Commentary

Environmental issues in clinical laboratories: pragmatic pathways to sustainability

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Every human activity has impact on the environment, including scientific activities in the laboratory. This is particularly true with laboratory medicine services, although poorly recognized until recently. Clinical laboratory activities have profound contribution to climate change. Current efforts in the laboratory medicine community are largely extrapolations of the collective efforts of the larger scientific community and the United Nations Sustainable Development Goals to sustain planet earth by ensuring sustainable practices in all spheres of human endeavor. High impact existing literature in the field was harnessed in the synthesis of this report. The United Nations' World Commission on Environment about thirty years ago gave the global community a definition of sustainable development, development that meets the needs of present without compromising the ability of the next generation to meet theirs. This equation appears to be under constant threat, constituting a challenge for the health care sector, practitioners, and the laboratory medicine community in particular that is a culprit in consuming more energy, water and generate huge hazardous toxic waste.

It is only in the last couple of years that this has dawned on the scientific community after the introduction of the concept of green chemistry which essentially implies sustainable use of scientific resources with minimal damage to the environment. Though many laboratories in the developed countries have accepted this challenge with vigor, it is yet to receive the desired impetus in many low- and medium-income countries particularly Africa. The global laboratory medicine community must acknowledge that clinical laboratories must curtail their environmental impact while providing quality laboratory medicine services by reducing energy and water consumption, minimizing hazardous waste generation and the utilization of toxic or hazardous chemicals, as well as recognizing sustainability as a target.

Introduction

In the last decade, the global scientific community has intensified its concern, probably ignited by the discussion at the 2016 World Economic Forum (WEF) at Davos, that by the year 2050, there will be more plastic in the oceans than fish, reflecting the level of environmental pollution [1]. The concept of sustainability was first introduced by the United Nations in the late 1980s [2] as an attempt to balance economic development with environmental protection and rescue Planet Earth from the catastrophe of climate change.

This culminated in the setting up of the United Nations World Commission on Environment and Development (UNWCED), chaired by the former Prime Minister of Norway, Gro Harlem Brundtland. This gave rise to the term sustainable development, defined as 'Development that meets the needs of the present without compromising the ability of the future generations to meet their own needs' [2]. Nearly 30 years later (2015), the UN introduced the 17 Sustainable Development Goals (SDGs), outlining how sustainability can be achieved [3].

Though our focus for clinical laboratories for decades has disproportionately been on the benefit to patients and clinical outcomes, the time has now come for the laboratory medicine community to be directly involved in the conversation and action plans to mitigate or reduce the problem. Clinical laboratories use 3-6 [4] more energy than typical office buildings and thus contribute substantially to carbon footprint. Clinical laboratories also generate large quantities of hazardous waste, byproducts of large chemical consumption [5].

Pathology laboratories have a philosophy of quality improvement using tools such as audits, nonconformances, and management reviews. An effective quality management system drives risk reduction in laboratory processes. In addition to these core elements, laboratories are increasingly adopting Lean Six Sigma methodologies to streamline processes and reduce waste. These approaches can be particularly effective in addressing climate change-related challenges within laboratories. By identifying and eliminating waste, improving efficiency, and minimizing environmental impact, laboratories can contribute to a more sustainable future. Harnessing this same system can improve a laboratory's environmental risk. The fundamental function of developing a plan to reduce environmental waste should involve an assessment of risk, a policy supported by management (and staff), an activity plan supported by measurable outcomes, audit and non-conformance processes, and oversight and accountability by management that provides some structure, a point of comparison and an external review process.

There is a growing list of clinical laboratories where there is a demonstrated awareness and action to reduce the carbon footprint [6–12].

A hospital or hospital network can take significant steps to reuse and recycle waste. The types of activity include the following [13].

Recycling of Materials

- Recycle polyvinyl chloride, such as saline bags (cut off introducers first) and oxygen tubing (no filters or Hudson masks).
- Recycle aluminium gas cylinders.
- Recycle surgical wraps.
- Recycle appropriate hospital soft plastics (e.g., syringe waste plastics, image intensifier covers, shrink wrap from a pharmacy, clear plastic covers used in radiology to cover detectors).
- Recycle stainless steel (eg, blue-handle single-use stainless steel instruments).
- Recycle e-waste (eg, computers and electronic equipment, clinical vacuums, , central sterile supply department broken equipment).
- Recycle wax (radiation therapists use wax to mould patient contours for radiation therapy).
- Recycle rubber gloves and surgical caps.

Energy efficiency

- Investigate key clinical areas with single-use electrical wires (e.g., occupational therapy, intensive care units, catheter labs, dermatology) for opportunities to reduce their use.
- Reinforce the practice of turning off or unplugging equipment when it is not in use (e.g., fume hood, oven, incubator, water bath, centrifuges, etc.).
- If equipment has a warm-up time or a set temperature, simply put it on an outlet timer to ensure that it is ready when lab operations begin.
- Hold excess hospital/department equipment swap days.

