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Towards Development Of Green Standards To Accredit Sustainable Supply Of Medical Devices

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Abstract - Given the urgency of climate change, it is time to think about new adaptation and mitigation strategies. Thus, it is imperative for medical technology industries and stakeholders working in health sector to align themselves with sustainable development objectives. So, at all stages, from conception to decommissioning, practices around medical devices produced in large quantities each year should be sustainable to contribute minimizing their probable impact on global warming. This study aims to guide accreditation prospects towards the development of green standards for all practices around medical devices. Between May to August 2025, a survey was conducted among biomedical technicians, clinical engineers, and hygienists in sub-Saharan Africa. 113 opinions on non-sustainable aspects of medical devices were collected. A unit score is assigned to each choice. The cumulative scores allow them to be ranked in order of priority. 45% of opinions relate to the development of an obsolescence management certification that will sanction the disposal by incineration or landfill of certain medical devices and their storage after decommissioning. 39% of opinions relate to the choice of energy used for the production and transportation of medical devices, from producing countries to consuming countries. Only 16% of opinions refer to the mode of use. The latter includes overuse, which reduces the lifespan of medical devices and boosts their renewal, on the one hand. On the other hand, single-use increases consumption and production of waste. The challenge of accreditation is to implement sustainable practices around medical devices to obtain sustainable solutions to healthcare issues. A sustainable approach includes green source energy for production, environmentally clean transportation, ecological medical technology using biodegradable and recyclable materials.

Keywords – Climate change, Sustainable supply, Medical devices.

INTRODUCTION

In the march towards achieving the Sustainable Development Goals (SDGs), respect for the Environment is the cornerstone. Indeed, many SDGs are closely linked to the environmental dimension. SDG 3 promotes a healthy life and well-being for populations. SDG 6 focuses on sanitation and universal access to drinking water. As for SDG 11, cities and other human settlements must be healthy and have an ecologically clean transport system. Regarding SDG 12, it establishes a rational use of natural resources and a reduction in waste production. SDG 13 aims to strengthen resilience to climate hazards and natural disasters. For SDG 14, it is essential to conserve and use the oceans, seas and marine resources respectfully seas and marine resources while SDG 15 fights against deforestation, desertification and biodiversity loss. All these objectives will not be achieved when water, air and soil, among others, are degraded and remain polluted.

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Given the urgency of global warming, it is time to think, (it is necessary to think) about new adaptation and mitigation strategies. Thus, it is time (imperative) that the medical technology and actors working in the health sector are aligned, in a pragmatic way, with the sustainable development goals. Since a notable paradigm shift has been observed in the health sector health, particularly following the recent global COVID-19 pandemic, we are witnessing a globalization of public health problems. There are no more borders in terms of health concerns and medical care. From the Northern Hemisphere to the Southern Hemisphere, we are fighting almost against the same pathologies, we should follow the same protocols as far as possible and adapt the same medical technical platforms. In the latter, biomedical equipment occupies a prominent place. Their design is becoming more and more sophisticated involving very demanding physical processes. Their quantity has increased considerably to cover the growing demand. Their production requires energy consumption. Their delivery at the level of the four cardinal points of the globe requires several means of transport given the geographical concentration of design industries. Their recurrent use would not be environmentally neutral, without footprint. Their elimination, following obsolescence, could be restrictive. Therefore, their impact on the Environment logically becomes non-negligible.

In fact, the medical device economy is a large and growing global market. Fortune Business Insights (2025) says that the global market stood at USD 542.21 billion in 2024 and is projected to record a valuation of USD 886.68 billion by 2032. It is driven by an aging population, the prevalence of chronic diseases, and technological advancements [1]. This situation raises many questions. What type of clean energy should be used for the design and transport of biomedical equipment? Are the materials used recyclable or biodegradable? Should we strive for accreditation of these practices focused around audits and certifications that verify and attest compliance with sustainable development standards? We are facing a challenge of respecting the Environment. A whole portfolio ‘eco-friendly’ to honor!

Thus, this study aims to guide accreditation prospects towards the development of green standards for all practices around medical devices. Therefore, it consists of raising awareness of global warming in order to contribute to slowing it down and to move towards a sustainable supply of medical devices in the optic of being accredited. This study of cases will serve as a " catalyst “. At all stages, from conception to decommissioning of medical devices, practices should be sustainable. Thus, after having contextualized climate change, a review of a set of so-called practices sustainable will be carried out. A case study of prioritizing the causes likely to violate respect for the environment, based on the perception of key players, will be conducted in sub-Saharan Africa.

