LabCoP Cookbook

of best practices

RECIPE #7: MANAGEMENT OF GUANIDINIUM THIOCYANATE CONTAINING WASTE FROM TESTING LABORATORIES

Policy

Regulation

Funding

Coordination

M&E

Implementation

1 INTRODUCTION

Safe disposal of laboratory waste is a critical component of good laboratory practice. Molecular diagnostic test services, including HIV viral load (VL) and coronavirus disease 2019 (COVID-19) testing, have the potential to generate guanidinium thiocyanate (GTC), a potentially toxic compound, which requires specialised treatment and disposal. Contact between GTC and acids or oxidizers, such as bleach, can release hydrogen cyanide gas in concentrations potentially dangerous to healthcare workers.[1-3] GTC is toxic to animals, humans and aquatic life, and must be managed as hazardous waste according to national regulations and manufacturer recommendations.[1-3]

Demand for VL testing and early infant diagnosis (EID) for HIV continues to increase to match the growing uptake of antiretroviral therapies. This results in growing waste management challenges in many laboratories and health facilities, particularly in low- and middle-income countries (LMICs). The recent need to scale up molecular testing for severe acute respiratory syndrome coronavirus 2 to respond to the COVID-19 pandemic has contributed an additional 731 000 litres of chemical waste (including GTC) as of January 2022.[4] This has exacerbated problems surrounding waste management in testing laboratories in LMICs, which may lack resources and proper infrastructure, resulting in poor compliance with waste management requirements.

Moreover, while manufacturers of molecular diagnostics recommend that GTC-containing liquid waste be disposed of according to country-specific regulations, guidelines or policies, these may be lacking in a number of LMICs in Africa. A survey of waste management practices revealed that liquid waste from HIV VL testing was poured down the drain in four of six African countries despite its harmful effects.[3] Additional challenges around waste management include a shortage of local technical expertise, a lack of infrastructural and technological capacity/innovations and limited financial and human resources to build sustainable waste management systems. Further complicating waste management is a lack of adequate information around the extent of waste being generated and limited awareness of the dangers of hazardous waste to people and the environment.

This LabCoP recipe summarises best practices and solutions proven to work for managing GTC waste in the LMICs of Africa. The recipe is particularly important for any programme conducting molecular testing, such as HIV testing programmes, but many best practices are applicable to broader laboratory waste. This recipe is intended to support the implementation of locally feasible strategies, address the risks posed by GTC waste and build the waste management capacity of healthcare workers. Ensuring that a safe and appropriate waste management system is in place for different hazardous materials can help reduce healthcare costs considerably.[5]

As a first step to improving country management of GTC waste, an assessment of the waste management landscape is necessary to identify gaps and opportunities for improvement around waste management in the country. Various assessment tools have been developed by stakeholders to support this step, including the *VL-self-assessment scorecard*, the Global Fund waste management assessment tools[6] and the *HIV Laboratory Waste Cost Assessment Framework (WCAF)*. Based on the gaps identified through these assessments, country teams may design targeted interventions to address strategic areas around waste management, such as policy and regulation, governance and coordination, infrastructure, implementation and monitoring and evaluation.

2 WASTE MANAGEMENT POLICY AND REGULATION

Policy and regulation around GTC waste needs to be reflective of the direct and indirect hazardous properties of the waste material. For GTC, key hazards include that it is harmful if swallowed, causes severe skin burns and eye damage and is harmful to aquatic life with long-term effects.[2] Consequently, waste management plans need to reflect the various risks posted by GTC to people and the environment.

Both policy and regulation guide practice. Consequently, if both are identified as gaps based on the initial assessment of waste management in the country, an essential first step is to review and evaluate the existing regulatory framework under which GTC waste can be managed in-country. At a local level, many healthcare facilities have unsatisfactory waste management practices due to the lack of waste management plans, as well as lack of enforcement and adherence to policies and standard guidelines.[3] Therefore, each health facility needs to develop a waste management plan for GTC based on the national guiding documents and strictly follow standard guidelines. Here, we share key considerations around evaluating and establishing the regulation, governance and coordination of waste management policies at the national and local/facility level.

KEY CONSIDERATIONS

- **National policy and regulatory frameworks may not exist.** Although countries may have some form of national guidance on general waste management, these often lack specific guidance around chemical waste such as GTC.

- **A dedicated team is required to drive policy and implementation.** This is to ensure that waste management policies are recognised by country leadership and implemented across healthcare facilities. Ideally, a laboratory technical working group under the guidance of the laboratory leadership should be responsible for driving policy and its implementation.

- **Consider the financial aspects of waste management in advance.** Prior to implementation, countries must consider the costs associated with implementing the waste management policies. This includes the cost of investment, the land (in case of landfill), infrastructure (such as treatment facilities, a storeroom, or burial at cemeteries), transport, containers and personal protective equipment required. There are also operating costs (fuel, electricity, water) and costs required for spare parts, maintenance of treatment facilities and staff salaries, as well as continuous professional development and capacity building for all involved in waste management. Financial aspects related to waste management should be analysed in terms of cost-effectiveness (the relative costs and outcomes of the project) and cost-benefits (the monetary value of the project's benefits).

- **Determine which current funding opportunities can be leveraged.** Countries should determine which funding opportunities are available to support GTC waste management initiatives prior to undertaking any activities.

- **Waste management activities across the country should be coordinated for efficiency.** When developing policy and guidelines, countries should aim to coordinate waste management activities wherever possible to improve the efficiency of practices. This requires identifying all potential sources of waste, especially when programmes (such as HIV, sexual reproduction, COVID-19 response) are siloed or vertical.

