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# The elephant in the room in greenhouse gases emissions: rethinking healthcare systems to face climate change. A rapid scoping review

Walter Cristiano[1], Chiara De Marchi[2], Kevin di Domenico[1], Ornella Punzo[1*], Aurora Mancini[1] and Laura Mancini[1]

**Abstract**

Healthcare systems (HSs) provide essential services to populations yet require a large amount of energy to perform duties and tasks. Specifically, 4.4% of global net carbon emissions can be attributed precisely to the activities of HSs. Therefore, it seems unlikely that the targets of zero carbon dioxide ($CO_2$) emissions by 2050, set by the Paris Agreement, will be met without rethinking the role and impact of HSs towards climate change. Here we summarize the available literature on $CO_2$ emissions depending on direct and indirect Hss activities. We show that the number of studies addressing this topic is still very limited and that most of the emissions derive from the supply chain HSs rely on to perform their tasks. Furthermore, we highlight how this topic is addressed unevenly among countries. Indeed, we found that less economically developed countries are less represented in the literature on this topic and that, even in economically developed countries, most of the studies come from English-speaking countries. In the discussion, we stress that health workers and policymakers should pay more attention to this issue in order to tackle climate change and related health issues, following the example of few virtuous countries. Finally, some potential impact mitigation strategies are discussed.

**Keywords** Healthcare carbon footprint, Healthcare decarbonization, Climate change, Planetary health, Public health policies

## Background

Climate change stands as one of the most pressing health threats to humanity, as acknowledged by the World Health Organization (Fact Sheet WHO [1]). The release of greenhouse gases (GHG) into the atmosphere as a result of human activities is one of the main drivers of the ongoing global temperature increase on a large scale [2]. Currently, the average global temperature exceeds the preindustrial era by more than 1.2 °C [3], and this trend is unlikely to halt in the near future [4]. This escalation has led to a rise in the frequency and intensity of extreme atmospheric events, including heatwaves, floods, droughts, and forest fires, posing grave threats to human and environmental health [5].

Climate change can impact human health by functioning as a syndemic, exacerbating pre-existing chronic conditions and interacting with social determinants of health, thereby intensifying existing health disparities [6].

In 2016, 55 countries ratified the Paris Agreement, urging Member States to decrease GHG emissions and cap the global temperature increase below 2 degrees in comparison to preindustrial levels. This document emerged as the primary output of the 21st Conference

*Correspondence:
Ornella Punzo
ornella.punzo@iss.it
[1] Ecosystems and Health Unit, Environment and Health Department, Italian National Institute of Health, Viale Regina Elena, 299-00161 Rome, Italy
[2] Department of Public Health and Infectious Diseases, Sapienza University of Rome, Piazzale Aldo Moro, 5-00185 Rome, Italy

of the Parties (COP) of the United Nations Framework Convention on Climate Change in 2015 [7].

Furthermore, in 2018 the Intergovernmental Panel on Climate Change emphasized and then reaffirmed in 2023 the imperative to limit the global temperature increase within 1.5 °C in the coming decades. Achieving this goal needs reducing carbon dioxide ($CO_2$) emissions to zero by 2050 [8]. It has been estimated that to meet this target, there should be an annual increase of 9.7% in energy production from renewable sources, aiming to satisfy the world's energy demand while adhering to the zero-emissions requirement [9]. The healthcare sector, with its mission of safeguarding and promoting health, should play a key role in mitigating the climate crisis. Despite this, its climate footprint is equivalent to 4.4% of global net carbon emissions [10], making it a major contributor to the climate crisis. This represents a paradox, considering that the healthcare sector is designated to address health issues globally. Healthcare contributes to GHG emissions through various sources, which can be categorized into Scopes 1, 2, and 3 (The Greenhouse Gas Protocol [11]) as outlined in Table 1.

Certain countries are actively working towards achieving the zero-emission target, exemplified by the United Kingdom (UK), which has committed to reaching it by 2040 [12]. However, it is important to note that the per capita emissions associated with the healthcare sector showed an increase between 2007 and 2016 in several countries globally, including the United States of America (USA), Japan, and China [9].

