Contribution of hospital pharmacists to sustainable healthcare: a systematic review

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ABSTRACT

Background With a global annual carbon footprint of the healthcare sector of 2 gigatons of CO_2e, healthcare systems must contribute to the fight against climate change. Hospital pharmacists could be key players in ecological transition due to their role in managing healthcare products. The aim of this study was to summarise the evidence on interventions implemented in healthcare facilities involving pharmacists to improve the environmental footprint of healthcare.

Methods This systematic review was conducted following PRISMA 2020 guidelines. The Medline, Web of Science and ScienceDirect databases were searched for studies published between 2013 and 2023. To be eligible for inclusion, studies had to include hospital pharmacists and present contributions aimed at reducing the environmental footprint of healthcare in healthcare facilities. Outcomes were the description of the contribution, the methods used and the stages of healthcare product lifecycle analysed. A Mixed Methods Appraisal Tool was used to assess the risk of bias for each study.

Results Seventeen studies were included. Pharmacists played a leading role in 15 (88%) and had a supporting role in the others. The healthcare products targeted were medicines (59%), medical devices (12%) or both (29%). The stages of the healthcare product cycle addressed by the contributions were elimination (71%), dispensing (35%), procurement and supply (35%), production (29%), and prescription (24%). Only two studies used life cycle assessment and only one assessed all three pillars of sustainability. Two studies had good methodological quality while the rest had at least one element of uncertainty.

Conclusion This review confirms the central role of the pharmacist and the importance of a multidisciplinary approach in implementing eco-responsible actions. It could be useful to hospitals and other teams wanting to improve sustainable actions and it emphasises the importance of collaborating with pharmacists when planning sustainable initiatives. Future eco-responsible initiatives must use robust reproducible methods.

Trial registration PROSPERO #CRD42023406835

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The healthcare system contributes to climate change and paradoxically contributes to the deterioration in the health of the population.
⇒ It is now possible to incorporate sustainable development into healthcare and to decarbonise healthcare systems.
⇒ No review has assessed pharmacist contributions to greener healthcare.

WHAT THIS STUDY ADDS

⇒ The methods used to measure the environmental impacts of an action are still heterogeneous, and the reference method (life cycle assessment) is insufficiently implemented.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This literature review provides an overview of eco-responsible hospital contributions conducted by hospital pharmacists.

BACKGROUND

The temperature of the Earth's atmosphere has risen by approximately 1°C since the late 19th century.[1] The impacts of climate change on our society and human health have been extensively studied for many years. In 2019 the *New England Journal of Medicine* described the major health risks, demonstrating, for example, that air quality can potentially affect cardiovascular diseases, asthma exacerbations and respiratory illnesses.[2] Paradoxically, although they care for people, healthcare systems contribute to global warming.[3] To achieve the goal of limiting the temperature increase to 1.5°C above the pre-industrial levels set by the 2015 Paris Agreement, all stakeholders have a role to play.[4] Healthcare systems must participate in the global fight against climate change and engage in sustainable development (SD) initiatives. SD was described as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" by Gro Harlem Brundtland, the Norwegian Prime Minister in 1987.[5] Healthcare professionals are gradually taking initiatives to reduce the environmental footprint of healthcare. In France, hospital pharmacists are responsible for healthcare products (HP) (medication and sterile medical devices) from supply to distribution in healthcare units. This cross-functional role positions them as potential key players in SD within healthcare facilities. Despite the emergence of studies evaluating the environmental impact of various actions within healthcare facilities, no reviews have specifically explored the contributions of pharmacists to assess their environmental footprint or the knowledge of healthcare professionals and patients on the subject. To address this gap, our systematic review sought to explore the involvement of hospital pharmacists in SD strategies by answering the following questions: (1) What is the role of hospital pharmacists in SD? (2) Who do they

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interact with, and how? (3) What methods do they use? and (4) Which stages of the lifecycle of HP are analysed? We thus identified and summarised articles on hospital pharmacists' contribution to assess the environmental impacts of healthcare.

METHODS

Sustainable development (SD)

SD is defined as economically efficient, socially equitable, and ecologically SD. These three foundational pillars of SD are conventionally represented by three spheres (social, economic and environmental) that intersect, with sustainability positioned at the intersection of the three. The simultaneous consideration of these three components is an essential prerequisite for the concept of sustainability.

Life cycle assessment (LCA)

Life cycle assessment is the most advanced tool for assessing environmental impact of products or services. This standardised approach (ISO 14040 standard) allows for the measurement of quantifiable effects of products or services on the environment. It analyses and quantifies the physical flows of material and energy associated with human activities throughout the life cycle of products. LCA is a multi-criteria approach as it provides results on various environmental impacts (up to 18 impacts including climate change, water resource depletion, etc). However, by evaluating only the environmental footprint of a product or service, LCA does not take into account the remaining two pillars of SD (economic and social).

Protocol and registration

This systematic review was conducted in accordance with the 2020 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines[6] (see online supplemental file 1) and the protocol was registered on PROSPERO (ID number CRD42023406835).[7]

Eligibility criteria

Eligible studies included research published between 1 January 2013 and 1 January 2023. The inclusion and non-inclusion criteria are summarised in table 1.

Table 1 Inclusion and non-inclusion criteria

Inclusion	Non-inclusion
Full-text articles published in peer-reviewed journals explicitly describing studies in sustainable development involving hospital pharmacists	Letters, comments, opinion pieces, editorials
No limit on the type of healthcare products targeted (drugs, medical devices)	Studies describing environmental pollution linked to healthcare establishments without the intervention of hospital pharmacists
Contributions carried out in health facilities (eg, university hospitals, private clinics)	Animal/veterinary studies
Operations carried out in any country in the world	Contributions taking place outside health establishments
	Life cycle assessment of healthcare products.
	Articles not in French or English.

Table 2 Search terms used

Environmental footprint terms	Pharmaceutical terms
Life cycle assessment(s), lifecycle assessment(s), life-cycle assessment(s), carbon footprint(s), greenhouse gas(es), sustainability, sustainable development, medical waste(s), environmental impact(s), ecologic, ecoresponsible	Hospital pharmacy, hospital pharmacist(s), pharmaceutical(s), medication(s), medical device(s)

Search strategy

Three databases were searched (Medline, Web of Science and ScienceDirect). The complete list of search terms is shown in table 2 and the search strategy is detailed in online supplemental file 2. Apart from the terms "hospital pharmacy" and "hospital pharmacist(s)", which were sought in the full text, all other terms were only sought in the article title. Studies deemed relevant from manual searches of the reference lists of selected articles were also retained.