- **Establishing a national technical working group to develop waste management policy, regulatory frameworks and implementation.** If relevant regulations and guidance are not available, then consider setting up a technical working group to develop the necessary guidance. This technical working group should ideally be facilitated by the Ministry of Health and may include national laboratory personnel and Ministry of Health staff with relevant experience. To begin, the group will need to identify any gaps in current policy and regulations around waste management, particularly concerning GTC waste, which need to be addressed. Subsequently, new national policies around laboratory waste may be developed, highlighting the importance of proper GTC management and areas for improvements in broader waste management in the country, considering relevant international agreements, conventions and best practices (discussed later in this section). Supporting regulations or practical guidelines and manuals with monitoring frameworks should also be developed to describe the responsibilities of healthcare service providers and medical waste handlers and explain the methods for their enforcement.[7] Kenya and Malawi are good examples of countries that have established technical working groups for waste management with specific responsibilities.

- **Adopting international policy and regulatory frameworks around waste management for consideration, if national frameworks are not available.** If national frameworks are absent or lacking, countries can consider use of several international agreements that contain guidance around the fundamental principles concerning public health, environmental protection and the safe management of hazardous wastes, particularly chemical waste. These include:
    - *The Stockholm Convention* is a multilateral treaty to protect human health and the environment from chemicals.
    - *The Basel Convention* focuses on control of transboundary movements of hazardous wastes and their disposal.
    - *The Bamako Convention* is similar to the Basel Convention, but specifically prohibits importation into Africa of any hazardous (including radioactive) waste, and focuses on the control of transboundary movement and management of hazardous wastes within Africa.
    - *The Rotterdam Convention* is a multilateral environmental agreement about pesticides and industrial chemicals that have been banned or severely restricted for health or environmental reasons by the countries and organizations that have agreed to the Convention.

- **Operationalising governing and regulatory instruments through development of guidance and standard operating procedures (SOPs) that can be used at the facility level.** Agreements and conventions need to be operationalised through national guidelines and SOPs. South Africa has a number of national strategies and SOPs that guide national-level and facility-level processes for waste handing, and disposal. This guidance from South Africa, linked below, can be used to inform the operationalising of national guidance in forms that can be used at the facility level. South Africa's *National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008)*, *National Health Act (Act 61 of 2003)*, *National Occupational Health and Safety Act (Act 85 of 1993)*, *Provincial Legislation*, and *Municipal By-laws* are operationalised through the *National Waste Management Strategy (NWMS) of 2011*, which supports the national health laboratory hierarchy in its approach to waste management.

- **Aligning waste management policy with national laboratory policy.** Waste management policies should be a mandatory requirement for in-country laboratory accreditation. Waste management for chemicals such as GTC should ideally be included in the national laboratory policy and should include guidance templates/ SOPs for waste management at the facility level. The national laboratory policies around waste management can also recommend training for different chemicals, including GTC waste management at a facility level.

- **Registration of waste generators.** All major hazardous waste generators, waste treatment facilities and waste disposal facilities can be registered at the national level, as is done in South Africa by the *South African Waste Information Centre*. These facilities should ideally be subject to compliance monitoring and enforcement, with penalties for non-compliance.

BEST PRACTICES / Funding

- **Mapping available funding for waste management from ongoing initiatives.** Waste management often does not have a well-defined budget line at the national level. Therefore, consider mapping available funding from ongoing initiatives. Potential funding sources include the United States President's Emergency Plan for AIDS Relief (PEPFAR), which has included management of GTC-containing waste as a priority in the *Country Operational Plans (COP)*. The Global Fund also has dedicated funding for waste management under its *Resilient and Sustainable Systems for Health Modular Framework Intervention Package*.

BEST PRACTICES / Coordination

- **Coordinating waste management at a central level to improve governance and efficiencies.** A priority action is establishing a centralised dedicated office for waste management at the national level. This office/technical working group should define roles and responsibilities for waste management at each level of the health system, including roles for manufacturers. Facility-level waste management can be coordinated by the quality and/or safety office, as established in the facility quality and safety manual. The office/technical working group should also set out to develop training and guides to help define the roles and responsibilities of all stakeholders, including health workers and waste handlers, involved in all waste management tasks.

3 WASTE MANAGEMENT IMPLEMENTATION

For the guidelines and policies around waste management to have impact, the guidance needs to be implemented at the national, local and facility levels. To support these efforts, countries can consult *guiding documents for the preparation of national healthcare waste management plans* from the World Health Organization, which include steps on how to develop and implement guidelines, and monitor the approach using different tools. Countries can adapt this guidance to their local settings to establish well-functioning waste management structures and support the implementation of policies and best practices.

KEY CONSIDERATIONS

- **Waste management needs to be prioritised throughout the healthcare and laboratory system, as resources are limited.** Given the chronic lack of resources around waste management, it is important to undertake work to highlight the importance of proper waste management everywhere GTC is generated and ensure waste management is a priority for all stakeholders (e.g., hospital managers). It may be challenging to monitor waste management everywhere GTC is generated; consequently, work needs to be undertaken to ensure that waste is properly managed and prioritised at a local and facility level.

- **Waste that can be measured can be planned for and disposed of correctly.** As such, effective waste management depends on the proper estimation of waste volume.