The aim of this work is to provide a concise summary of the peer-reviewed findings and evidence regarding the contribution of healthcare systems (HSs) to the global carbon footprint. This parameter is commonly employed to gauge the impact of an individual, a product, a service, or an organization on GHG emissions, expressed in terms of $CO_2$ equivalent tonnes (tCO2e). We also aim to provide insights to potentially develop a framework for implementing practical solutions and best practices aimed at reducing carbon emissions in the healthcare sector.

## Main text

### Materials and methods

We developed the research protocol adhering to the guidelines for writing a rapid review suggested both by the WHO [13] and the recommendations of the Cochrane Collaboration [14]. We chose to conduct a rapid scoping review [13, 15] as we believe that the urgency of the climate crisis needs a rapid knowledge synthesis that this kind of review can offer.

### Research question

Our research question aligned with the objective of our work and it was formulated as follows: "What are the peer-reviewed findings regarding the contribution of HSs to the global carbon footprint?"

### Eligibility criteria

We incorporated studies that presented data on the carbon footprint of HSs at both national and regional levels. To ensure the reliability of carbon emissions measures and expedite our search, we exclusively considered studies supported by quantitative data published in peer-reviewed journals. Therefore, grey literature was excluded from our search. Additionally, only papers written in English were included. We further expanded our scope to include data on the carbon footprint estimation resulting from the activity of individual hospitals. In this context, clinics were identified as the smallest units for examination in our review. We encompassed publications quantifying specific scopes in the emission chain, such as water consumption, space heating and cooling, transport, or overall emissions. Notably, studies focusing on the impacts of individual medical procedures or hospital departments were omitted due to the challenge of generalizing their results. Eligibility criteria are summarized in Table 2.

### Searching

We gathered the studies included in our search by screening the PubMed database (all fields). The search string was formulated as follows: ((healthcare systems) OR (hospitals)) AND (($CO_2$ emissions) OR (carbon

**Table 1** Emission categories according to the GHG Protocol

| Emission category | Description |
|---|---|
| Scope 1 | Emissions coming directly from healthcare facilities and health care owned vehicles |
| Scope 2 | Indirect emissions from purchased energy sources such as electricity, steam, cooling, and heating |
| Scope 3 | All other indirect emissions from the healthcare supply chain (production, transport, and disposal of goods and services, such as pharmaceuticals, food, medical devices, etc.) |

**Table 2** Eligibility criteria

| Eligibility criteria | |
|---|---|
| Subject | Carbon emissions from Healthcare Systems |
| Data source | Quantitative data published on peer-reviewed journals |
| Timeframe | Not Specified |
| Language | English |
| Geographical region | Not Specified |
| Emission source | From single healthcare facilities up to national level |

footprint)). All studies available until 9th November 2023 were collected, without setting an initial time limit.

### Study selection

Following the selection criteria outlined above, two researchers (CDM and WC) independently screened all publications retrieved by reviewing both titles and abstracts. Any disagreements were resolved through discussion between the two authors at the conclusion of the screening process. The next phase included a third author (KDD), who equally collaborated to screen all included full-text studies. The studies were distributed among the three authors, ensuring that each publication was independently reviewed by two authors. After screening all the full-text studies, the authors compared their findings pairwise, and in the event of any discrepancies, the third author intervened to resolve conflicts.

### Data extraction

One author (CDM) extracted the data, encompassing the following information: authors, year of publication, country of publication, study goals, results, and potential limitations. In instances of uncertainty, the opinions of the other authors were sought. Ultimately, the evidence obtained from the search was synthesized narratively, and the data were summarized through a table.