Study selection

Using inclusion and exclusion criteria, two authors (MP, VC) independently selected relevant articles based on title and abstract readings and subsequently analysed them. In case of disagreement, the opinion of a third author (GL) was considered.

Risk of bias assessment

The same methodology was used for assessing the methodological quality of the included studies. The methodological quality of the included studies was evaluated using the 2018 version of the Mixed Methods Appraisal Tool (MMAT) due to the different study methodologies.[8] Each study was assessed according to seven items depending on the study design (non-randomised quantitative, descriptive quantitative, or mixed method), classed as 'yes', 'no', or 'can't tell'. The algorithm employed to assist in selecting the category of criteria is shown in online supplemental file 3. No quality score was calculated because the MMAT developers advise against calculating an overall score from the ratings of each criterion. Additionally, it is not recommended to exclude studies solely based on low methodological quality.

Data collection and data items

Two authors (MP, VC) independently extracted data including the year, country, research question/objective, targeted HP (medication, sterile medical devices), description of the contributions, the pharmacist's role (lead or support), type of participant, outcomes measured and the stage of the pharmaceutical process targeted (purchasing/procurement, prescription, preparation/pharmaceutical compounding, dispensing/distribution of care services, elimination). The results of all selected articles were summarised in two Excel spreadsheets. These different tables are available in the results section. Missing data were specified in the tables.

RESULTS

Study selection

A total of 829 articles were found from the initial database search, of which 121 were duplicates. After removal of 618 articles that were not relevant and a further 11 which could not be retrieved, 79 articles were assessed, with 69 deemed ineligible mostly due to the absence of a pharmacist (n=48). With the seven studies found by the manual search of reference lists, 17 articles were included in this review. The search process is shown in figure 1.

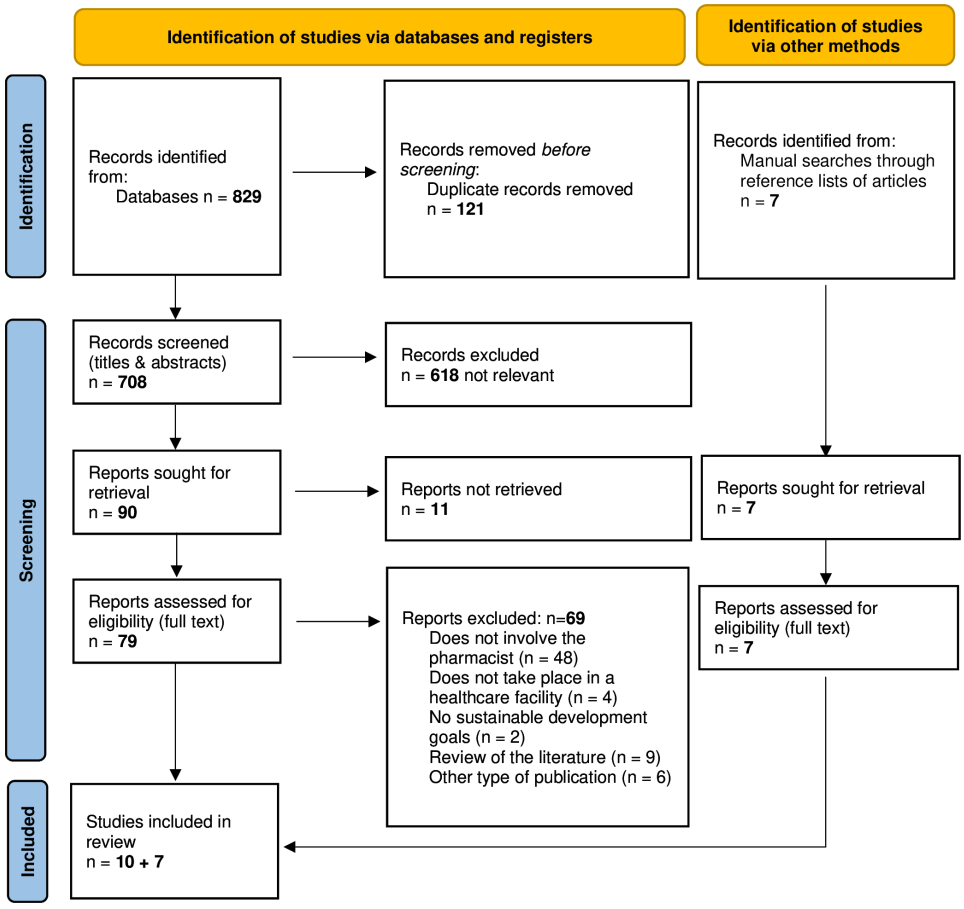

Figure 1 Summary of the the search process.

Study characteristics

Study characteristics are summarised in online supplemental table 1. All 17 included studies described contributions taking place in a healthcare facility. Only one study was carried out in the central sterilisation unit,[9] while the other studies assessed the hospital pharmacy, the operating room, and/or other care departments. The studies were primarily based in Europe and North America: France (n=4), USA (n=4), Ethiopia (n=2), Saudi Arabia (n=2), and one each from England, Italy, Netherlands, Brazil, and Spain. For 10 studies (59%) the contribution involved a team composed exclusively of pharmacy personnel (pharmaceutical team).[10–19] The remaining studies (41%) involved medical (healthcare professionals)[18 20–25] or mixed multidisciplinary teams (healthcare professionals and professionals from other fields such as a sustainability engineer). The study by Rouvière *et al*[9] was the only one involving a mixed multidisciplinary team.

Description of contributions

The description of contributions is summarised in online supplemental table 2.

Studies highlighted the contribution of hospital pharmacists to the SD across various stages of the HP cycle. Some studies were interventional,[9 11 18 20–22 24 25] where pharmacists directly or indirectly implemented actions aimed at reducing the environmental impact of care. Others were observational studies[10 12 13 19] led by pharmaceutical research teams, reflecting the practices of healthcare professionals or patients. Some studies used several methods concurrently. Most studies (53%) included a survey in their contributions.[9 10 12 13 15–17 19 20] This could involve a questionnaire asking healthcare professionals or patients about waste management[15 16 19] or assessing the social pillar of SD through staff satisfaction.[20] The description of the questionnaires used in the articles is shown in online supplemental file 5.

