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Evaluación de impacto ambiental de las tecnologías sanitarias: estado del arte y perspectivas de futuro

Environmental Impact Assessment of health technologies: State of the art and perspectives

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Palabras claves:
tecnologías, sanitarias, impacto, ambiental, basura, dióxido, carbono.

Resumen

Introducción: El impacto ambiental generado desde el sector sanitario en la actualidad se ha constituido como uno de los principales inconvenientes a nivel mundial, debido entre otras cosas a que las tecnologías sanitarias tuvieron un crecimiento exponencial en cuanto a su elaboración debido a la pandemia del COVID 19 generando niveles de residuos sólidos sanitarias jamás imaginados; esto incluso obligó a varios gobiernos de turno a generar políticas sanitarias que traten de mitigar el impacto negativo de estos desechos. **Objetivo:** La presente investigación tiene como objetivo explorar los métodos utilizados en distintas partes del mundo para evaluar el impacto ambiental generados por las tecnologías sanitarias. **Metodología:** Se realizó una revisión de la literatura científica en las principales bases de datos y se seleccionaron 16 artículos científicos de los últimos cinco años que evalúan el impacto ambiental de las tecnologías sanitarias, además se trabajó mediante un enfoque cualitativo. **Resultados:** La revisión bibliográfica reflejó que las diversas tecnologías sanitarias tienen una incidencia del 1 al 5% en el impacto ambiental a nivel mundial. Donde la mayor parte de emisiones provienen de inhaladores de que están compuestos por hidrofluorocarbonos, endodoncia dental, resonancia magnética, laringoscopios de metal o plástico, envases farmacéuticos de plástico o aluminio y las pruebas de hematología fueron las tecnologías sanitarias con mayor impacto ambiental. Los principales factores que implican el alto impacto ambiental por parte de las tecnologías sanitarias fueron: uso de electricidad, consumo de combustibles fósiles, ropa médica, desinfecciones prolongadas, equipos tecnológicos, reactivos, entre otros. **Conclusión:** Se concluyó que la tecnología sanitaria genera a nivel mundial un gran daño negativo al medio ambiente, donde año tras año se incrementan los niveles de basura y emisiones de dióxido de carbono como principales contaminantes.

Keywords:
Technologies, health, impact, environmental,

Abstract

Introduction: The environmental impact generated by the health sector has currently become one of the main drawbacks worldwide, due among other things to the fact that health technologies had exponential growth in terms of their development due to the COVID

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garbage, dioxide, carbon.

pandemic. 19 generating levels of solid health waste never imagined; This even forced several governments in power to generate health policies that try to mitigate the negative impact of this waste. Objective: The objective of this research is to explore the methods used in various parts of the world to evaluate the environmental impact generated by health technologies. Methodology: A review of the scientific literature was conducted in the main databases and 16 scientific articles from the last five years that evaluated the environmental impact of health technologies were selected. In addition, work was conducted using a qualitative approach. Results: The bibliographic review reflected that the various health technologies have an impact of 1 to 5% on the environmental impact worldwide. Where most emissions come from inhalers that are composed of hydrofluorocarbons, dental endodontics, magnetic resonance imaging, metal or plastic laryngoscopes, plastic or aluminum pharmaceutical containers, and hematology tests were the health technologies with the greatest environmental impact. The main factors that imply the high environmental impact of health technologies were use of electricity, consumption of fossil fuels, medical clothing, prolonged disinfections, technological equipment, reagents, among others. Conclusion: It was concluded that health technology generates great negative damage to the environment worldwide, where year after year the levels of garbage and carbon dioxide emissions as the main pollutants increase.

Introduction

Health technologies, also known as health or medical technologies, correspond to tools, equipment, devices, procedures and designed systems that promote the improvement of the provision of medical services and care (Sanni et al., 2019). They are related to several areas of medicine, among which are: medicine, nursing, dentistry, pharmacy, rehabilitation, public health and health management (Avivit & Itamar, 2017). The Pan American Health Organization (PAHO, 2023) mentions that this type of technology also involves medicines and medical techniques for both prevention and health promotion.