Initially, a brief literature review will be conducted on the context of climate change uniting its diagnosis, its potential causes, its probable consequences, the mapping of sustainable practices around medical devices. Next, the methodology adopted will be presented, followed by the presentation of the results to be interpreted. Finally, recommendations will be made.

I. Climate context change

The writings are abundant and varied. The development on the context of climate change relates to the situational analysis of global warming, the possible causes and the consequences probable.

Climate is the long-term weather pattern in a region, typically averaged over 30 years ([2], [3]). Climate change or global warming could be considered as temperature fluctuations due to natural phenomena or activities harmful human beings to the Environment. However, according to the United Nations, the main driver of this change remains the human footprint. Indeed, in the United Nations Framework Convention on Climate Change (UNFCCC), climate change is defined as a change that is ‘exclusively’ attributed directly or indirectly to human activity, altering the composition of the atmosphere and which is added to the natural variability of the climate [4].

Thus, the ecosystem does not ensure its universal harmonious character anymore. The relevant analysis of the causes of climate change would allow to map the most salient consequences.

I.1 Climate change diagnostic

In the synthesis report of March 20, 2023, of the Intergovernmental Panel on Climate Change (IPCC), it was found that " the increase in global temperature has further increased and is directly due to human activity » [5]. The period between 2011 and 2020

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is assumed to be the warmest in approximately 125,000 years. Indeed, the surface temperature of the globe has increased by 1.1°C compared to that of the slice ranging from 1850 to 1900. The extent of recent warming is notorious over a so short period, roughly just a decade. In addition, the concentration of carbon dioxide in the atmosphere has reached an unprecedented rate in two million years. Whatever the efforts provided, global warming could reach +1.5°C as early as the 2030s.

Extreme weather events such as heat waves, heavy rainfall, floods, droughts and cyclones are manifesting themselves recurrently. These extreme weather cases prove that the atmosphere, oceans, the cryosphere and biosphere have been profoundly altered.

According to the Climate Diagnostics Bulletin of August 2025, « The indices are standardized by the mean annual standard deviation, with the exception of the Tahiti and Darwin SLP anomalies which are in hPa. Positive (negative) values of the zonal wind index at 200 hPa imply westerly (easterly) anomalies. Positive (negative) values of zonal wind indices at 850 hPa imply easterly (westerly) anomalies. Anomalies are deviations from the means of the 1991-2020 base period [6]. A situation that is alarming because all these findings do not predict better days.

I.2 Causes

Human activities, mainly the combustion of fossil fuels, deforestation and intensive agriculture, are the main cause of global warming by increasing greenhouse gases in the atmosphere.

The Earth absorbs solar energy, which warms it, and emits this heat as thermal radiation, mainly infrared. Greenhouse gases in the atmosphere absorb and re-emit infrared radiation, which slows the rate at which it can pass through the atmosphere and escape into space [7]. Human activity since the industrial revolution — mainly the extraction and combustion of fossil fuels (coal, oil and natural gas) [8] — has increased the amount of greenhouse gases in the atmosphere, leading to a radiative imbalance. In 2019, CO2 and methane levels in the atmosphere increased by approximately 48% and 160% respectively since 1750 [9]. The concentration of CO2 is much higher than in the last 2,000,000 years. Methane concentrations are much higher than they were in the last 800,000 years [10].

Apart from the combustion of fossil fuels, other causes could be deforestation, agriculture, livestock farming, human activities and the industrial productions.

I.3 Consequences

By modifying natural balances (temperatures, water cycle, marine and air currents, etc.), climate change is responsible for significant disturbances. Among the most immediate consequences: the increase in the frequency, duration and intensity of extreme weather events (floods, storms, cyclones, droughts and forest fires, heat waves…) Other, slower-evolving phenomena are also perceptible: the melting of ice and the rise in sea levels, the progressive erosion of coasts, desertification, the rarefication of resources, the disruption of ecosystems and the disappearance of certain species [11.]

Health consequences are also worth noting. Indeed, air pollution could worsen respiratory and cardiovascular pathologies. Waterborne diseases, infectious and vector-borne diseases would develop [12], among others. To remedy this situation or mitigate the most damaging possible effects, green standards should be elaborated for each key sector key. A final accreditation in each area will motivate their correct implementation.