The second most commonly targeted contribution was waste collection. Seven studies (41%) documented the waste generated[18 21 23 24] and/or weighed it.[9 20 22]

Four studies (24%) used quality management techniques to help develop and implement their contribution.[11 18 21 25] Lin *et al*[18] and Abbasi *et al*[25] employed the 'lean management' technique and Furukawa *et al*[21] used the 'Lean Six Sigma' technique. Toerper *et al*[11] employed a computer simulation technique to develop the optimal production schedule. Four studies (24%) used theoretical and practical training in addition to other methods to improve their study outcomes.[9 11 21 24] Only two studies (12%) used LCA, which is currently the most advanced tool for assessing the environmental impact of a contribution. Rouvière *et al*[9] conducted their own LCA to quantify the environmental impacts of their actions whereas Leraut *et al*[14] used LCA results published in the literature.

The role of the pharmacist was identified in each study. In 15 studies (88%) pharmacists were defined as the pilot, directly implementing or executing the action.[9–21 24 25] In the remaining studies,[22 23] pharmacists played a supporting role in the contribution and the implementation did not directly depend on them.

Regarding the HP distribution circuit, the majority of contributions focused on the disposal phase of HP (71%).[9 10 13 15–17 19–24] Six studies (35%) evaluated the purchasing and procurement stages of HP[9 10 12 13 17 20] and six studies (35%) addressed the dispensing and distribution stages of HP to healthcare

units.[10 13 14 17 21 24] Five studies (29%) involved the preparation of medications (pharmaceutical compounding) within the production units of the hospital pharmacy,[10 11 17 18 25] or the operating room.[23] Finally, four studies (24%) focused on medical prescription.[10 13 17 21]

Risk of bias in the studies

The bias risk analysis for each study is shown in online supplemental file 4. Two of the non-randomised quantitative studies were judged as being of good quality.[9 20] The remaining studies received at least one 'Can't tell' response and were therefore considered of lower quality. The maximum number of 'Can't tell' responses obtained per article was two (n=4).[10 21 22]

Only one study received a 'no' response,[11] which was the response to the question 'Are the confounders accounted for in the design and analysis?' in the quantitative non-randomised studies category.

The questions that received the most 'Can't tell' responses were: 'Are there complete outcome data?' and 'Are the confounders accounted for in the design and analysis?' for quantitative non-randomised studies; 'Is the risk of non-response bias low?' for quantitative descriptive studies; and 'Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?' for mixed methods studies.

Results of interventions

Online supplemental table 1 summarises the outcomes measured in the studies. These criteria included environmental impact measurements (expressed in kgCO2e, weight of waste), economic impacts, and any other relevant qualitative results.

Regarding the primary outcome of environmental impact, only one study calculated the impact of its interventions on the environment.[9]

Among the studies that evaluated the number or weight of waste through their research, 100% showed a reduction in waste generated after the interventions.[9 11 18 20–22 24 25] Six studies conducted different assessments to highlight the extent of HP waste and its economic impact or sought to identify pharmaceutical waste management practices. By assessing the disposal practices of healthcare professionals and/or patients, Mohammed *et al*,[15] Gidey *et al*[16] and Al-Shareef *et al*[19] showed that methods of healthcare product disposal were varied, including open-air incineration,[15] household waste,[19] with a small portion being returned to the pharmacy (1.7%).[19] Gidey *et al* found that 60.7% of surveyed patients had received no information about HP disposal methods,[16] while Al-Shareef *et al* reported that preferred methods for teaching good disposal practices included social networks (16.72%), mobile applications (14.17%) and hospital pharmacists (13.91%).[19] The engagement of healthcare professionals in SD was assessed by Giraud *et al*[12] and Singleton *et al*.[13] Giraud *et al* focused on HP procurement procedures by pharmacists and reported that 90% of HP suppliers considered themselves to be significantly or very significantly engaged, with 40% of sustainable purchasing criteria being integrated into the overall rating by at least one buyer. Singleton *et al* explored the engagement of hospital pharmacists in the NHS carbon reduction policy and highlighted the main barriers to incorporating SD into their practice, such as a lack of professional training and the absence of environmental guidelines.[13]

Two studies described SD actions that could be initiated by pharmacists. Bekker *et al* identified 14 actions in 'developed countries'[10] and Alhomoud identified 21 actions in the Gulf countries.[17]

Only one study simultaneously evaluated the three pillars of SD.[20] In this study the social pillar was assessed by three different means: calculation of the difference in equipment preparation time; analysis of musculoskeletal disorder factors; and surgeon satisfaction survey regarding the implementation of the custom pack.

Nine studies (53%) measured the economic effects of their intervention.[9 11 15 18 20 22–25] For eight studies it was an economic gain[11 15 18 20 22–25] and for one study it was an additional economic cost.[20]

The economic impact analysis of interventions has most often been conducted based on the price of HP saved through the implementation of the intervention, notably using the bottom-up micro-costing methodology based on unitary costs from a hospital perspective (89%).[9 11 15 18 20 23–25]

The economic impact was also analysed by calculating the average monthly savings in the segregation of healthcare waste, considering prices from the contract with the company responsible for hospital waste removal (11%).[22]

DISCUSSION

The main findings of this systematic review have been summarised in a graphical abstract shown in online supplemental file 6. Seventeen studies describing contributions to reduce the environmental footprint of healthcare involving hospital pharmacists were included in this review. In the majority, the pharmacist had a leading role (88%) and they were integrated into a pharmaceutical team (59%), a multidisciplinary medical team (35%) or a mixed multidisciplinary team (6%). These results demonstrate the central and cross-disciplinary role of hospital pharmacists in the field of SD. The only study that implemented a mixed multidisciplinary team was also the only study to have used LCA, the reference method for calculating the environmental impacts of actions.[9] The other methodologies used to reduce the environmental footprint of healthcare included surveys, waste collection and/or weighing, quality management methods and theoretical and practical training. Waste collection was the most commonly used method (41%) but, in most studies, no environmental impact results were extracted from these data beyond reduction in the mass of waste generated. Some studies presented methodological uncertainties (eg, non-response bias, incomplete effect data) leading to studies that were less reproducible and less robust. Furthermore, since most of the included studies were qualitative, it is difficult to draw conclusions about the actual impact of the contributions. Finally, the study by Rouvière *et al*[9] demonstrated significant environmental impacts by involving both medical and non-medical personnel (sustainability engineer) using the reference methodology and presenting good methodological quality. Although LCA is the reference methodology, this literature review shows that LCA is rarely applied in healthcare. It is a rigorous methodology that requires human resources, theoretical and practical training, and specific software. This demanding methodology would benefit from a designated team member, such as a pharmacist, with the knowledge and skills in this field to carry out these studies.