This may be a significant contribution to resolving the considerable environmental and health impacts of our scientific activities. The laboratory medicine community owes it as a responsibility to society and to sustainable development to contemplate the following actions:

- Decrease individual and environmental footprint.
- Put global guidelines on recycling.
- Scientists should consider the use of glass appropriate to replace plastics.
- Adoption of the measures already advocated by many toxicology groups to be considered. - the 3 Rs.
- Sound management of chemicals by all clinical laboratories to be given priority of place by putting in place functional 'Health and Safety Committees'
- The health and safety aspect of the training of laboratory medicine professionals should be expanded to encompass the environmental and ecotoxicological impact of scientific activities in clinical laboratories
- Regular educational sessions could be held for sharing

tools and ideas to bring everybody to the same level- taking cognizance of developmental diversity- advanced, moderately advanced, and low and medium- income nations (LMICs).

- Importantly, manufacturers/ suppliers should be part of the after-life management of their products; they must put strategies in place to ensure an environmentally sound approach to the disposal of associated accessories or waste.

These collaborative/collective approaches may be a tremendous scientific pathway to address the laboratory medicine community's hitherto neglected role in its activities' environmental and health impact.

The Situation in African Clinical Laboratories

It is evident from the foregoing that the global community is currently grappling with one of the most daunting problems of the past and present centuries, climate change. Unarguably, it primarily arises from unregulated unsustainable human industrial and scientific activities of which laboratory medicine practice is a key contributor, which may be more accentuated in Africa. Africa, though essentially belonging to the broad group of LMICs owing to economically constrained peculiarities, contributes hugely, but is not keeping pace with measures being taken by the advanced nations to implement sustainable practices. The quality of clinical laboratories in developing countries is poor due to a lack of adequate resources, proper regulations, and supportive health care [14,15].

Current efforts in the African laboratory medicine community are largely extrapolations of the general efforts of the larger scientific community and the United Nations Sustainable Development Goals to sustain Planet Earth by ensuring sustainable practices in all spheres of human development. Targeted clinical laboratory medicine efforts are the exception rather than the norm. (High-impact existing literature in the field was harnessed in the synthesis of this report). The United Nations' World Commission on Environment, at least three decades ago, gave the global community a definition of sustainable development: development that meets the needs of the present without compromising that of the next generation, as earlier pointed out, a framework only patyially enforced in many African countries. This equation appears under constant threat, constituting a challenge for the health care sectors, practitioners, and the laboratory medicine community, which are culprits in consuming more energy and water and generating huge hazardous toxic loads, generally in Africa.

Though in the last couple of years, it has dawned on the scientific community in Africa after introducing the concept of green chemistry, which essentially implies sustainable use of scientific resources with minimal environmental damage, implementation in Africa is, at best, fragmentary. Though many laboratories in developed countries have accepted this challenge with vigor, it is yet to receive the desired impetus in many low- and medium-income countries, particularly in Africa. The African laboratory medicine community must have to acknowledge that clinical laboratories must curtail their environmental impact while providing high quality laboratory medicine services by reducing energy and water consumption, minimizing hazardous waste generation and the utilization of toxic or hazardous chemicals, and eliminating adverse impacts on sustainability as a target. It should also reevaluate the use of low technology energy, intensive processes with higher carbon footprint and attendant more significant environmental adverse outcomes, such as duplicated energy sources (particularly emmisions from alternate energy generating plants).

Figure 1: A typical energy source in an African country.

This type of plant has great potential of contributing.

It is remarkable that, though considered among the low—and medium-income countries, Africa's pollution intensity (pollution generated per unit of production) is among the highest in the world. This is coupled with an already existing problem with municipal waste management and poorly implemented environmental laws.

Recourse to point-of-care testing (POCT) in many African clinical laboratories because of economic benefits (cheaper), mostly single-use plastics, exacerbates plastic pollution. Economic and resource limitations create difficulties in acquiring appropriate recircling and sound waste disposal technology.

All these may culminate in more profound, unsustainable practices, leading to a greater risk of environmental toxicity and damage and a disproportionate contribution to a more severe climate change compared to their testing volume or capacity.

Thus, it is a public health/ laboratory medicine priority in Africa to put measures in place to ensure sustainable laboratory medicine practice. As well recognized in pollution and exposure science studies, 'poisoning one part of the globe and the whole world is poisoned', pollution knows no international boundary. The rest of the scientific community must form partnerships with Africa to eradicate laboratory medicine's associated adverse environmental impact and ensure green laboratory medicine practice for the world community.

The significant difference between African clinical laboratories and those of the advanced world is lower economic capacity and technology, which is not surprising. There is also the case of preexisting environmental disorder arising from unenforced environmental regulations and laws, making the situation in Africa a more serious one. There is also greater recourse to POCT and other single-use devices that may have a broader environmental impact- poorly managed waste disposal.

Education and training on the concept of the environmental impact of laboratory medicine, or green laboratory medicine and green chemistry, should receive priority attention in Africa.

Partnerships with advanced nations where the concept of sustainable laboratory medicine practice should be the next step.