There are multiple health technologies used in Ecuador, however, the main ones are described below in the following table:

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Table 1

Health technologies used in Ecuador

Health technology	Description
Magnetic resonance imaging	It uses magnetic fields and waves to create images of the body, and identify soft tissue injuries, neurological problems, heart disease and musculoskeletal disorders.
Hearing implants	These devices are surgically implanted to provide hearing to people with severe to profound hearing loss.
Infusion pumps	These devices are used to deliver medications, nutrients or fluids into the body in a controlled and precise manner.
Radiation therapy	Radiation therapy uses ionizing radiation to destroy cancer cells and shrink tumors.
Advanced prosthetics	Modern prosthetics use advanced technology to replicate the function of lost body parts, such as limbs and organs.

Fountain: Avivit & Itamar (2017)

Therefore, these technologies, mainly medical devices and drugs, tend to cause great damage to the environment, where year after year the levels of garbage and carbon dioxide emissions as the main pollutants increase (Scott et al., 2020). In Ecuador, these types of technologies are constantly evaluated based on the suggestions of the WHO, however, at the environmental level there are very few studies (Ministry of Public Health, 2021).

It is very important to constantly assess the environmental impact in order to identify which health technologies are causing harm (Sanni et al., 2019; Scott et al., 2020). This type of impact takes into consideration human and natural activities and measures their effects on the ecosystem, biodiversity, natural resources and climate. It can generate positive and negative effects and manifests itself in the following ways: air, water and soil pollution, ecosystem degradation, loss of biodiversity, depletion of natural resources, climate change, among others (Habert et al., 2020).

In this way, medical devices have a negative environmental impact since they are the main air pollutants, while drugs contaminate water and soil if there is no adequate production and disposal process (Scherhaufer et al., 2018). Air pollution is due to the excessive production of greenhouse gases, which caused global warming on earth (Rahman et al., 2022).

Generally, environmental impact assessments (EIA) are used, which encompass a series of tools used to evaluate the possible environmental effects of projects, policies, programs or human activities before their implementation, in order to identify mitigation measures and make informed decisions about their environmental viability and sustainability (Dos Santos et al., 2019). Based on the above, the usefulness of EIAs in the field of health technologies can be clearly identified; in terms of viability, it must be taken into account that any remediation process must consider an appropriate cost, so that the proposed measures are executed.

It should be noted that environmental impact assessments (EIA) provide detailed information on the geology, hydrology, flora and fauna of a particular place, in order to identify some consequences of a human activity and therefore the establishment of preventive and control measures, to minimize as much as possible the impact on the environment (Marchvsky et al., 2018). As is evident, the assessments are the basis for proposing measures that seek to mitigate the damage caused to the environment, because without this data it would not be possible to propose measures that contribute substantially to reducing the effects of health technologies, where, as has been shown, the impacts are negative and their processing is urgent in some countries.

Methodology

The present study has a qualitative research approach, the type of research is bibliographic-documentary, descriptive, explanatory research, in addition the research method is analytical-synthetic, from the above we can establish that a complete bibliographic review was carried out, where the following criteria were established:

Inclusion criteria

- Articles from the scientific bases:PubMed, Scielo, Redalyc, MDPI, NCBI and Science Direct.
- Articles published from 2018-2023.
- Articles in English or Spanish.
- Types of study: systematic reviews, experimental controlled trials, cohort studies and meta-analysis.

Exclusion criteria

- Articles from other non-established scientific bases.
- Undergraduate, graduate, or doctoral documents

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- Articles with restricted access
- Studies with incomplete or ongoing data

Search strategy and presentation of results

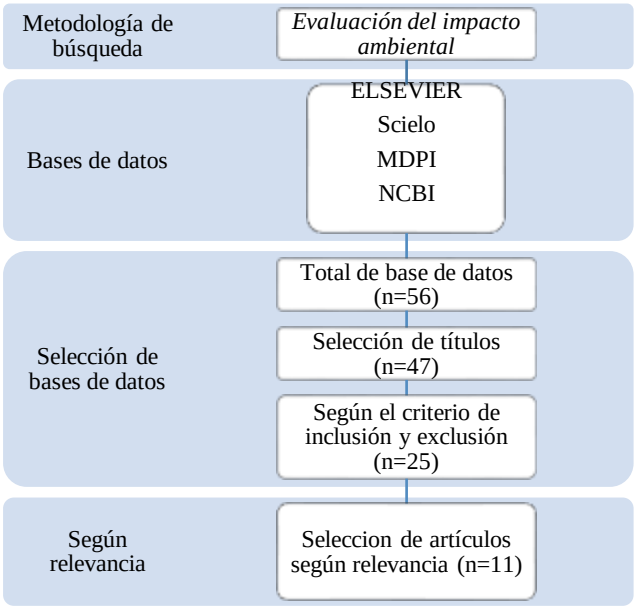
First, a search was performed in the following databases: PubMed, Scielo, Redalyc, MDPI, NCBI and Science Direct. Key terms used for the search were:

- "Environmental impact assessment"
- "Health technologies"
- "Medical devices"
- "Impact assessment"

After carrying out the search for articles in the databases, they were evaluated and selected using the prism method; for this, the documents must comply with certain inclusion and exclusion criteria previously established. The selection was carried out by checking the items of the method; this process consists of a flow chart that organizes and structures the studies with identification, screening, eligibility and selection criteria. As shown below in Figure 1:

Figure 1

PRISMA method for searching for results



Fountain:Do Nascimeinto et al. (2019)

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It should be noted that there is a considerable number of investigations that reflect the concern of various governmental and private organizations about the negative impacts generated by health technology, to the point of being responsible for greenhouse gases that have become an addition to global warming and overproduction after the pandemic, which generates large amounts of solid waste that in several countries were the trigger for generating environmental policies.

Results

The results of the bibliographical review are presented in the following table, making a relationship between the environmental impact assessment and the health technology frequently used in Ecuador and that has been applied in the world, so we can emphasize the following:

Table 2

Results of the bibliographic-documentary review

Qualification	Authors and year of publication	Methodology	Health technology	Results
The environmental footprint of healthcare: a global assessment	Lenzen et al. (2020)	Carbon footprint	Health care	Global healthcare has a global environmental impact of between 1-5%. In terms of greenhouse gas and air pollutant emissions, the healthcare sector causes a large proportion of the total footprint (4.4% of greenhouse gases, 2.8% of PM, 3.4% of NO and 3.4% of N2O3 emissions. 6% of SO2).
Environmental impact of inhalers for respiratory diseases.	Panigone et al. (2020)	Carbon footprint	Metered dose inhalers and dry powder inhalers	Of the inhalers analysed, it was determined that medium-dose inhalers have the greatest environmental impact, since they have a booster in their infrastructure. The carbon footprint results were: Medium-dose inhalers: 82-119 g CO2, Dry powder inhalers: 8 g CO2

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Table 2

Results of the bibliographic-documentary review (continued)

Qualification	Authors and year of publication	Methodology	Health technology	Results
Environmental sustainability in endodontics. A life cycle assessment (LCA) of a root canal treatment procedure	Duane et al. (2020)	Life cycle analysis: ISO 14040:2006	Dental endodontic procedure	A root canal treatment contributes 4.9 kg of carbon dioxide equivalent emissions (CO2 eq), due to the following factors: dental clothing, surface disinfection (isopropanol), disposable bibs (paper and plastic), single-use stainless steel instruments and the use of electricity.
Life cycle assessment of pharmaceutical packaging	Bassani et al.(2022)	Life cycle analysis	Pharmaceutical packaging	There is a large variation in impacts within alternative packaging for the same medicine, being more significant for ampoules (up to five times) than for bottles and sachets. The use of aluminium presents very high impacts, particularly in terms of acidification, while PVC presents very low environmental impacts.
Health care pollution and public health damage in the United States: an update	Eckelman et al.(2020)	Greenhouse gas emissions	Health care	In 2018, more than 500 million metric tons were produced, with a per capita production of 1,700 kg of CO2. This is due to the following factors: medical equipment, pharmaceutical and chemical supplements, plastics, textiles, paper, technological equipment.
Life-cycle environmental emissions and health damages from the Canadian health system: an economic-environmental-	Eckelman et al.(2018)	Greenhouse gas emissions	Health care	The health system was responsible for 33 million tonnes of carbon dioxide equivalents (CO2e), as well as more than 200,000 tonnes of other pollutants. Medicines are considered the main factor causing damage to health.

epidemiological analysis				

Table 2

Results of the bibliographic-documentary review (continued)