Furthermore, only one study investigated all three pillars of SD.[20] The social pillar is often neglected in favour of the ecological and economic pillars, but to meet the definition of SD, this third aspect must be assessed and taken into account. The aim of the social aspect is to ensure a quality of work life for practitioners and caregivers throughout the care process, while also satisfying all users. This pillar can be assessed through satisfaction surveys; Mouarbes *et al* evaluated the social pillar by

analysing musculoskeletal disorder factors and conducting satisfaction surveys in staff.[20]

Regarding the economic pillar, only nine studies examined the economic impact of interventions.[9 11 15 18 20 23–25] These studies focused on the prices of HP, demonstrating the savings achieved through the reduction of pharmaceutical waste or changes in care practices. Indeed, the 'micro-costing' approach is the most precise method for estimating the actual cost of a healthcare intervention in a healthcare facility. However, in this approach, the estimated costs reflect the state of practice at a particular healthcare facility. On the other hand, the additional costs related to personnel generated by data collection or the implementation of actions were not assessed and can vary the economic impact of an action. Conversely, potential time saving-related economic gains were not reported in the studies. It would be interesting to integrate the costs of healthcare personnel into economic studies of interventions.

Despite the heterogeneous results of the contributions, this literature review shows that the actions already cover all the key stages of the HP circuit. The disposal of HP was addressed in almost all studies, indicating that the amount of waste generated by healthcare facilities is a significant concern and waste-related actions were generally the first initiatives taken. However, some studies took place in developing countries, making it challenging to compare the results with those of developed countries with different regulations, for example, regarding HP disposal. Few contributions have been described concerning the purchase, procurement and stock management of HP. As shown by Giraud *et al*, implementing sustainable actions at this stage of the HP circuit requires commitment from suppliers, healthcare facilities and governments to update regulations.[12] Although suppliers claim to be committed to sustainable policies (with 90% of criteria being considered important or very important by the suppliers), the practical implementation of these results needs further evaluation. Thus, mandatory questionnaires for suppliers, specifically targeting HP, to incorporate environmental rating in procurement contracts seem necessary to initiate a sustainable approach. Regarding the dispensing and distribution of HP in healthcare units, the studies were mainly descriptive and applied to specific services, making the reproducibility of these contributions more challenging.[24] Contributions targeting the pharmaceutical prescription stage highlighted the importance of consolidating prescriptions for patients requiring specific preparations or medications to minimise waste. However, no study has explored the potential role of the pharmacist in the concept of eco-directed prescribing. It is conceivable that, in the coming years, pharmacists could raise awareness among prescribers about the environmental impact of prescribed medications and medical devices in their role as clinical pharmacists. However, this role would require transparency from suppliers regarding the environmental impact of their pharmaceutical products, as well as the mobilisation of governments to update regulations, especially in terms of marketing authorisations or CE marking access.

Regarding the pharmaceutical compounding stage, the included studies focused on optimising pharmaceutical compounding to limit dose wastage. These studies applied quality management methods initially designed for the automotive industry. These methods, aimed at improving the quality and efficiency of work processes, seem relevant for optimising production processes.

In parallel, several studies showed a lack of environmental knowledge, indicating a deficiency in practitioner training.[13 16 19] Pharmacists could contribute to the theoretical and practical environmental training of future healthcare professionals by integrating directly into health studies curricula. They could also participate in the theoretical and practical training of their colleagues, encouraging good practices in pharmaceutical waste disposal, for example.

The locations targeted by the contributions were mostly the hospital pharmacy or the operating room (94% of included studies). Only one study included the sterile processing department by implementing the recycling of defective metallic medical devices ineligible for repair.[9] The sterilisation unit is a significant consumer of water (washers, autoclaves, air conditioning circuit in the controlled atmosphere area), electricity (washers, autoclaves) and plastics (sterile packaging), concentrating numerous environmental challenges. As this service is not always under the responsibility of the pharmacist, particularly in France, it may explain the low number of studies included in our research. Nonetheless, the study by McGain *et al*, who calculated the environmental impact of extinguishing inactive autoclaves, optimising loads or implementing automatic standby mode in this unit, reported a reduction of 79 tons of CO_2 per year.[26]

This study has several limitations to be considered. The low number of articles identified in this review may be due to the lack of explicit mention of the pharmacist's role in the studies, despite their participation, or to differences in pharmaceutical responsibilities between countries. To overcome this limitation, the reference lists of included publications were manually searched, which is why some articles were only found through manual searches. However, numerous studies can be found in the grey literature but we did not search the grey literature sources because of the sometimes lower methodological quality and difficult access to these studies. Studies focusing on medications (88%) were more numerous than those on medical devices (41%). This imbalance may be related to the fact that the management of medical devices is not necessarily the responsibility of the pharmacist in all countries. Finally, some reports may have been missed despite our broad search strategy and new studies may have been published since our last search and will continue to emerge.

The topic of SD is not currently mentioned in the French Public Health Code regarding the missions of the hospital pharmacy and hospital pharmacists. However, the 2010 version of the hospital pharmacy reference framework already stated that hospital pharmacists should take SD into account and integrate its challenges.[27] This role involves economic management concepts (eg, procurement policy), social responsibility and environmental responsibility.

This systematic literature review is the first to specifically address the role of hospital pharmacists in SD contributions within healthcare institutions. It serves as a starting point to enable hospital pharmacists to engage in the development, implementation and monitoring of SD actions. It demonstrates that, through their cross-functional role and expertise, hospital pharmacists are major players in the ecological transition of healthcare institutions and can actively contribute to the shift towards low carbon healthcare systems. This review could also signal to hospital managers that pharmacists ought to be involved in SD. Based on this review, the first step for a hospital pharmacist wishing to implement SD actions would be creating or participating in a sustainable multidisciplinary working group including various professional profiles. The actions implemented should be monitored using before-and-after indicators and LCAs should be undertaken to obtain robust results. Social and economic pillars should be integrated into the methodology as early as possible to assess all three pillars of SD. Any action initiated could begin with theoretical training for healthcare professionals to provide

them with the necessary knowledge. Moreover, further studies are still required to evaluate the feasibility and environmental impact of interventions in sterilisation or chemotherapy production units. Other studies are also required to assess the role and environmental impact of the clinical pharmacist—for example, e-prescribing, raising awareness during pharmaceutical interviews and the impact of pharmaceutical interventions on healthcare facility effluents.

CONCLUSION

This systematic review shows that there is limited research published on the role of pharmacists in interventions to reduce the environmental impact of healthcare, and that most of the existing studies do not use the standard method (LCA) to quantify their impacts. The results of the studies were heterogeneous but cover all stages of the healthcare product cycle, which nonetheless confirms the central role of the pharmacist and the importance of a multidisciplinary approach in implementing eco-responsible actions. Future studies should systematically quantify the environmental impacts of their interventions and describe the role of each participant to improve the robustness of results and enhance replicability.