## Results

### Literature search and selection

From the rapid review of the literature, 867 records were retrieved. After screening titles and abstracts, 21 were selected. Of the eligible studies, only 9 met all the inclusion criteria, leading to the exclusion of the remaining 12. The study selection flowchart is summarized in Fig. 1. Among the identified studies, 5 reported data derived from HSs, 2 from health regions, and 4 focused on individual hospitals or clinics, i.e., healthcare facilities. The information extracted from the included studies is reported in narrative format and categorized based on

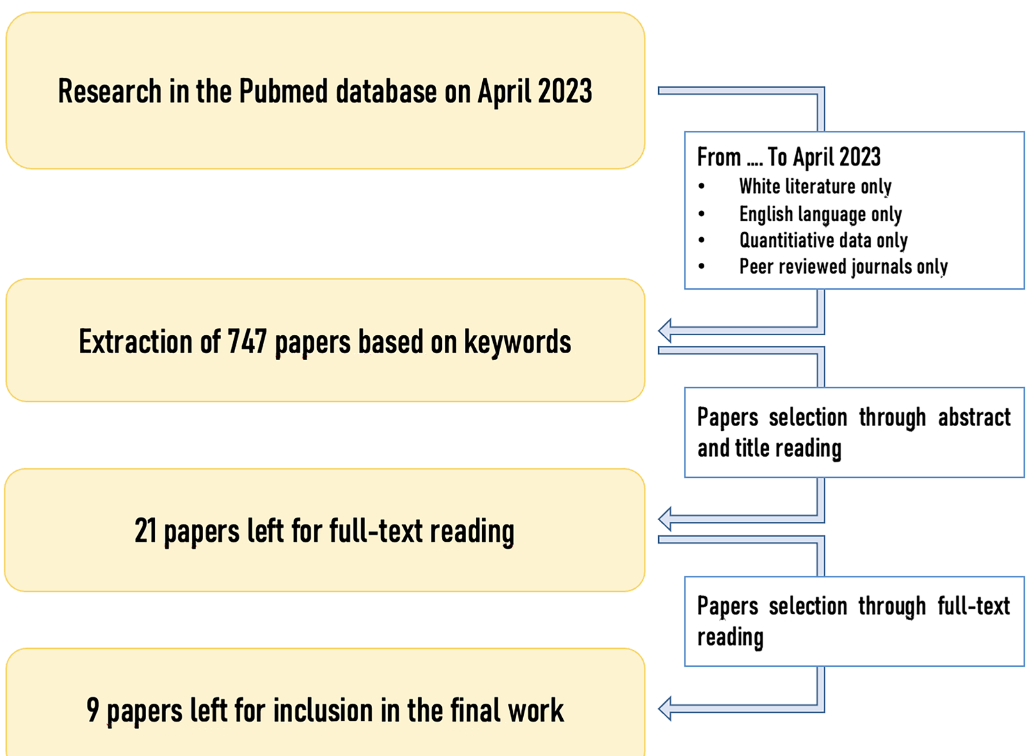


**Fig. 1** Screening process flowchart

the setting: "healthcare systems and health region" and "healthcare facilities". Data are summarized in Table 3, while Fig. 2 shows the different contributions of HSs to GHG emissions reported in the studies that we retrieved aligned to the corresponding emission category.

### Healthcare system and health region

The work of Salas and colleagues [16] concerned the healthcare carbon footprint across various national health systems in 2016. The authors incorporated data from multiple studies in their work to craft an analytical paper informing about the GHG emissions impacts of HSs in numerous countries. Globally, the carbon footprint of HSs in 2016 was estimated to represent 4–6% of all emissions. The authors underlined that, although Scope 1 emissions are within the most direct control of healthcare facilities, they contribute only for 17% to the total emissions. Over 70% of healthcare emissions originate from diverse categories in Scope 3, which are seldom calculated or reported by health systems. The study reveals variations in carbon footprints across medical specialties and treatments, indicating considerable room for improvement among high emitters.

The other studies [17–20] examining HSs focused on GHG emissions in England, the United States, Australia, and China. The first study used a hybrid model to quantify emissions within Scopes 1, 2, and 3 of the GHG Protocol, as well as patient and visitor travel emissions, covering the period from 1990 to 2019. In contrast, the others employed the input–output life-cycle assessment method to estimate GHG emissions in 2007, 2014/2015, and 2012, respectively.