Regarding the case of medical devices, sustainability would rely on their production, transport, acquisition, use, decommissioning and final disposal.

II. SUSTAINABLE PRACTICES

The implementation of the " sustainability » approach is closer, within the framework of medical devices, to production, transport, acquisition and decommissioning.

At all stages, from conception to decommissioning of medical devices, practices should be sustainable car their quantity is no longer to be neglected. According to Prome [13], only seven categories of devices have generated turnover figures amounting to USD 260 billion when processing data from 2019. The frames for glasses or similar items and their parts, corrective glasses, protective or

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similar glasses, instruments and appliances for medicine, surgery, dentistry, mechanotherapy devices, massage devices, psychotechnics, ozonotherapy, oxygen therapy, aerosol therapy devices, the respiratory resuscitation equipment and other respiratory therapy equipment, the apparatus respiratory and gas masks, items and orthopedic appliances, prostheses, earphones, devices to be held in the hand, to be worn on the person or to be implanted in the body, in order to compensate a deficiency or infirmity, X-ray equipment or equipment using alpha, beta or gamma radiation, for medical, surgical, dental, radiophotography or radiotherapy equipment, X-ray tubes and other X-ray generating devices, voltage generators, control desks, screens, tables, chairs and similar examination or treatment supports are all medical devices that can be cited. This demonstrates their plural nature.

II.1 Sustainable production

Sustainable medical device production standards emphasize the use of environmentally friendly materials, energy-efficient processes, waste reduction through design for disassembly and recycling, and ethical manufacturing practices.

These aspects include material selection and innovation, reducing energy and water consumption, implementing the 5 Rs of sustainable development (refuse, reduce, reuse, repurpose, recycle), and designing for longevity and modularity. Companies must also establish transparency in their supply chains, monitor their environmental performance, and design devices for responsible end-of-life disposal in order to meet regulatory requirements and environmental management objectives [14].

II.2 Sustainable transportation

Sustainable transportation of medical devices involves the use of cleaner vehicles such as electric vans, optimizing delivery routes through AI, and improving supply chain efficiency to reduce fuel consumption.

It also involves adopting a circular economy approach in the manufacture of means of transport, including the use of bio-source materials, design for longevity and recyclability, and waste reduction during their production. The main levers are technological innovations in route optimization and vehicle efficiency, as well as regulatory support for green initiatives. As the healthcare logistics market continues to grow, the importance of addressing issues such as regulatory compliance, environmental sensitivity and on-time delivery is becoming increasingly apparent [15].

II.3 Sustainable procurement

Sustainable procurement of medical devices involves a comprehensive life cycle approach, taking into account the environmental, economic and social impacts of devices, from their production to their disposal, in order to ensure their long-term health and environmental sustainability.

Key steps include a thorough needs assessment, mobilizing a multidisciplinary team of experts, choosing devices with a lower impact and longer life, and integrating sustainability clauses into procurement contracts. The aim is to support sustainable health systems and services by ensuring that devices are properly managed, maintained and, ultimately, used to their full potential, rather than becoming waste [16].

II.4 Sustainable use

Sustainable use of medical devices involves reducing environmental impact by promoting device reuse, using environmentally friendly materials, improving energy efficiency, and designing devices that are easier to disassemble and recycle.

Key strategies include transitioning from single-use to multiple-use products where possible, choosing biodegradable or recycled materials, reducing packaging waste, implementing energy-efficient operations, and preparing for responsible end-of-life management to promote a circular economy in the healthcare sector [17].

II.5 Sustainable decommissioning

Sustainable decommissioning of medical devices involves designing them for reuse and recyclability, the implementation of recovery and refurbishment programs, and the guarantee of safe and environmentally friendly disposal methods, such as recycling or reconditioning.

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It prioritizes waste minimization, carbon footprint reduction and the protection of public health and the environment by extending the life of devices, recovering valuable materials and avoiding the hazards of improper waste disposal [18].

All these aspects or characteristics of sustainability are overlapped. This means that they are logically linked and demonstrate the consistency that strongly contributes to the achievement of the objectives.

III. METHODOLOGY

Between May and August 2025, a survey was conducted among biomedical technicians, clinical engineers, and hygienists in sub-Saharan Africa to gauge their level of perception of the impact environmental.