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PRISMA 2020 Checklist

Supplementary File 1: PRISMA 2020 checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	p.1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Yes
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	p.3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	p.3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	p.5
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	p.5
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	p.5
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	p.5
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	p.6
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	p.6
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	p.6
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	p.6
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	p.6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	p.6
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	p.6
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	p.6
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	NA
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	NA
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	p.6

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	NA
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	p.7
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	p.6
Study characteristics	17	Cite each included study and present its characteristics.	p.8
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Supplementary file 4
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	NA
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	NA
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	NA
	20c	Present results of all investigations of possible causes of .	p.7
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	NA
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	NA
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	p.11
	23b	Discuss any limitations of the evidence included in the review.	p.14
	23c	Discuss any limitations of the review processes used.	p.14
	23d	Discuss implications of the results for practice, policy, and future research.	p.15
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	p.4
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	p.4
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	p.17
Competing interests	26	Declare any competing interests of review authors.	p.17
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	p.17

PRISMA 2020 Checklist

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

Supplementary File 2: *Complete search strategy*

PUBMED

(life cycle assessment*[Title]) OR (lifecycle assessment*[Title]) OR (life-cycle assessment*[Title]) OR (carbon footprint*[Title]) OR (greenhouse gas*[Title]) OR (sustainability[Title]) OR (sustainable development[Title]) OR (medical waste*[Title]) OR (environmental impact*[Title]) OR (ecologic*[Title]) OR (eco-responsible[Title]) OR ("Carbon Footprint*"[Mesh]) OR ("Medical Waste"[Mesh]) OR ("Sustainable Development"[Mesh]) OR ("Greenhouse Effect"[Mesh])	(hospital pharmacy) OR (hospital pharmacist*) OR (pharmaceutical*[Title]) OR (medication*[Title]) OR (medical device*[Title])

WEB OF SCIENCE

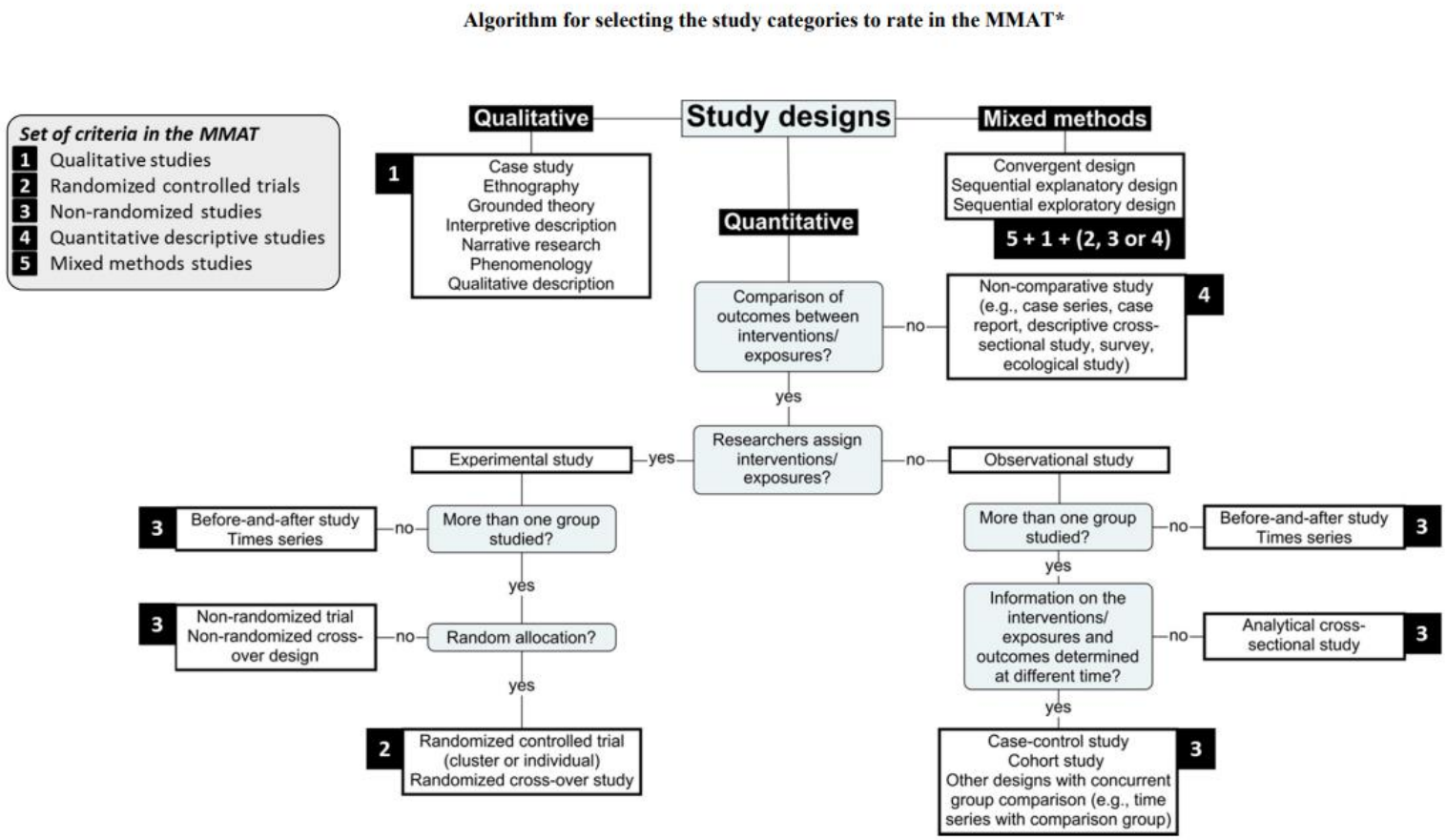
TI=(life cycle assessment) OR TI=(lifecycle assessment) OR TI=(life-cycle assessment) OR TI=(carbon footprint) OR TI=(greenhouse gas) OR TI=(sustainability) OR TI=(sustainable development) OR TI=(medical waste) OR TI=(environmental impact) OR TI=(ecologic) OR TI=(ecoresponsible)	ALL=(hospital pharmacy) OR ALL=(hospital pharmacist) OR TI=(pharmaceutical) OR TI=(medication) OR TI=(medical device)

SCIENCE DIRECT

"life cycle assessment" OR "carbon footprint" OR "sustainable development" OR "medical waste" OR "environmental impact" OR "ecologic"	"pharmacy" OR medication OR "medical device"

Pitard M, *et al. Eur J Hosp Pharm* 2024;0:1–6. doi: 10.1136/ejhpharm-2024-004098

Supplementary File 3: *Algorithm for use of MMAT*



*Adapted from National Institute for Health Care Excellence. (2012). *Methods for the development of nice public health guidance*. London: National Institute for Health and Care Excellence; and Scottish Intercollegiate Guidelines Network. (2017). *Algorithm for classifying study design for questions of effectiveness*. Retrieved December 1, 2017, from http://www.sign.ac.uk/assets/study_design.pdf.