The carbon footprint for the National Health System (NHS) in England in 2019 was estimated at 25 megatonnes (Mt) of $CO_2$ equivalent ($CO_2$e), reflecting a notable decrease of approximately 26% from 1990 [20]. A significant factor in this reduction was the decarbonization of the energy system, contributing to a 64% reduction in building energy from 1990 to 2019 and serving as the main driver for a 43–45% decrease in total national GHG emissions over the same period. The largest proportion of emissions, accounting for 62% (15.6 Mt $CO_2$e), was attributed to the supply chain, followed by the delivery of care at 24% (6.1 Mt $CO_2$e), and travel to and from NHS sites by patients, visitors and staff commuting at 10% (2.4 Mt $CO_2$e). Private health and care services commissioned by the NHS contributed the final 4% (1 Mt $CO_2$e).

In the USA, the cumulative impact of healthcare activities accounted for 8% of the total GHG emissions,

**Table 3** List of the main findings of the reviewed studies

| Reference (> Authors) | Country | Level of study | Period of study | Emission category considered | Study category |
|---|---|---|---|---|---|
| [16] | / | Global | / | | Healthcare systems and health region |
| [20] | United Kingdom | National (NHS England) | 1999–2019 | Scopes 1, 2, and 3 and patient and visitor travel emissions | Healthcare systems and health region |
| [17] | United States | National (NHS United States) | 2007 | Direct effects of health care activities and indirect effects that include upstream supply-chain effects | Healthcare systems and health region |
| [18] | Australia | National (NHS Australia) | 2014–2015 | Input–output life-cycle assessment | Healthcare systems and health region |
| [19] | China | National (NHS China) | 2012 | Input–output life-cycle assessment | Healthcare systems and health region |
| [21] | Scotland | Regional (carbon footprint of NHS Scotland) | / | Travel emissions | Healthcare systems and health region |
| [22] | Greece | Local (GHG emissions of a Military Hospital in Athens) | January and December 2018 | Electricity, Fossil fuels, Transport activities, Refrigerators, Air-conditioning systems, Waste disposal | Healthcare facilities |
| [23] | United Kingdom | Local (carbon footprint of a geriatric clinic) | Before and after the COVID 19 pandemic | Patient travel, staff travel, PPE, water, waste, telecommunications and heating/lighting the clinic facilities | Healthcare facilities |
| [24] | United Kingdom | Local (carbon footprint of a specialist palliative care unit) | 2021 | Medical and non-medical which included energy, waste and transport | Healthcare facilities |