Previously, all ideas likely to be detrimental to the Environment impact in the sphere of medical equipment come from key stakeholders. Indeed, the design of these equipment requires the provision of an energy source. Since the nature of this energy is important when talking about sustainability and global warming. Once designed, they must be transported from the designing countries to the user countries, which are often located in separate hemispheres. Thus considerable distances will have to be covered and whatever the means of transport chosen, a combustible substance is used to produce energy in internal combustion engines.

In addition, their untimely use decreases their lifespan, encourages their renewal and increases the amount of obsolete equipment. Their electrical power determines their capacity and their size. Their disposal by landfill or incineration has negative effects on the soil, crops, water tables and air.

Finally, the material obsolete stored for a very long time damages the storage floors. These alterations are transmitted to the neighboring surfaces. In addition, these devices contain motherboards that house electronic components containing heavy metals that can contaminate the soils. The latter become sterile for planting trees guaranteeing a certain ecosystem in the absorption of carbon dioxide.

Thus, the main question is: What could be the impact of medical devices on climate change? The proposed points of view choices are as follows:

- The type of energy used for their design;
- The pollution generated during their transport from producing countries to consuming countries;
- Their mode of operation in relation to their frequency of use and their energy power;
- Their disposal by burial or incineration;
- Obsolete equipment unnecessarily stored and containing electronic components, among other things;
- Others.

A part that acts as a question 'Other proposals' with open answers is reserved as the last point. These other proposals will be formulated as recommendations.

Opinions on non-sustainable aspects of medical devices will be collected. The adopted approach consists of in a exercise of prioritization. A unit score is assigned to each choice. The cumulative scores allow them to be ranked in order of priority.

IV. RESULTS AND DISCUSSION

After reviewing the response forms, 113 opinions on non-sustainable aspects of medical devices were collected. 29 responses were obtained for the type of production energy used, i.e. a rate of 26%. As for the energy involved in transport, the responses represent about fifteen, i.e. a proportion of 13%. Concerning the mode of use, 18 responses were recorded, i.e. a rate of 16%. Regarding the mode of use, 18 responses were recorded, i.e. a rate of 16%. For the mode of use, 31 responses were noted, i.e. a proportion of 27%. Compared to obsolete equipment, 20 responses were obtained, i.e. a rate of 18%.

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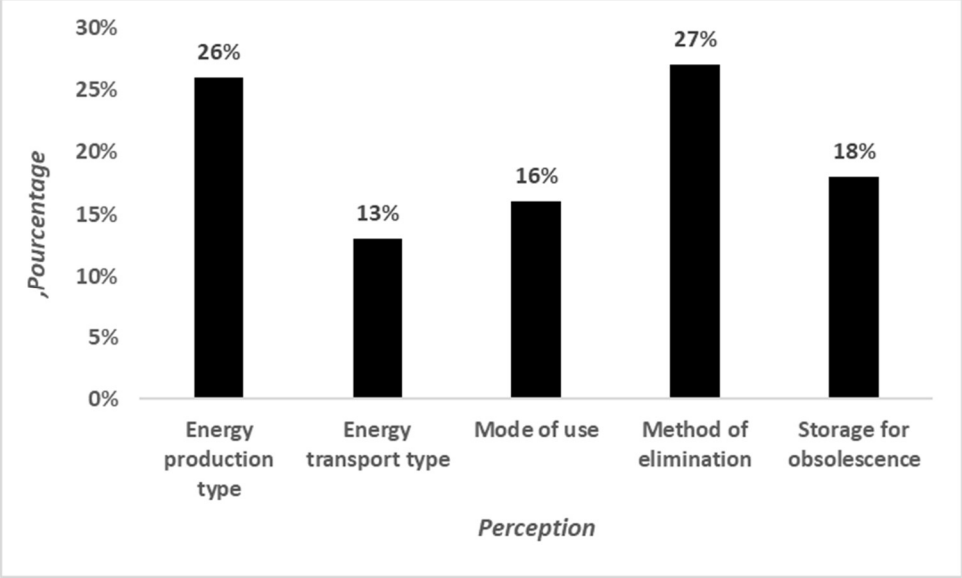

Source: Our data

Figure 1: *Environmental impact perception*

The analysis by order of priority offers the following spectrum:

- The maximum percentage is occupied by the method of elimination;
- The second weighting relates to the type of energy used for the design of medical devices;
- Storage by obsolescence is classified in third position;
- The mode of use comes in the penultimate position;
- The minimum weighting is occupied by the type of energy used for transport.