Supplementary File 4: *Risk of bias, detailed table*

Leraut et al., 2022 [13]	Mouarbes et al., 2022 [12]	Singleton et al., 2022 [11]	Giraud et al., 2022 [10]	Rouvière et al., 2022 [9]		
Yes	Yes	Yes	Yes	Yes	P1. Are there clear research questions?	PRELIMINARY QUESTIONS
Yes	Yes	Yes	Yes	Yes	P2. Do the data collected answer the research questions?	
	Yes			Yes	Are the participants representative of the target population?	NON-RANDOMISED QUANTITATIVE STUDIES
	Yes			Yes	Are the measurements appropriate regarding both the outcome and intervention (or exposure)?	
	Yes			Yes	Are the data on effects (*outcomes*) complete?	
	Yes			Yes	Are the confounders accounted for in the design and analysis?	
	Yes			Yes	During the study period did the intervention (or did the exposure) take place as planned?	
					Is the sampling strategy relevant to address the research question?	DESCRIPTIVE QUANTITATIVE STUDIES
					Is the sample representative of the target population?	
					Are the measurements appropriate?	
					Is the risk of non-response bias low?	
					Is the statistical analysis appropriate to answer the research question?	
Yes		Yes	Yes		Is there an adequate rationale for using a mixed methods design to address the research question?	STUDIES WITH MIXED METHODS
Yes		Yes	Yes		Are the different components of the study effectively integrated to answer the research question?	
Yes		Can’ t tell	Yes		Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	
Can’ t tell		Can’ t tell	Can’ t tell		Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	
Yes		Yes	Yes		Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	

Pitard M, *et al*. *Eur J Hosp Pharm* 2024;0:1–5. doi: 10.1136/ejhpharm-2024-004098

Tsang et al., 2019 [18]	Alhomoud, 2020 [17]	Gidey et al., 2020 [16]	Barbariol et al., 2021 [15]	Mohammed et al., 2021 [14]		
Yes	Yes	Yes	Yes	Yes	P1. Are there clear research questions?	PRELIMINARY QUESTIONS
Yes	Yes	Yes	Yes	Yes	P2. Do the data collected answer the research questions?	
Yes			Yes		Are the participants representative of the target population?	NON-RANDOMISED QUANTITATIVE STUDIES
Yes			Yes		Are the measurements appropriate regarding both the outcome and intervention (or exposure)?	
Can’ t tell			Can’ t tell		Are the data on effects (*outcomes*) complete?	
Yes			Yes		Are the confounders accounted for in the design and analysis?	
Yes			Yes		During the study period did the intervention (or did the exposure) take place as planned?	
	Yes	Yes		Yes	Is the sampling strategy relevant to address the research question?	DESCRIPTIVE QUANTITATIVE STUDIES
	Yes	Yes		Yes	Is the sample representative of the target population?	
	Yes	Yes		Yes	Are the measurements appropriate?	
	Can’ t tell	Can’ t tell		Can’ t tell	Is the risk of non-response bias low?	
	Yes	Yes		Yes	Is the statistical analysis appropriate to answer the research question?	
					Is there an adequate rationale for using a mixed methods design to address the research question?	STUDIES WITH MIXED METHODS
					Are the different components of the study effectively integrated to answer the research question?	
					Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	
					Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	
					Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	

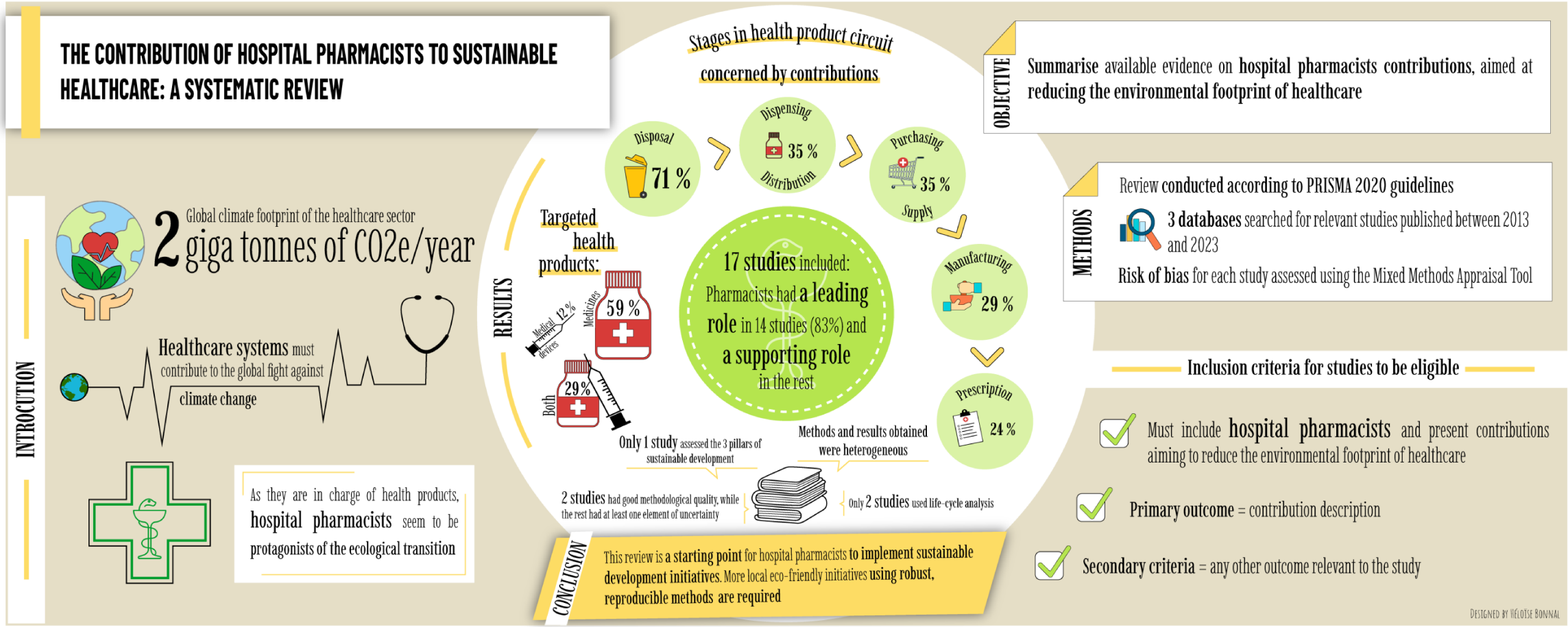
Al-Shareef et al., 2016 [23]	Furukawa et al., 2016 [22]	Abbasi et al., 2017 [21]	Bekker et al., 2018 [20]	Lin et al., 2018 [19]		
Yes	Yes	Yes	Yes	Yes	P1. Are there clear research questions?	PRELIMINARY QUESTIONS
Yes	Yes	Yes	Yes	Yes	P2. Do the data collected answer the research questions?	
	Yes	Yes		Yes	Are the participants representative of the target population?	NON-RANDOMISED QUANTITATIVE STUDIES
	Yes	Yes		Yes	Are the measurements appropriate regarding both the outcome and intervention (or exposure)?	
	Can’ t tell	Can’ t tell		Yes	Are the data on effects (*outcomes*) complete?	
	Can’ t tell	Yes		Can’ t tell	Are the confounders accounted for in the design and analysis?	
	Yes	Yes		Yes	During the study period did the intervention (or did the exposure) take place as planned?	
Yes					Is the sampling strategy relevant to address the research question?	DESCRIPTIVE QUANTITATIVE STUDIES
Yes					Is the sample representative of the target population?	
Yes					Are the measurements appropriate?	
Can’ t tell					Is the risk of non-response bias low?	
Yes					Is the statistical analysis appropriate to answer the research question?	
			Yes		Is there an adequate rationale for using a mixed methods design to address the research question?	STUDIES WITH MIXED METHODS
			Yes		Are the different components of the study effectively integrated to answer the research question?	
			Can’ t tell		Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	
			Can’ t tell		Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	
			Yes		Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	