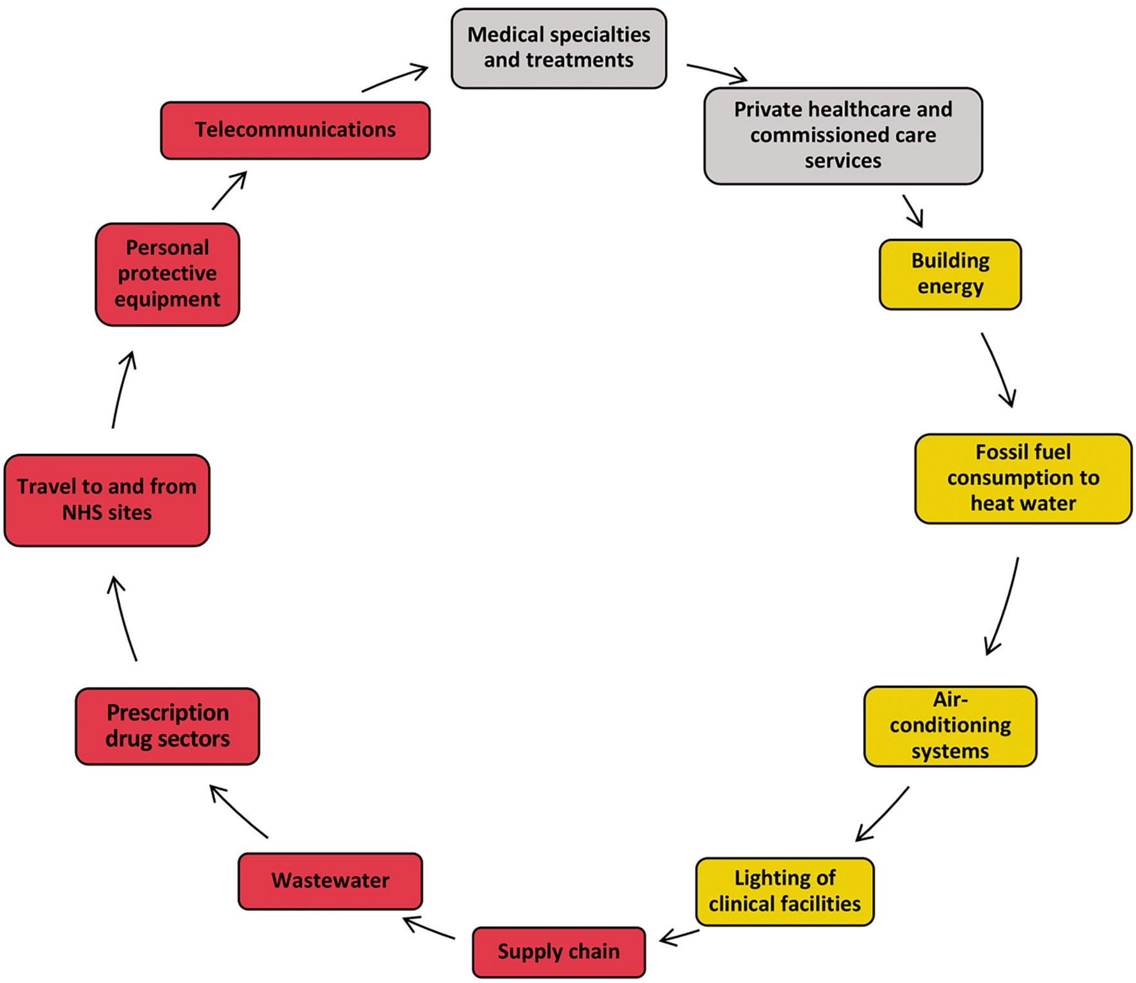


**Fig. 2** Different types of contributions of the HSs to GHG emissions. Different colors indicate a specific emission category, as underlined by the GHG Protocol (grey = Scope 1; yellow = Scope 2; red = Scope 3)

equivalent to an estimated total of 546 million metric tons of $CO_2$e [17]. The major contributors were the hospital and prescription drug sectors (39 and 14%, respectively). $CO_2$ emissions represented about 80% of total global warming potential.

In Australia, the total $CO_2$e emissions attributed to healthcare were 35,772 kilotonnes, constituting 7% of the country's entire $CO_2$e emissions [18]. Hospitals, including their capital expenditure, accounted for approximately half of the total healthcare emissions, while pharmaceuticals contributed to an additional 20% of total $CO_2$e emissions. Direct $CO_2$e emissions from the use of fuel (specifically gas for hot water) in healthcare contributed to 10% of the total, whereas indirect $CO_2$e emissions due to purchasing from other economic sectors contributed to nearly 90% of the total.

The last study investigating the emissions of a healthcare system was the one by Wu [19]. In China, the carbon footprint of the healthcare system in 2012 amounted to 315 Mt $CO_2$e emissions, representing 2.7% of the national total GHG emissions. Public hospitals, non-hospital-purchased pharmaceuticals, and construction emerged as the top three categories with the highest footprint, contributing to 47%, 18%, and 15%, respectively.

In assessing the carbon footprint of travel, NHS Scotland, and specifically the Grampian health region, were examined [21]. The estimates were derived by combining data from NHS England and a published report estimating the carbon footprint of NHS Scotland. The mean of the two estimates served as the best approximation for the annual travel emissions from NHS Scotland, totaling 489.000 tonnes of $CO_2$. With the Grampian region comprising approximately 10% of the Scottish population, a proportional breakdown for the region's travel emissions would be 48.885 tonnes of $CO_2$. The authors then explored the potential role of telehealth in reducing the overall carbon footprint of the NHS.