- **Not every technology is suitable for the management of GTC waste in the country, and the right specifications for quantity and type of waste are critical.** Even when utilising appropriate technology, e.g., incineration, consider that incinerators can differ in their treatment capacity and associated equipment, such as automatic feeding and exhaust filtration systems. Keep in mind that more complex equipment will require a higher level of maintenance than simpler technologies/equipment.

- **Countries may lack waste management infrastructure, including no staff assigned to waste management in the country.** For example, incinerator and cement factories may not be available in the country, and as a result, alternative technology or outsourcing might be necessary to manage GTC waste. Where there are no other options, countries may have to consider exporting waste to other countries with appropriate facilities. This should be a last resort and requires strict adherence to laws around exportation of hazardous materials.

- **Centralising waste management and using existing systems can be cost-effective.** At different steps throughout laboratory waste management, simple actions can be taken to help reduce overall waste management costs with limited financial investment, particularly establishing centralised waste management facilities and utilising existing systems (e.g., sample transport systems).

BEST PRACTICES

- **Establishing tools to quantify and cost waste management.** Consider utilising a laboratory waste cost analysis framework tool to measure the volume and cost of biohazardous waste. The *HIV Laboratory Waste Cost Assessment Framework (WCAF)* is one such tool that can be used. The WCAF is a Microsoft Excel-based tool to support accurate quantification of solid and liquid waste generated in PEPFAR-supported countries, co-developed by Roche Diagnostics and the United States Centers for Disease Control and Prevention.

Example: waste generated in South Africa each year

- South Africa has a population of around 59 million people. In 2018, the country generated around 50 million kg of healthcare-associated hazardous waste.[8] In addition, the country generates around 110 000 kg of chemical waste each year.[8]

- **Practising the waste management hierarchy of the '3Rs': reduce, reuse and recycle.** The waste management hierarchy is based around the concept of the '3Rs': reduce, reuse and recycle, and relates to the sustainable use of resources. Best practices in waste management are to avoid waste creation or recover as much of the waste as possible in or around a healthcare/laboratory facility, rather than disposing of it by burning or burial.[7] Some interventions for GTC waste management range from avoidance (most preferred) to disposal (least preferred), with examples outlined in Figure 1.[7]

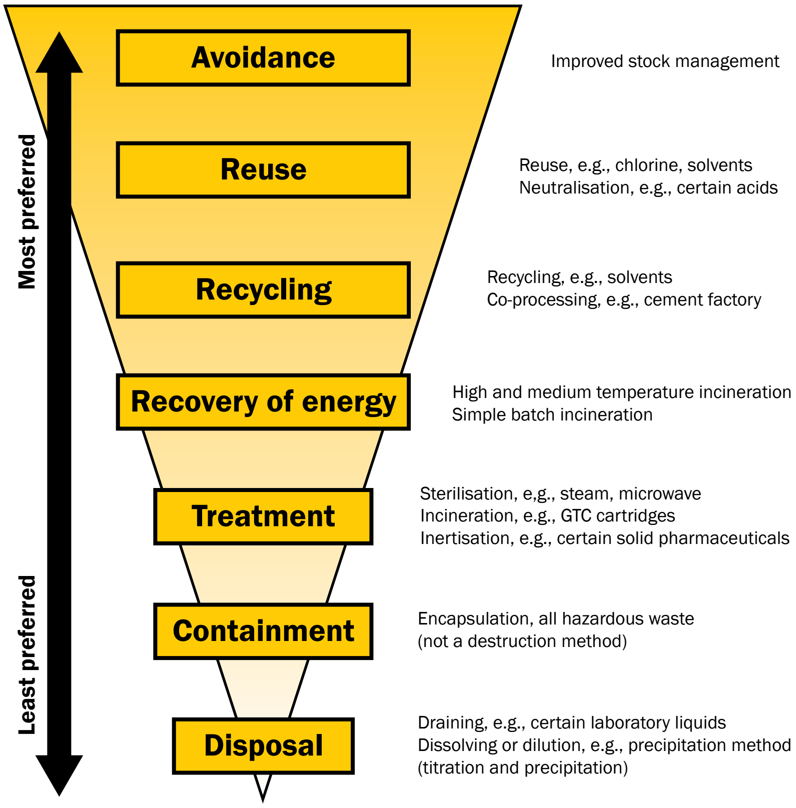


Figure 1. Overview of interventions and best practices to improve medical waste management in laboratories that produce waste from viral load testing, including GTC

- **Centralising waste management and using existing systems.**
  - **Establishing waste management centres:** For instance, establishing a regional centralised waste treatment policy through the installation of larger units is more cost-effective and reduces the number of pollution sources compared with using multiple smaller waste treatment units. A centralised waste treatment approach also renders monitoring, service and maintenance of treatment facilities easier to carry out than multiple smaller waste treatment units.
  - **Utilising existing transport networks:** Some countries, e.g., Uganda and Kenya,[9] have well-established systems for transporting essential medicines and other medical supplies to healthcare facilities.[10, 11] This logistic system can be considered for waste transport.

- **Setting guiding principles for waste management.** The management of GTC waste should adhere to the principles of waste management, which aim to minimise, segregate, store, transport and dispose of waste appropriately in conjunction with monitoring and regulation of the process (outlined in Figure 2).

Figure 2. Guiding principles for medical waste management (including GTC)

Minimisation
of waste generation

This includes minimising the amounts of waste generated by reducing the scale of unnecessary laboratory/facility procedures.