Qualification	Authors and year of publication	Methodology	Health technology	Results
The carbon footprint of Australian healthcare	Malik et al. (2018)	Greenhouse gas emissions	Health care	It generated CO 2 e emissions of around 35,772 kilotons. Pharmaceutical drugs, radiology and pathology were the main generators. Direct CO 2 e emissions from fuel use (gas for hot water) in health care contributed to 10% of total CO 2 e emissions, while indirect CO 2 e emissions due to purchases from other economic sectors contributed to almost 90% of total emissions.
The carbon footprint of hospital imaging in Australia	McAlister et al.(2022)	Life cycle analysis	Chest X-ray (CXR), Mobile Chest X-ray (MCXR), Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Ultrasound	The mean CO2e emissions were 17.5 kg/scan for MRI; 9.2 kg/scan for CT; 0.8 kg/scan for CXR; 0.5 kg/scan for MCXR; and 0.5 kg/scan for ultrasound. The main factors were: scanning time and excessive electricity use.
Life cycle assessment and cost calculation methods for device acquisition: comparison of reusable laryngoscopes.	Sherman et al.(2018)	Life cycle impact assessment	Laryngoscopes	Laryngoscope handles and blades made of metal and plastic were found to produce 16-18 times more carbon dioxide than those made of reusable steel. This is because they require adequate levels of cleaning, reprocessing, and premature wear before their useful life.

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Table 2

Results of the bibliographic-documentary review (continued)

Qualification	Authors and year of publication	Methodology	Health technology	Results
Carbon footprint impact of asthma and COPD inhaler choices	Janson et al. (2019)	Greenhouse gas emissions	Inhalers	Metered dose inhalers (MDI) containing chlorofluorocarbons were replaced by dry powder inhalers (DPI) and MDI containing hydrofluorocarbons (HFC). While HFCs do not deplete the ozone layer, they do generate potent greenhouse gases. The annual carbon footprint (CO2 e) was 17 kg for MDI; and 439 kg for HFC.
The carbon footprint of pathology testing	McAlister et al.(2020)	Greenhouse gas emissions	Pathology tests	CO 2 e emissions for hematology testing were 82 g/test, 73–91 g/test for coagulation profile, and 116 g/test for complete blood count. CO 2 e emissions for biochemical testing were 0.5 g/test (0.4–0.6 g) for C-reactive protein, 45–53 g/test) for arterial blood gas assessment, and 99 g/test for urea and electrolyte assessment. The majority of CO 2 e emissions were associated with sample collection, laboratory reagents, and energy use.

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Table 2

Results of the bibliographic-documentary review (continued)

Qualification	Authors and year of publication	Methodology	Health technology	Results
Challenges and solutions for estimating environmental impact in health technology assessment.	Hubbert et al. (2023)	Life cycle analysis.	Hypothetical LCA for a single-use/reusable scalpel.	Healthcare has a high environmental cost; the NHS is responsible for 4% to 5% of the UK's carbon footprint. Consequently, environmental impact is gaining importance in Health Technology Assessment (HTA) decision making, and Life Cycle Assessments (LCAs) can quantify this impact. However, there are current challenges in performing LCAs, requiring results to be interpreted with caution.

Discussion

In recent years, environmental impact assessment has become a measure to reverse the effects of climate change, and above all, prevention. It is promoted worldwide and even accepted by the United Nations as an environmental public policy (Perevochtchicova, 2023). It is even a great tool for achieving sustainable development as it quickly helps make decisions that do not affect the environment and generate protection (Do Nascimeinto et al., 2019). It delimits human and natural activities that can cause damage to the environment based on (Espinoza, 2021):

- Satisfactory actions for the environment
- Positive or negative consequences detected at the beginning
- Prevention and mitigation of negative consequences
- Rating compliance with environmental policies
- Execution of prevention studies for positive and negative impacts.

Despite the requirement to carry out Environmental Impact Assessments, in Ecuador there is little research on the subject and it focuses solely on construction issues, sewage systems, crops, agricultural activity, wastewater and even tourist activities (Ministry of Public Health [MSP], 2021; Perevochtchicova, 2023). However, in reference to sanitary

technologies, there are none, which is why the most used ones in the country were identified and an EIA was searched for them.

It was identified that worldwide, all healthcare technology has a global impact ranging from 1-5%, due to the following aspects: use of natural resources, waste generation, polluting emissions, among others. The healthcare sector is responsible for 4.4% of total GHG emissions. This is significant, since GHGs contribute to climate change by trapping heat in the atmosphere. Among these gases, N2O is mentioned, which is a potent greenhouse gas, with a contribution of 3.4% by the healthcare sector (Lenzen et al., 2020).