### Healthcare facilities

Among the studies identified, some focused on specific settings, such as hospitals or clinics. One study calculated the GHG emissions of a Military Hospital in Athens, Greece, with a capacity of 550 beds and up to 1000 staff members [22]. According to the authors, the hospital's total emissions for the year 2018 amounted to 8389.2 $CO_2$e. The majority of these emissions stem from energy consumption, with electricity contributing 62.9% of the total emissions (5275.3 $CO_2$e), and fossil fuels consumption accounting for an additional 32.2% (2706.2 $CO_2$e). Moreover, emissions from refrigerators were 0.1% (5.2 $CO_2$e), and air-conditioning systems contributed 4.0% (338.5 $CO_2$e) in terms of fluorinated gas emissions. Lastly, waste disposal represented 0.8% (64.0 $CO_2$e). Additionally, as per a previous paper by the same authors, the footprint of transportation activities in 2018 was 1402 tonnes of $CO_2$e (t$CO_2$e), bringing the total carbon footprint of the hospital to 9791.2 t$CO_2$e.

Two papers examined the carbon footprint of smaller healthcare settings. The first one [23] delved into the carbon footprint of an outpatient clinic within a UK Geriatric Medicine department, investigating the effect of virtual consultations before and after the onset of the COVID-19 pandemic. The authors factored in patient travel, staff travel, personal protective equipment, water, waste, telecommunications, and the heating/lighting of clinic facilities in their calculations. They did not include embedded carbon in preexisting vehicles or computer hardware, as well as emissions associated with requested investigations or secretarial work, as these factors remain constant despite COVID-19 adaptations. The main finding was a reduction in the overall carbon footprint of the mixed consultation clinic, decreasing from 72.1 to 55.34 kg of $CO_2$e per month, mainly attributed to decreased emissions from patient travel.

The last study aimed to calculate the carbon footprint of a specialist palliative care unit in the southwest of England [24]. The methodology involved categorizing various activities into two main resource areas: medical and non-medical. These areas encompassed energy, waste, and transport, with the latter utilizing a survey to approximate the total mileage. The estimated emissions stood at 420 t$CO_2$e, with the major contributors identified as travel (35%), gas (33%), and non-medical supplies (17%).

## Discussion

We presented the outcomes of a rapid scoping review conducted to gather insights into carbon emissions associated with HSs activities, a potential health threat that is likely to be globally underestimated. According to our inclusion criteria, the results indicate a scarcity of evidence regarding the impact of HSs on carbon emissions and, consequently, on climate change. However, our search revealed recent efforts to address these crucial issues, with 7 out of 9 retrieved papers being published from 2018 onwards. This trend likely mirrors the increased awareness spurred by the Paris Agreement in recent years.

The literature search highlights a notable geographical concentration of retrieved papers, primarily originating from English-speaking nations, e.g., UK, Australia, and the USA, with limited exceptions in countries like China and Greece (only 2 papers out of 9). Consequently, there is a valid inference that our findings may lack representation of the global scenario. It becomes imperative to broaden the scope with studies from diverse regions to comprehensively map the current carbon footprint situation. While our results may not offer a globally representative perspective, the homogeneity observed in more industrialized countries still holds significance. However, it is crucial to acknowledge that less economically developed countries might present a different landscape.

It is fundamental to understand that, despite some efforts, indirect emissions are increasing on a global scale [25]. Both Scope 2 and Scope 3 emissions can be classified as indirect. Notably, in studies conducted in the UK and Australia, the majority of the carbon footprint is attributed to indirect emissions. In line with the recent work of Rodríguez-Jiménez et al. [26], our findings echo a similar pattern, indicating that most emissions arise from sources included in Scope 3, such as the supply chain. Reducing Scope 3 emissions poses a greater challenge compared to Scope 1 and 2. The complexity arises from the imperative to involve external suppliers in implementing strategies to mitigate their emissions. In European Union (EU) Member States, road transportation alone is estimated to account up to 26% of the total $CO_2$ emissions [27]. Case studies in Greece [28] and Austria [29] have affirmed the pivotal role of transportation activities in GHG emissions within HSs. Considering that a significant portion of transportation emissions in the healthcare sector stems from patient travel to and from hospitals [28], mitigation measures may include enhancing telemedicine [30] and optimizing public transport management [28, 31]. In this context, discouraging private transport usage could yield substantial positive impacts on public health [32].