The mapping of environmental headings concerning medical devices offers a non-uniform spectrum. These headings constitute:

- The methods of use;
- Obsolescence management;
- The choice of energy.

So, 45% of opinions relate to the development of an obsolescence management certification that will sanction the disposal by incineration or landfill of certain medical devices and their storage after decommissioning. 39% of opinions relate to the choice of energy used for the production and transportation of medical devices, from producing countries to consuming countries.

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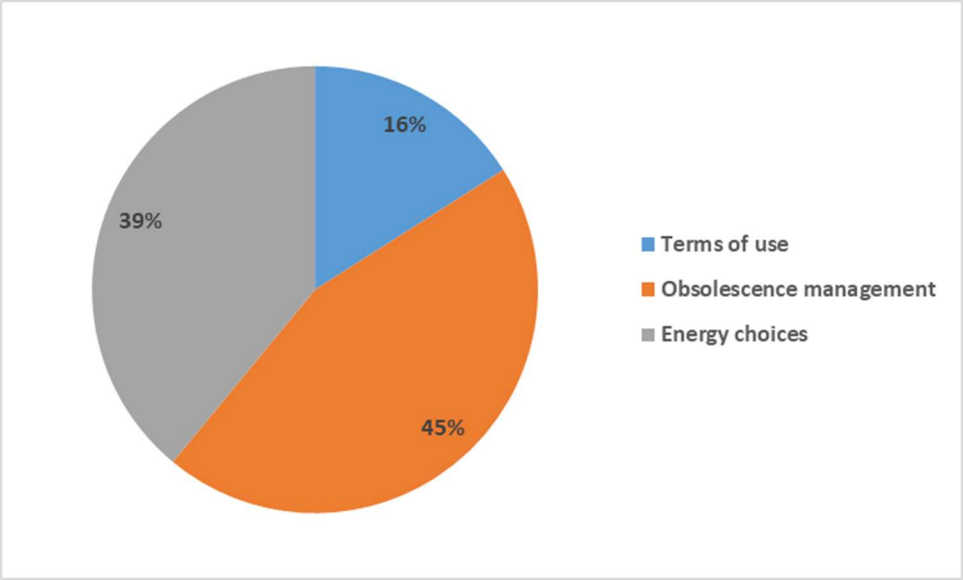

Source: Our data

Figure 2: *Mapping by categories*

Only 16% of opinions refer to the mode of use. The latter includes overuse, which reduces the lifespan of medical devices and boosts their renewal, on the one hand. On the other hand, single-use increases consumption and generates waste.

V. CONCLUSION AND RECOMMANDATIONS

This study allowed us to carry out a prioritization exercise based on a perception of the impact environmental of the actors involved in the sector of medical devices. The methods of eliminating waste from medical devices are much more urgent while the type of energy used for their transport would seem less of a priority. Nevertheless, all aspects of non-sustainability proposed are relevant because they are likely to contribute to global warming over time.

Several recommendations were made by the various actors. We must think of new renewable energies for the conception and transport of medical devices. We must promote multiple use by considering developing versatile and safe sterilization devices. Research should be carried out with the aim of producing less toxic and effective solvents for their proper cleaning and disinfection. Il faut songer à délocaliser les industries de technologies médicales de l'hémisphère Nord vers l'hémisphère Sud. Cependant, les pays émergents doivent investir dans la fabrication locale afin d'améliorer l'accès aux produits de santé, de réduire la dépendance aux importations et de favoriser le développement économique. La fabrication locale de dispositifs médicaux a un caractère réducteur de la pollution générée par le transport et un impact socio-économique. En effet, elle peut favoriser la diversification économique, la création d'emplois et un meilleur accès à des soins de santé de qualité dans les régions en développement. La croissance du secteur a des répercussions positives sur les activités auxiliaires, telles que les fournisseurs de matières premières et les services logistiques. Les principaux facteurs influençant sa croissance comprennent la demande croissante de procédures mini-invasives, le développement des soins à domicile et l'intégration des nouvelles technologies.

The challenge of accreditation is to implement sustainable practices around medical devices to obtain sustainable solutions to healthcare issues. A sustainable approach includes ecological medical technology using biodegradable, recycling materials, green source energy for production, environmentally clean transportation.

Looking ahead, a directory of environmental management tools for biomedical equipment needs to be developed. The ultimate question is: how to become eco-friendly?

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