Toerper et al., 2014 [25]	Mosquera et al., 2014 [24]		
Yes	Yes	P1. Are there clear research questions?	PRELIMINARY QUESTIONS
Yes	Yes	P2. Do the data collected answer the research questions?	
Yes	Yes	Are the participants representative of the target population?	NON-RANDOMISED QUANTITATIVE STUDIES
Yes	Yes	Are the measurements appropriate regarding both the outcome and intervention (or exposure)?	
Yes	Can’ t tell	Are the data on effects (*outcomes*) complete?	
No	Can’ t tell	Are the confounders accounted for in the design and analysis?	
Yes	Yes	During the study period did the intervention (or did the exposure) take place as planned?	
		Is the sampling strategy relevant to address the research question?	DESCRIPTIVE QUANTITATIVE STUDIES
		Is the sample representative of the target population?	
		Are the measurements appropriate?	
		Is the risk of non-response bias low?	
		Is the statistical analysis appropriate to answer the research question?	
		Is there an adequate rationale for using a mixed methods design to address the research question?	STUDIES WITH MIXED METHODS
		Are the different components of the study effectively integrated to answer the research question?	
		Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	
		Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	
		Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	

Supplementary File 5: *questionnaire table*

Element measured by questionnaire	How measured	Number of items	Where accessed and language choices	Reference
Staff awareness and interest on sustainable development.	Open-ended questions.	Not available	Not available	Rouvière et al., 2022 [9]
1. Level of environmental "maturity" of healthcare product suppliers. 2. Integration of SD criteria into procurement procedures by healthcare product buyers.	Self-assessment using a four-point Likert scale (--/-/+/++).	30	Available in French and English.	Giraud *et al.*, 2022 [10]
1. Pharmacist's awareness of the Sustainable Development Unit (SDU) and Coalition for Sustainable Pharmaceuticals and Medical Devices (CSPM). 2. Barriers to including sustainability in clinical decision-making processes. 3. If they believe pharmacists have a responsibility and the power to address these identified barriers.	Yes/No and one open-ended questions.	5	Published in appendix 2 of publication. Available in English.	Singleton *et al.*, 2022 [11]
Staff satisfaction of new intervention.	Net Promoter Score (NPS) measured from 1 (not at all satisfied) to 10 (high user satisfaction).	1	Not available	Mouarbes *et al.*, 2022 [12]
Pharmaceutical waste disposal methods.	Structured checklist adopted from Logistics Indicator Assessment Tool (LIAT) and World Health Organisation waste management checklist.	Not available	Not available	Mohammed *et al.*, 2021 [14]
Knowledge of how to dispose of unused and out-of-date medicines.	Yes/No and multiple-choice questions.	7	Published as Table 2 of publication. Available in Tigrigna and English.	Gidey *et al.*, 2020 [16]
Feasibility and importance of activities implemented by pharmacists to reduce drug wastage.	Modified Bekker's questionnaire.	21 activities measured	Available in English and Arabic.	Alhomoud, 2020 [17]
Activities undertaken by pharmacists and their importance and feasibility.	Yes/No for if activity undertaken, plus importance and feasibility both measured on a 1 (not) to 5 (very) scale.	16 activities measured	Published in Appendix B of publication.	Bekker *et al.*, 2018 [20]
Quantification and characterization of expired and unused medications at home. Attitude and method of medication disposal.	Open -ended, yes/No and multiple-choice questions	16	Published in Appendix-A of publication. Available in English and Arabic	Al-Shareef *et al.*, 2016 [23]