Role of the IFCC Task Force on Environmental Impact of Laboratory Medicine (TF-EILM)

The IFCC has been active in the environmental waste field for some years, initially in 2012 with the formation of an ad hoc IFCC Panel on the Environmental Responsibility of Clinical Laboratories and then in 2023 with the creation of the Task Force on Environmental Impact of Laboratory Medicine (TF-EILM). The IFCC panel produced a set of proposals for mitigating the environmental impact of clinical laboratories.

The TF-EIFM was created with the following goals:

1. Identify existing peer-reviewed, high-quality publications that describe the impact of laboratory medicine operations on the environment and actions that laboratories and manufacturers can take to reduce the negative impact.

   Creation of awareness
   - Develop staff consciousness of the laboratory's activities' impact on the environment. Find ways to address the problem before attempting any kind of certification.

   Preliminary environmental review
   - Identify activities that significantly impact the environment.

   Aim
   - Establish overall goals, set targets, and plan activities as part of an Environmental Management System (EMS).

   Training
   - Prepare a training program for the laboratory staff.

   Available legislation
   - Identify legal requirements related to environmental aspects of the laboratory's activities and establish a register of these.

   Audits
   - Schedule audits and management reviews. The audits should identify areas of waste and opportunities for lessening the environmental footprint.

   Documentation

   Prepare the following documents:
   - An EMS manual.
   - Protocols for handling emergencies, such as spills.
   - A list of contractors and the contracts that the laboratory has entered into.
   - Develop a policy document advocating for health authorities and accreditation bodies to incorporate green lab practices into their checklists or agendas.
2. Develop recommendations and practice guidelines that laboratories in developed and developing countries can implement to reduce the environmental impact of laboratory operations without compromising the quality of services provided to patients.
3. Develop a plan to share information and educate IFCC national society and corporate members.
4. Identify existing peer-reviewed, high-quality publications that describe the laboratory testing that can be performed to measure both levels and biological effects of toxic environmental chemicals in human biological material, including studies to demonstrate the concentrations of chemicals found in human biological tissues (human biomonitoring).

5. As required, the Task Force will establish a formal collaborative link with the EFLM Task Force on Green Labs and other IFCC groups and organizations involved in related activities.

The task force's key responsibility is essentially to minimize the environmental impact of laboratory medicine operations while still delivering high-quality care to patients, by upholding sustainability-compatible systems and procedures summarized as follows:

- Reduce energy consumption.
- Reduce water consumption.
- Reduce hazardous waste generation, including CO2 (green gas)
- Reduce the use of harmful chemicals

All the above can be achieved by embracing the concept of green chemistry and the principle of registration, evaluation, authorization, and restriction of chemicals (REACH), introduced by the European Chemical Agency (ECHA) [16,17].

The remit of the TF-EILM is, therefore, at least in part in alignment with the United Nations Sustainable Development Goals (SDGs), reminding us of the following:

- That scientific practices, including laboratory medicine practice, contribute to environmental degradation, including gas emissions, especially CO_2 emissions, plastic pollution, toxic and infectious waste, and other environmental concerns.
- Scientists have gradually come to the realization of the environmental footprint of their activities and the need for change or adjustment for a more sustainable environment and world.

Despite this realization, there is the inertia to act, which may be driven by economic concerns, a significant consideration for many LMICs, particularly those in Africa, knowledge deficit and dearth of the required data to address the problem, thus inability to implement sustainable laboratory medicine practice. The laboratory medicine community feels as a community that she has a responsibility to address the sustainability agenda.

Obstacles to Adopting Sustainability and their Mitigation

It is perhaps appropriate to underscore the obstacles to sustainability in laboratory medicine and their pragmatic mitigation, although the last paragraph succinctly addressed them. Lack of broad scientific outlook is a perceived barrier to implementation of sustainability. Others may include absence of peer education on green chemistry and leadership that drives systematic laboratory practice and paucity of evidence of the environmental impact of laboratory medicine and causal root factors. Additional factors that may be contributory to non-embracing of sustainable practices in laboratory medicine include poor and rigid traditional workplace practices, absence or insufficient financial support and perhaps lack of conviction on the part of scientists and other laboratory medicine practitioners [13, 18].

The overarching requirement that will be a panacea for mitigating the obstacles to sustainable laboratory medicine will include peer education, training and mentoring of the next generation of scientists in laboratory medicine, updating of knowledge by those in the laboratory medicine community and the pathways of IFCC and constituent federations in sustainable laboratory medicine.

Our organization, IFCC, as the global leader and watchdog in laboratory medicine, feels she has an obligation to lead the multidisciplinary, international effort aimed at promoting sustainable chemical and material consumption. It is felt that scientists must incorporate the sustainability of best practices in their activities and motivate colleagues to embrace sustainable laboratory medicine practices.

Conclusion

Although most of the scientific community, especially the chemical community recognized the significance and implications of these developments; environmental degradation and thus climate change, the global laboratory medicine community was slow in responding until recently.

The IFCC responded to this gap in environmental stewardship early (2023) by setting up one of the newest task forces (TF-EILM), with five vital remits highly congruent with the green chemistry concept.

Author Declaration and Ethical Consideration

The authors declare no conflict of interest.

Ethical approval

None.

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