Segregation
of waste at point of generation

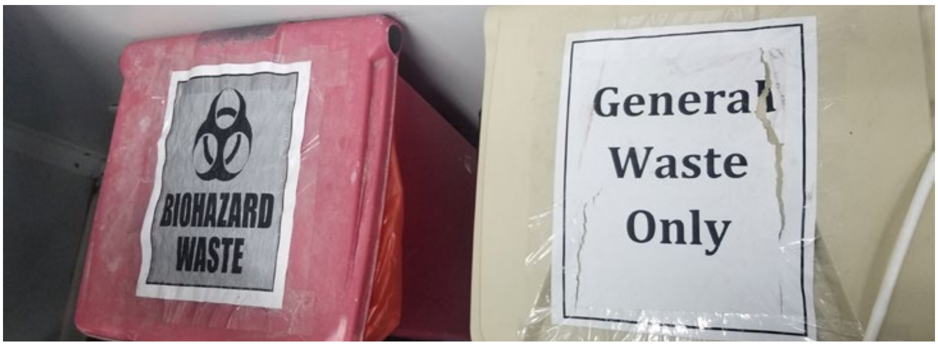
This includes specific separation of waste during collection by setting apart waste by type at points of generation. Implementing a three-bin system with colour-coding can facilitate segregation: sharps (yellow or red containers), infectious healthcare waste (yellow or red bags/ bins) and general non-infectious waste (black bags/ bins). See Table 1 for waste segregation categories. Regarding GTC waste, the cartridges from point-of-care testing that contain GTC should be separated from other forms of waste to ensure that they go through the appropriate treatment and disposal processes.

Segregation of waste in wheelie bins - Eswatini

Packing
of waste

Storage
of waste

Space within the facility is required for safe storage of waste prior to pre-treatment, where applicable. It is vital for highly infectious waste to be immediately pre-treated (i.e., autoclaved or chemically treated) before it is combined with the other medical waste for final disposal. Labelling should be clear and in a manner that will allow the hazards to be clearly and accurately identified (for example, if the waste includes sharps or is hazardous when inhaled).



Simple segreagation of waste - Jamaica

Transportation
of waste

Safe routes for the transportation of waste need to be established prior to the waste being created. Only gazetted/appointed medical waste transporters and handlers should be allowed to move medical waste from the facility to disposal points. Prior to loading waste for transportation, it must be weighed, and the actual weight recorded appropriately.

Disposal
of waste

Appropriate disposal facilities should be identified for each waste state of matter (i.e., solid, liquid or gaseous waste). Potential methods include incineration for solid waste, encapsulation, pyrolysis (thermal degradation of organic material in the absence of oxygen), among others.

Category of medical laboratory waste	Types	Examples
Hazardous waste	Infectious waste	• Body fluids, such as blood, sputum, urine, nasal/oral secretions • Body tissue, such as biopsies • Contaminated or body fluid-soiled wearable items such as gloves, aprons • Used/soiled specimen containers • Discarded diagnostic samples • Contaminated sundries from patients with infections (e.g., swabs, bandages and disposable medical devices)
	Sharps (also often classified as infectious waste)	• Used needles, pipette tips • Broken glassware • Lancets, surgical blades
	Chemicals	• Corrosive chemicals, namely acids and alkalis • Carcinogenic chemicals • Halogens, such as chlorine, iodine • Radioactive elements • Oxidising substances and organic peroxides • Flammable liquids • Pharmaceuticals such as microbiological antibiotic discs
Non-hazardous waste	Papers	• Used office/printer paper • Paper packages, cardboard, etc.
	Packages	• Uncontaminated plastic bottles • Shipping pallets

Table 1: Categories, types and examples of medical laboratory waste generated from HIV viral load/early infant diagnosis and COVID-19 testing

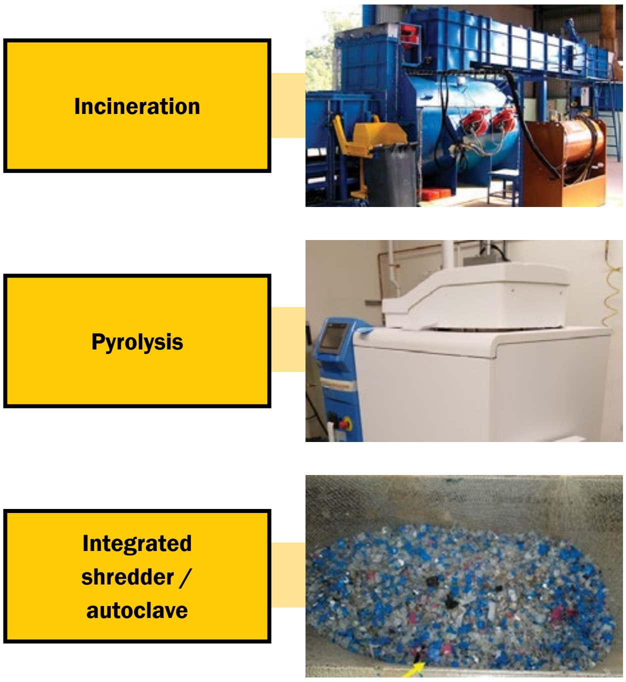
BEST PRACTICES (CONT.)

- **Centralising waste management for point-of-care cartridges or processing of liquid waste.** Centralising waste management for certain materials may be a cost-effective option, depending on the setting. For example, south Sudan has about 30 decentralised VL/EID and COVID-19 testing sites generating small quantities of GTC waste from all corners of the country. With a high capacity incinerator at the central level (at the National Public Health Laboratory), the recommendation is that each decentralised testing site should hold and transfer waste once every quarter to the central waste disposal unit for their final safe disposal.