However, as mentioned earlier, indirect emissions also result from various forms of energy consumption categorized under Scope 2, including electricity, steam, and air-conditioning. To illustrate, the study by Bozoudis and colleagues revealed that the carbon footprint of the

Greek military hospital they examined was predominantly attributed to electricity consumption. Fossil fuel consumption for heating purposes ranked as the second most significant source of emissions, while the third most impactful category was linked to transportation activities. Projections for 2030 indicate a similar pattern, with an expected decrease of around 35% in GHG emissions [22]. At first glance, energy consumption is intertwined with all-scope emissions from a broader perspective. On one hand, energy is required whenever any hospital facility is turned on, and on the other hand, energy is needed to meet the demand for fossil fuels, ultimately linking to upstream energy emissions in the supply chain [20]. Energy production's role in increasing the healthcare sector's carbon footprint underscores the importance of addressing energy supply arrangements to mitigate emissions and promote a transition to renewable energy sources. This green deal ultimately requires sector coupling in the future development of energy planning [33]. Some evidence suggests that this process has already begun [20, 34]. In recent years, it has been shown that a substantial contributor to the reduction of carbon emissions in the English NHS is due to the decarbonization of the energy system. This process, occurring over the last thirty years, results in a tiny fraction of Scope 2 GHG directly related to building energy for delivering care [20]. However, despite the transition to renewable energies boosting decarbonization in all sectors, including healthcare, some issues need to be considered. Firstly, the possibility of making this transition varies between countries. Higher levels of economic globalization seem related to higher chances of promoting a transition to renewable resources [35]. Moreover, economic stability and good income levels appear to be prerequisites for achieving such a transition from fossil fuels to renewable energy sources, with countries having higher average income levels positively impacting electricity consumption. In this framework, higher technological development would allow lower costs from renewable sources to generate electricity in higher-income countries, while middle and lower-income countries would struggle to import expensive technologies to sustain a shift towards sustainability [36].

According to the 17 United Nations (UN) Sustainable Development Goals (SDGs), strategies to achieve climate, environmental, economic, and social sustainability should become top priorities in the political agenda of the member states. Healthcare GHG emissions are strictly related to at least three goals: SDG 3, which focuses on health and aims to ensure healthy lives and promote well-being for all; SDG 7, which aims to ensure access to everyone to affordable, reliable, sustainable, and modern energy; SDG 13, which ambitiously aims to tackle climate change and its impacts by taking a set of urgent actions [37]. If most of the emissions in the healthcare sector come from indirect sources, focusing our efforts on them becomes crucial to effectively reduce overall GHG emissions at a system level. In this framework, different mitigation strategies have been proposed to be implemented. For instance, the promotion of energy communities among EU Member States is in that direction. EU Directives 2018/2001 [38] and 2019/944 [39] introduce the idea of energy communities and mandate that Member States work together to ensure that energy production increasingly relies on renewable resources. Energy communities can be meant as partnerships between companies, customers, and local authorities looking for innovative actions that help the energy transition towards renewable resources, favoring private investments in this sector, and providing benefits to the citizens through the increase of energy efficiency and the lower of bills while potentially creating local job opportunities [40]. In this sense, HSs should cover the idea of forming energy communities that may represent a useful tool both to improve electricity consumption and ultimately save costs. Supporting the idea that an energy transition towards sustainability can yield economic benefits, there have been suggestions that companies' adoption of best practices is associated with higher financial performances [41]. Even simple steps, such as replacing traditional luminaries with LED lighting, could have a strong impact on reducing GHG emissions [42]. Other mitigation measures to face Scope 2 emissions may include the most frequent use of low-carbon technologies for providing energy, such as passive ventilation and cooling or solar photovoltaic [43].

The significance of environmentally suitable alternatives to conventional patient care procedures is emphasized by Alshqaqeeq and colleagues, who highlight the challenge of limited data on the environmental impact of health services. There is a call to encourage health workers to explore alternatives that enhance environmental health while upholding the quality of care [44]. In alignment with Sapuan and colleagues, our work underscores the urgent need for the health sector to disrupt the cycle in which efforts by HSs to address health issues, often chronic and resource-intensive, inadvertently contribute to greater damage at a public health level, escalating energy demand and, therefore, overall carbon emissions [45].