In parallel to the previous research are those described by Bassani et al.(2022)and Eckelman et al.(2018), which indicate very worrying data on the environmental impact caused by the entire health sector. Which indicate that due to medicines, radiology, pathologies and the use of electricity, they generate high quantities of carbon dioxide (200,000) and greenhouse gases. Which implies the need to review the practices of production, distribution and disposal of medicines to minimize their negative impact on human health and the environment. In 2018, more than 500 million metric tons were produced, with a per capita production of 1,700 kg CO2.

Similarly, studies were found that evaluate the environmental impact of certain health technologies, such as: inhalers, pathological devices, laryngoscopes, radiological examinations, dental implements, among others. Regarding inhalers that are mainly used to cure asthma, the study by Panigone et al. was identified.(2020)and Janson et al.(2019), in which they analyzed medium dose inhalers (MDI) and dry powder inhalers (DPI), determining that the first type is the one that causes a greater environmental impact, with a carbon footprint that ranges between 82-119 gCO2e mainly due to the presence of a propellant. On the other hand, the second investigation delimits that the composition of the inhaler also generates high environmental impacts, since most of them contain hydrofluorocarbons, one of the main polluting chemical compounds. This shows that the choice of the type of inhaler can have a significant impact on the environment.

Regarding dental aspects, a study on endodontics by Duane et al. was taken into consideration.(2020)They determined that this procedure produces around 4.9 kg of carbon dioxide equivalent (CO2 eq.) Due to a series of factors, which are described below:

- **Dental clothing:**Probably made of synthetic materials such as polyester or polypropylene, it can contribute to CO2 eq emissions during its manufacture, transportation and disposal at the end of its useful life (Duane et al., 2020).
- **Disinfection of surfaces**: The use of isopropanol for surface disinfection is a common practice in medical and dental settings. However, isopropanol is a

chemical compound that can contribute to greenhouse gas emissions during its production and transportation, as well as during its use and disposal (Duane et al., 2020).

- **Electricity:**The use of electricity during endodontics, for example to power medical equipment and lights, can also contribute to CO2 eq emissions, depending on the energy source used to generate it. If the electricity comes from renewable sources such as solar or wind power, the associated emissions may be lower compared to electricity generated from fossil fuels (Duane et al., 2020).

McAlister et al. (2022) analysed the impact of X-ray examinations, through which it was determined that MRI can generate up to 17.5 Kg of CO2e, 9.2 Kg for CT scan, 0.8 Kg in a chest X-ray. This variation can be explained by differences in the technology used, the scanning time and the energy requirements associated with each type of scan. The main driver of this is the examination time, where procedures that require more scanning time, such as MRI and CT, tend to generate higher CO2e emissions due to prolonged energy consumption.

Sherman et al. (2018), for their part, identified a high environmental impact in laryngoscopes that have a metal or plastic structure because the entire manufacturing process involves large inputs that are used very few times. Bassani et al.(2022), in their research on pharmaceutical packaging, also states that the high impact is due to the presence of plastics and aluminum. While McAlister et al. (2020), in pathological tests, determined that high carbon dioxide emissions are mainly due to sample collection, laboratory reagents and energy use.

Conclusions

- It was determined that the health technologies frequently used in Ecuador generate a negative environmental impact, because they produce large quantities of greenhouse gases, which promote climate change, even affecting human health. Although health technologies are an essential component to guarantee efficient, effective and quality medical care at all levels of the health system, it is very important to analyze the entire life cycle of these products in order to prevent severe damage to the environment.
- It was identified that all healthcare involves a high environmental impact with an incidence of 1-5% worldwide. Where the majority of carbon dioxide emissions are due to the consumption of fossil fuels. Of the healthcare technologies analysed, it was identified that those causing high environmental impacts were: medium dose inhalers composed of hydrofluorocarbons, dental endodontics, magnetic resonance imaging, metal or plastic laryngoscopes, pharmaceutical packaging made of plastic or aluminium and haematology tests.

- It was determined that the main factors that imply the high environmental impact of health technologies were: use of electricity, consumption of fossil fuels, medical clothing, prolonged disinfection, technological equipment, reagents, among others, which have undoubtedly promoted the creation and application of environmental policies that reduce the environmental impact by the governments in power.
- It was concluded that the results of the various investigations highlight the importance of evaluating and comparing the environmental impact of different healthcare technologies, and of carefully considering the environmental implications when choosing between different treatment options, and underline the continued need to seek greener and more sustainable alternatives in the design and manufacture of medical devices to minimize their impact on the environment.

Conflict of interest

The authors declare that there is no conflict of interest in relation to the submitted article.

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