- **Selecting the appropriate incinerator type for the waste material.** In accordance with the Stockholm Convention, the best available technology should be used to achieve emission of lower than 0.1 ng toxic equivalents (TEQ7)/m^3 of dioxins and furans.[7] The GTC compounds contained in VL/EID, COVID-19 and other testing reagents must be incinerated at a high temperature (≥ 850 °C) within the second combustion chamber of the incinerator with a retention time of at least 2 seconds.[12] There is a diverse range of medical waste incinerators, for example, Incinco (Stevenage, United Kingdom), Inciner8 (Southport, United Kingdom), Macrotec's MacroBurn (Stanger, South Africa), SA Incinerator (Randburg, South Africa), Alfa Therm (India), Elastec's MediBurn (Carmi, Illinois, United States), Pennram (Williamsport, Pennsylvania, United States), and TTM (Cölbe, Germany).

- **Considering other technological innovations for waste management.** Cement factories offer ideal conditions for high temperature incineration (> 1400 °C at the burner side and > 1050 °C at the entrance side of the kiln), or medium temperature incineration (> 850 °C at the precalciner side). In May 2018, the Médecins Sans Frontières mission in Malawi eliminated 2000 kg of hazardous waste using the Shayona Cement Factory in Malawi, at a cost of $1.52 United States dollars (USD)/kg.[13] However, cement factories are not available in all countries and, where available, may not always be willing to process hazardous waste. Some laboratory waste can be disposed of using non-burn technologies, such as neutralisation and encapsulation; these technologies are being explored in certain settings. Other innovations include using charcoal to absorb liquid waste, which can help reduce the volume of waste produced. In Mozambique, charcoal has been used to solidify VL liquid waste (click the link *here* for more information on how this was conducted).
The feasibility of other methods can also be explored, for example, the use of non-burn technologies such as neutralisation and encapsulation, the use of saw dust and pyrolysis.

Examples: Types of incinerators for waste material



Example: There are some non-burn technologies such as integrated shredding/autoclaves as seen immediately above to process cartridge waste

- **Outsourcing waste management and using public-private partnerships.** Outsourcing medical waste treatment and disposal to private companies can avoid the costs associated with the construction, operation and maintenance of treatment facilities and may be cost-effective in some settings.[14] For example, in Zimbabwe, a private company located in Harare has been contracted to collect used cartridges and sample reception vials for disposal at a centralised location.[15]

- **Exporting waste, if in-country methods are not available.** If considering waste exportation, a one-off method employed by Mozambique was the exportation of liquid chemical waste to South Africa for high temperature incineration in a licenced specialised hazardous waste plant as per the Basel Convention.[16] Challenges with this method included the long administrative process, which took over six months to complete, hence requiring long-term storage of the hazardous waste.[16] The method was also expensive compared with local incineration ($6.85 USD per kg for exportation compared to $1 USD per kg for incineration).[16] In addition, waste exportation is limited to the countries that have ratified the Basel Convention, and transport companies must have authorisation in both countries prior to transportation.[16] In waste exportation, the country from where the waste originated should remain responsible for monitoring all steps to ensure that contracted parties complete the waste transportation, treatment and final disposal as required. A waste destruction form should serve as documentary evidence of these steps.

- **Servicing and maintaining of waste management equipment.** Service-level agreements for waste management would be ideal, but they are not always available. Consequently, it is important to ensure there are maintenance personnel with the various capacities and skills required, including management, trouble-shooting skills and adequate training in general bio-medical engineering.

- **Involving manufacturers or suppliers in the disposal of waste.** Applying reverse logistics, the waste products can be moved back to manufacturers or suppliers.[17] In Malawi, couriers (from Riders for Health) who transport samples have carried small quantities of waste to a district hub, from where a vehicle has been used to transport larger amounts of waste to the incinerator.

- **Using technologies that generate less toxic waste.** Avoiding technologies that use toxic substances, for example, cyanide derivatives like GTC, means generating less hazardous waste. Examples include Merck's GenElute™-E Single Spin DNA and RNA Purification Kits, which have been designed specifically to address environmental issues. The products contain sustainable packaging, substantially reducing the use of plastic, and allow safer disposal as they do not contain or produce hazardous liquid waste.[18] The kits can be used with a number of non-GTC producing transport media (e.g., Hologic, Copan).[19] Moving forward, an important consideration for countries is the selection of technologies generating less toxic waste as part of their laboratory harmonisation policies.

4 MONITORING AND EVALUATION

Monitoring and evaluation (M&E) is an important component of safe, robust and cost-effective waste management systems. M&E enables assessment of the quantities and characteristics of the waste being generated and the effectiveness of the management strategies. The waste management M&E strategy should include a description of the overall programme, indicators to be used, an implementation plan, data sources and a reporting system, data analysis, report dissemination plan and data quality assurance plans. A baseline assessment is also very important while setting up a new system to provide reference data for planning and programme evaluation at a later stage.