## Conclusions

The WHO has just released the "Operational framework for building climate resilient and low-carbon health systems" [46]. This document seeks to guide UN Member States in reducing the contribution of HSs to climate change. In pursuit of this ambitious objective, the framework offers essential guidelines on how each country can address climate-related health risks through the adoption of low-carbon health practices. Additionally, the operational framework provides recommendations on monitoring progress in this endeavor.

Keeping this in mind, our aim is to ensure that our efforts are followed by a reflective analysis focused on identifying the key hubs where tangible actions can be implemented. Given that Italy is the country where we live and work, our intent as healthcare sector professionals is to advocate for accelerating the transition to more sustainable ways of working in our national healthcare system. To achieve this goal, we will strive to develop a coherent framework for Italian healthcare system and hospitals in the near future in agreement with the WHO Operational framework abovementioned, offering practical solutions to combat climate change and promote sustainability, finally hoping to provide a model for other countries.

In the last UNFCCC Climate Change Conference in Glasgow (COP26), fifty countries have committed to developing low-carbon health systems and only six EU countries have submitted formal commitments to the COP26 Presidency to strengthen and develop sustainable HSs.healthcare systems. Notably, Italy is not on the list of signatory countries [47], suggesting that data are missing and political awareness on this topic is lacking.

Our study could finally provide important information for policymakers. As agreed upon by the UN SDGs, political actions should be oriented towards sustainability in all sectors. The WHO has recognized this challenge and addressed it by introducing a path for increasing the climate resilience of HSs. Being informed about the primary role that HSs could play in emphasizing the effects of climate change would allow policymakers to implement mitigation strategies more effectively in their agendas. Our work contributes to actively improving sustainability through a holistic approach that could serve as a benchmark for the healthcare sector. In particular, it would be useful to address innovative political measures aimed at improving living conditions in the context of the smart city concept [48], thus ideally allowing for effective long-term health prevention and mitigation risk strategies.

It is projected that the healthcare sector's impact on the climate crisis will continue to rise in the coming years, as stated in the Health Care Without Harm and Arup's Health Care's Climate Footprint Report [49]. It is imperative for healthcare systems and professionals to assume a leadership role in acknowledging and curbing their influence on climate change. The scientific community as a whole is urged to recognize this issue as a top priority.

## Limitations

Our study, by its very nature, rewards speed in the revision work. However, this virtue also comes with limitations, despite our thoroughness. The main limitation is represented by the fact that we only looked at one database. Though pertinent to the focus of our study, utilizing a single database has inherent limitations. However, this approach aligns with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines [50] and can expedite the review process, especially in emergency conditions such as those imposed by the current climate crisis, demanding swift responses in support of stakeholders and authorities. Further research may include searching in different databases, such as Scopus or Web of Science. The second limitation lies in the scarcity of keywords used, although very accurate. Alternative keywords to use in the future might include "clinics" and "climate change".

**Abbreviations**

| | |
|---|---|
| WHO | World Health Organization |
| GHG | Greenhouse gases |
| COP | Conference of the Parties |
| UNFCC | United Nations Framework Convention on Climate Change |
| CO2 | Carbon dioxide |
| UK | United Kingdom |
| USA | United States of America |
| HSs | Healthcare systems |
| tCO2e | Tonnes of carbon dioxide equivalent |
| NHS | National Health System |
| Mt | Megatonnes |
| EU | European Union |
| UN | United Nations |
| SDGs | Sustainable Development Goals |

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**Author contributions**
LM, CDM, and WC conceptualized the work. WC and CDM designed the work. WC and CDM screened titles and abstracts of the retrieved publications. WC, CDM, and KDD screened the full text of the publications included and analyzed the results. CDM performed the data curation. KDD, WC, CDM, and OP developed figures and tables. WC, CDM, KDD, and OP drafted the original version of the manuscript. AM and LM revised the work. LM and OP supervised the work.

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**Competing interests**

The authors have no competing interests to declare that are relevant to the content of this article.

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