0.05	0.005	2	0.01
Extruder	KW	40	0.05	2	2	4
Thermoplast	KW	30	0.05	1.5	8	12
Total electricity						**17.1**
Items						
Used syringes			110	0.130		**14.3**
Transport						
Fuel			0.5	15		7.5*
Salaries			Monthly salary	Hourly salary		
Worker for shredder			150	0.85	2	1.7
Worker for the metal detector			200	1.14	2	2.3
Worker for the extruder			200	1.14	2	2.3
Worker for the thermoplast			300	1.70	8	13.6
Total salaries						**19.9**
TOTAL RECURRENT COSTS for 130 kg of syringes (excluding transport)						**51.3**
TOTAL RECURRENT COSTS for 130 kg of syringes (including transport)						**58.8**
TENTATIVE GENERATED REVENUE from sale of syringes**						**71.5**
MINIMUM PROFIT from recycling 130 kg of syringes (excluding transport)						**20.2**
Minimum profit from recycling 130kg of syringes (transport costs included)						**12.7**
PROFIT PER SYRINGE (without transport)						**0.0008**
PROFIT PER SYRINGE (with transport)						**0.0005**

* based on the assumption that 5l of fuel were needed per trip and that three trips were necessary to collect the 130kg of syringes, transport costs are estimated to be US$7.5

** based on the assumption that recycled plastic can be sold at least at a price five times higher than the price paid for the used syringes.

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