BEST PRACTICES

- **Undertaking baseline assessments.** Assessments can be conducted at baseline and periodically using standardised tools. Examples of such tools include the *VL/EID waste management assessment tool* by the African Society for Laboratory Medicine (ASLM) and United States Centres for Disease Control, and the *Global Fund waste management assessment tools*.[6]

- **Defining indicators for M&E.** To set up a monitoring plan, it is fundamental to define indicators of achievement or performance. Indicators need to be defined for monitoring improvement and performance around waste management for GTC. Indicators to consider include:
    - Availability of national guidelines on chemical waste management, including GTC.
    - Availability of funding (plans) to support waste management implementation.
    - Proportion of laboratories that have GTC-containing waste and are disposing of the waste according to national (alternative) guidelines.
    - Level of waste management practices at laboratories, including for GTC. This may include compliance with correct disposal of sharps, infectious waste disposal or general waste disposal.
    - Number or proportion of staff who have received training on waste management for GTC.
    - Availability of waste management infrastructure at laboratories suitable for GTC management, for example, the number of facilities with incinerators adequate for handling GTC waste.
    - Proportion of compliance with safe handling of waste in accordance with the safety operation procedures, for example:
        - Occupational safety (e.g., use of personal protective equipment)
        - Proper segregation at source
        - Availability and use of bags, containers, bins and other equipment
        - Marking, labelling and signage
        - Internal transport and storage
        - Treatment and disposal

KEY CONSIDERATIONS

- **Methods of data analysis.** Testing facilities should determine the quantities of waste being produced and estimated costs for disposal. A simple weighing scale should be available as standard practice to assess the amount of waste being generated. Waste calculators to quantify the amount of waste generated by testing facilities can also be valuable for such analyses.

- **Data sources and data collection tools.** Sources of M&E data can include facility records, waste transportation records, waste management companies and waste regulatory bodies. Implementing a waste management dashboard at the facility and national levels is also a viable option for monitoring.

- **Implementing waste information systems.** Waste information systems can help improve waste management and may already exist in some countries. For example, South Africa has a waste information system that captures routine data on the amount of waste generated, recycled and disposed of on a monthly and annual basis.[20] The National Health Laboratory Service in South Africa also monitors the return of waste destruction certificates to verify the destruction of waste by private waste disposal companies.

- **Optimising the number and location of incinerators for managing GTC waste.** Optimisation can be done using geospatial information systems-based modelling (e.g., *LabMaP*, *OptiDx*). This should be preceded by a mapping exercise to identify the geo-location of existing incinerators and their functionality.

ANNEX 1

Key strategic considerations for waste management and biosafety of HIV viral load testing and laboratory services

Strategic areas	Strategic options*	Priority action items for improvement**
Policy and regulatory frameworks	• Ensure there is a national legal policy and regulatory framework to address waste segregation, audit trail for waste destruction, and defined roles and responsibilities of stakeholders • Review legal, regulatory and policy frameworks to address GTC waste across all sectors • Improve practical guidance for waste management at both the national and facility levels	• Develop standards for national waste management, with support from LabCoP and other collaborating partners on the ground, e.g., United States Centers for Disease Control and Prevention, Médecins Sans Frontières, CHAI, UNICEF, etc. • Adapt regulatory or legal frameworks from other countries (e.g., Basel Convention signing as done by South Africa and Mozambique) • Include waste management (including for GTC) in national laboratory policies and strategic plans • Include guidance/standard operating procedures on chemical waste management, e.g., Malawi and Zimbabwe
Governance and coordination	• Establish a waste management technical working group for national coordination • Assign roles and responsibilities for waste management at all levels of the laboratory system (central, regional, district, facility) • Involve manufacturers or suppliers in the disposal of waste (apply reverse logistics, where the waste product moves back to manufacturers or suppliers)	• Consider/advocate for a dedicated office of waste management and biosafety at the national/regional/facility levels based on the South Africa and/or Kenya models • Establish a functional national technical working group, including implementing partners and stakeholders (based on the Kenya model) • Leverage well-established systems for transporting essential medicines and other medical supplies to healthcare facilities • Assign roles and responsibilities to stakeholders, e.g., using the Kenyan model where disposal of expired products (reagents, drugs) is the responsibility of the central supply agency[21] • Design clear job descriptions and provide necessary training for GTC waste management at all levels using the entry point of the HIV programme, including a maintenance team to service incinerators using the ASLM/ PEPFAR collaboration model[22]
Financing	• Leverage current funding opportunities from PEPFAR, the Global Fund and donors around HIV, tuberculosis, malaria work • Request funds from manufacturers as part of their social duty • Obtain clear cost estimates for differentiated laboratory waste management as part of overall testing services	• Review costs associated with waste management, such as VL machine-specific waste management, e.g., using the CHAI model in Zimbabwe's costing exercise for GeneXpert cartridges, which took into account various costs, including the cost of service and handing waste, plus associated materials (biohazard bags), transport and incineration certificate fee, to bundle the cost of managing waste per cartridge/VL/EID test. • Submit plans to the Global Fund programming or reprogramming cycle, PEPFAR Country/Regional Operational Plan, and others, and allocate money as part of the LabCoP • Establish contracts with private companies for efficient handling of waste, e.g., through public-private partnerships

Strategic areas	Strategic options*	Priority action items for improvement**
Infrastructure	• Expand the implementation of on-site conventional systems for waste disposal • Consider utilising cement factories for high-temperature incineration • Install new systems and innovative strategies • Improve the transportation system for waste from place of generation to place of destruction	• Optimise the number and location of incinerators for managing GTC waste, using geospatial information systems-based modelling (e.g., *LabMaP*, *OptiDx*) • Pilot systems such as drainage, or charcoal absorption, solvent recovery and immobilisation options for other laboratory waste • Consider transporting waste to a local cement factory for treatment • Design a cost-effective waste transportation system based on the model of sample transport used in Uganda or South Africa[11] • Develop standards for infrastructure (e.g., drainage and waste management systems) • Comply with recommendations and standards of the waste management system, particularly in the design phase of new laboratories and renovations, including the complete flow of waste from generation to disposal areas (e.g., storage, treatment and disposal) • Update the inventory of essential spare parts for the range of incinerators in country
Partnerships and collaboration	• Facilitate collaboration between disease programmes for cost sharing of waste management • Establish public-private partnerships for transportation and disposal of waste • Consider cross border collaboration • Include waste management costs as part of contractual agreements with manufacturers	• Include manufacturer take-back schemes into contract agreements • Select diagnostic technologies with less toxic chemical alternatives to GTC in diagnostic tests, e.g., guanidine hydrochloride and sodium hypochlorite • Encourage manufacturers to conduct research and development on effective waste management solutions • Request that manufacturers and donors install high-temperature incinerators in LMICs as part of their social responsibility and aligned with national policies • Encourage manufacturers to revise cost per test according to the 'polluter pays' principle, where they share responsibility for the waste management costs of their products
Monitoring and evaluation	• Reduce opportunities for non-compliance to good waste management practices at the national and facility levels • Monitor GTC waste from generation to processing and destruction • Assess the cost-effectiveness of various methods of waste management for GTC	• List and prioritise measurable indicators for monitoring GTC waste management against set standards (e.g., 'certificate of destruction' used as proxy for waste destruction by the National Health Laboratory Service, South Africa) • Implement use of a waste calculator to quantify amount of GTC waste generated by testing facilities (e.g., *SAWIS* used to monitor amount of waste generated monthly in South Africa) • Implement a waste management dashboard at the facility and national levels for ease of monitoring • Design audit and assessment schedules using the South African model • Compare the cost of various GTC waste management methods in relevant set ups (e.g., Zimbabwe, Malawi, Mozambique costing models) • Establish waste management process indicators at baseline, and introduce regular monitoring using standard checklists, for example, the Global Fund capacity assessment for healthcare waste management, or the ASLM tool for HIV VL and EID molecular waste management considerations

ASLM, African Society for Laboratory Medicine; EID, early infant diagnosis of HIV; GTC, guanidinium thiocyanate; SAWIS, South African Waste Information System, VL, viral load.

* **Strategic options:** alternative strategies that affect key factors, which determine the success of an outcome or desired goal.
** **Priority action items:** implementation steps required to achieve the strategic option/decision that leads to the goal.

REFERENCES

1. Paik S and Wu X. Measuring toxic gases generated from reaction of guanidine isothiocyanate-containing reagents with bleach. Chemical Health and Safety 2005; 12: 33-38. DOI: 10.1016/j.chs.2004.12.002.
2. BIOSPECTRA. Guanidine Thiocyanate Safety Data Sheet.
3. Odhiambo CO, Mataka A, Kassa G, et al. Managing laboratory waste from HIV-related molecular testing: Lessons learned from African countries. Journal of Hazardous Materials Letters 2021; 2: 100030. DOI: https://doi.org/10.1016/j.hazl.2021.100030.
4. World Health Organization. Global analysis of health care waste in the context of COVID-19. 2022.
5. Dziekan G, Chisholm D, Johns B, et al. The cost-effectiveness of policies for the safe and appropriate use of injection in healthcare settings. Bull World Health Organ 2003; 81: 277-285. 2003/05/24.
6. ASLM. February 2020 Waste Management Training: The Assessment of WM Practices in VL & EID Labs in Kenya. 2020.
7. World Health Organization. Safe management of wastes from health-care activities, 2nd ed. 2014.
8. National Institute for Occupational Health South Africa. Health Care Waste Management Policy & Regulatory Framework South Africa, https://bnegash-my.sharepoint.com/personal/fabebe_aslm_org/_layouts/15/onedrive.aspx?id=%2Fpersonal%2Ffabebe%5Faslm%5Forg%2FDocuments%2Fconference%20presentations%2FLabCoP%20Face%20to%20face%20meeting%2022%2D%2025%20Oct%202019%20ET%20For%20All%2FDay%204%20Friday%2025%20October%20WM%2Fbest%20practices%20and%20solutions%20from%20the%20field%2FHEALTH%20CARE%20WASTE%20MANAGEMENT%20POLICY%20and%20REGULATORY%20FRAMEWORK%20SOUTH%20AFRICA%20Ms%20Mmashela%20Kgole%2Epdf&parent=%2Fpersonal%2Ffabebe%5Faslm%5Forg%2FDocuments%2Fconference%20presentations%2FLabCoP%20Face%20to%20face%20meeting%2022%2D%2025%20Oct%202019%20ET%20For%20All%2FDay%204%20Friday%2025%20October%20WM%2Fbest%20practices%20and%20solutions%20from%20the%20field&ga=1 (2019, accessed 24 February 2023).
9. Fonjungo PN, Alemnji GA, Kebede Y, et al. Combatting Global Infectious Diseases: A Network Effect of Specimen Referral Systems. Clinical Infectious Diseases 2017; 64: 796-803. DOI: 10.1093/cid/ciw817.
10. ASLM. August 2022 LabCoP ECHO Session: Measuring the Progress of Integrated Sample Transport Systems. 2022.
11. ASLM. Feb 2018 ASLM LabCoP ECHO Session: Sample Transport. 2018.
12. Ndlovu Z, Fajardo E, Mbofana E, et al. Multidisease testing for HIV and TB using the GeneXpert platform: A feasibility study in rural Zimbabwe. PLoS One 2018; 13: e0193577. 2018/03/03. DOI: 10.1371/journal.pone.0193577.
13. Van Den Noortgate J. ASLM 2018 Satellite session -Waste Management Strategies for HIV Viral Load and Early Infant Diagnosis, http://aslm2018.org/waste-management-strategies-for-hiv-viral-load-and-early-infant-diagnosis/ (2018, accessed 28 October 2022).
14. USAID. Public-Private Partnerships for a Centralized Waste Disposal Treatment Plant in Eastern Uganda, https://publications.jsi.com/JSIInternet/Inc/Common/_download_pub.cfm?id=12676&lid=3 (2012, accessed 28 October 2022).
15. Simbi R. ASLM 2018 Satellite session -Waste Management Strategies for HIV Viral Load and Early Infant Diagnosis, http://aslm2018.org/waste-management-strategies-for-hiv-viral-load-and-early-infant-diagnosis/ (2018, accessed 28 October 2022).
16. LabCop. Waste management training session. In: LabCop ECHO Sessions 2019.
17. Joel, Kinobe, Girma, et al. Reverse Logistics Related to Waste Management with Emphasis on Developing Countries—A Review Paper. In: 2012.
18. Ongaro AE, Ndlovu Z, Sollier E, et al. Engineering a sustainable future for point-of-care diagnostics and single-use microfluidic devices. Lab Chip 2022; 22: 3122-3137. 2022/07/29. DOI: 10.1039/d2lc00380e.
19. Sigma-Aldrich. User Manual GenElute™-E Viral RNA/DNA Kits. 2021.
20. Department of Environmental Affairs. South African Waste Information Centre (SAWIC), http://sawic.environment.gov.za/ (accessed 26 October 2022).
21. Kenya Medical Supplies Authority. Citizen Service Charter Delivery. Available from: https://www.kemsa.co.ke/service-delivery-charter/ (accessed 24 February 2023).
22. ASLM. PEPFAR collaboration. Available from: https://aslm.org/what-we-do/pac/ (accessed 24 February 2023).

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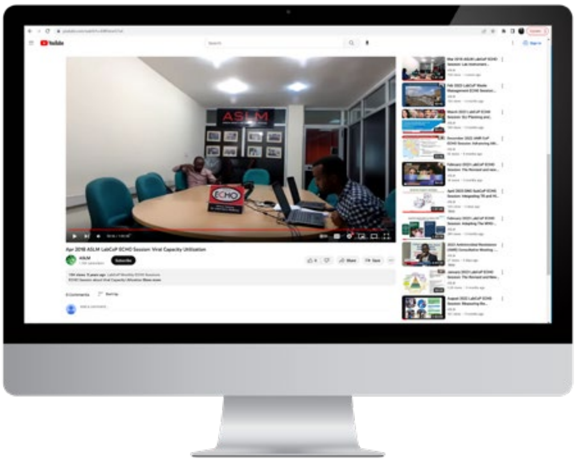

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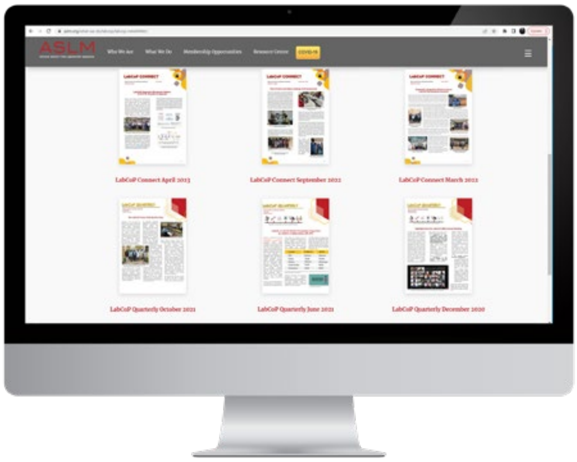

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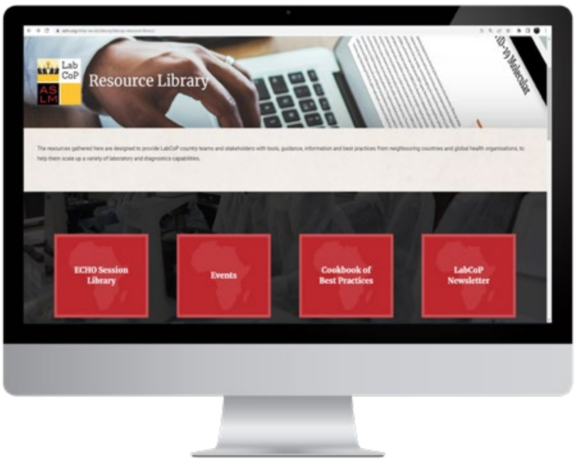

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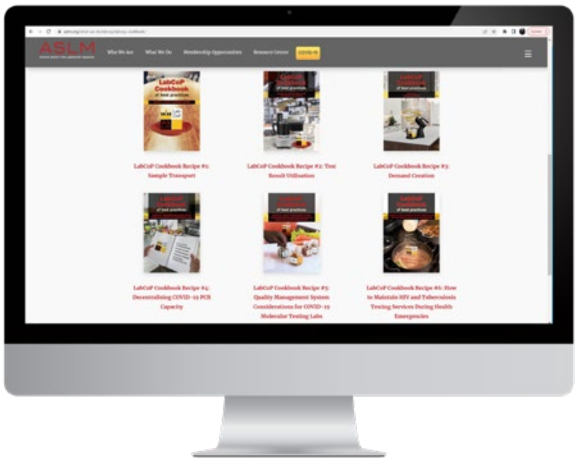

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