Supplementary file 6: Graphical abstract



***SUPPLEMENTARY TABLE 1**: Characteristics of the studies included (n = 17)*

Author, year of publication	Country of study, care service targeted by the contribution, type of team carrying out the study	Research question(s)/objective(s)	Pillar of SD studied			Measured results		
			Economic	Environment	Social	Environmental impact	Economic impact	Other results
Rouvière *et al.*, 2022 [9]	France OR/hospital pharmacy/Sterile Processing Department Mixed multidisciplinary team	Evaluate the ecological and economic impact of implementing sustainable actions in the operating room and sterile processing department.	X	X		Annual savings of - 203 tonnes of CO2e - 707 tonnes of 1.4 DCB (environmental toxicity) - 156 tonnes of 1.4 DCB (human toxicity) - 1071 m2 year eq culture (land use) - 610 kg eq Cu (mineral resources) - 9 tonnes eq Oil (fossil resources) 551 m3 (water consumption)	Annual gain: - 5188 € TTC	/
Giraud *et al.*, 2022 [10]	France Hospital pharmacy Pharmaceutical team	What is the progress in the level of commitment to sustainability among healthcare product suppliers? What are the degrees of 'applicability' and importance of these sustainability initiatives as perceived by healthcare product buyers?		X		/	/	90% of suppliers declare themselves committed to a significant or very significant degree. 40% of the criteria are integrated into the overall rating by at least one of the buyers.
Singleton *et al.*, 2022 [11]	England Hospital pharmacy Pharmaceutical team	Assess the involvement of hospital pharmacists in the carbon emissions reduction policy of the National Health Service (NHS)		X		/	/	Obstacles to the inclusion of SD items in the healthcare product supply chain: Government support Lack of professional training Absence of clinical practice guidelines Budget constraints Lack of environmental knowledge.
Mouarbes *et al.*, 2022 [12]	France OR Multidisciplinary medical team	Assess the three pillars of SD following the implementation of custom pack usage in the operating room.	X	X	X	The custom pack does not significantly reduce the amount of waste: - 10/intervention (213g/intervention) vs	Cost of all instruments used per operation: - 58€	Social Impact: Time savings at various stages. Significant reduction in the number of movements

Author, year of publication	Country of study, care service targeted by the contribution, type of team carrying out the study	Research question(s)/objective(s)	Pillar of SD studied			Measured results		
			Economic	Environment	Social	Environmental impact	Economic impact	Other results
						36/intervention (221g/intervention)	Cost of a custom pack: - 106€	performed by nurses (opening equipment, waste sorting)."
Leraut *et al.*, 2022 [13]	France Hospital pharmacy Pharmaceutical team	Take stock of national inhaler consumption as well as carbon footprint data for the main inhalers dispensed in France in both community and healthcare settings.		X		Carbon footprint of pressurised metered-dose aerosols: - 11 to 28kgCO2e/can Carbon footprint of dry powder inhalers/mist inhalers: - 1kgCO2e/box Inhalers containing salbutamol have the highest carbon impact: - 310 ktCO2e in 2019 (city and HFs data)	/	Number of specialities by type of device marketed in France (2019): - 78 (68 %) dry powder inhalers - 34 (30 %) pressurised metered-dose aerosol specialities - 3 (2 %) mist inhaler type specialities
Mohammed *et al.*, 2021 [14]	Ethiopia Hospital pharmacy Pharmaceutical team	What is the amount of healthcare product wastage in HFs? How is healthcare product waste managed in these HFs?	X			/	Average annual wastage rate: - US$159,763 (4%)	Most wasted pharmaceutical class: - Anti-infectives (23%). Most wasted pharmaceutical form: - Tablets (21%) - Injectables (16%). Most wasted healthcare products in terms of value: - Medium-sized examination gloves - Clarithromycin 500mg (tablets) - Chloramphenicol 250mg (capsules) Primary reason for wastage: - Expiry (92%) Most common method of healthcare product disposal: - Open-air incineration (64%).

Author, year of publication	Country of study, care service targeted by the contribution, type of team carrying out the study	Research question(s)/objective(s)	Pillar of SD studied			Measured results		
			Economic	Environment	Social	Environmental impact	Economic impact	Other results
Barbariol *et al.*, 2021 [15]	Italy OR/care service Multidisciplinary medical team	Assess the wastage of medications in operating rooms and intensive care units and calculate its economic impact.	X	X		Total annual wastage rate: - from 36% to 40% Annual mass of avoidable medical waste: - 4698 kg	Cost of annual waste: - 78 060€ Annual cost of disposing of avoidable waste: - 10 000€	Medicines responsible for the cost of waste (54%): - epinephrine - atropine - ephedrine Annual time spent reconstituting unused medication: - 1512 hours.
Gidey *et al.*, 2020 [16]	Ethiopia Hospital pharmacy Pharmaceutical team	Assess the knowledge and practices of medication disposal by patients picking up their treatments at the Hospital pharmacy Unit (Hospital pharmacy).		X		/	/	Among the people surveyed: - 52% were not familiar with pharmaceutical waste. - 61% did not receive any information on how to dispose of medications.
Alhomoud, 2020 [17]	Saudi Arabia Hospital pharmacy Pharmaceutical team	Identify waste reduction and medication wastage minimization efforts carried out by pharmacists in the Gulf countries and evaluate their feasibility and implementation.		X		/	/	Identification of 21 actions categorized by the medication pathway: 1- Prescription Stage 4/6 responding countries provide advice to prescribers on the quantities to be prescribed. 2- Dispensation Stage In 4/6 responding countries, pharmacists adjust the quantities of prescribed medications. 2/6 countries schedule patients on the same day to optimize the preparation of intravenous medications.

Author, year of publication	Country of study, care service targeted by the contribution, type of team carrying out the study	Research question(s)/objective(s)	Pillar of SD studied			Measured results		
			Economic	Environment	Social	Environmental impact	Economic impact	Other results
								3- Remaining Stages - None of the responding countries re-dispense returned medications from healthcare services. The activities at each stage are considered to be important or very important and feasible or very feasible for waste reduction.
Tsang *et al.*, 2019 [18]	United states OR Multidisciplinary medical team	Optimize the circuit of refrigerated anaesthetic medications in the OR to minimize wastage.	X	X		The quantity of drugs wasted decreased significantly for each speciality, with the exception of *nitro-glycerine* vials (standard deviation pre- *vs.* post-intervention: 2.5 *vs.* 2.1 with p=0.559).	Significant reduction in the weekly cost of wasting medicines: - US$1,188.59 vs US$322.96 ($P < 0.001$)	/
Lin *et al.*, 2018 [19]	United States Hospital pharmacy Pharmaceutical team	Evaluate the impact on waste production of: -Increasing the use of pre-reconstituted intravenous (IV) medications (e.g., multi-compartment bags and frozen solutions). - Increasing the frequency of intravenous pharmaceutical compounding.	X	X		Increased use of reconstituted medicines: - 698 discarded doses/month avoided (equivalent to 67L/month) Increased production frequency: - reduction in the number of doses wasted by 394 doses/month (equivalent to 78L/month)	Increased use of reconstituted medication: - significant savings of $11,581/month Increased production frequency: - insignificant savings of $3,431	/
Bekker *et al.*, 2018 [20]	Netherlands Hospital pharmacy Pharmaceutical team	Identify actions taken by pharmacists in developed countries to reduce drug wastage. Evaluate the implementation of these actions, their importance and their feasibility		X		/	/	Questionnaire completed by 89 pharmacists (dispensing and hospital) in 22 developed countries. Fourteen actions identified and classified according to the medication circuit: 1- Prescription stage - 68% of responding countries carry out medication reviews.

Author, year of publication	Country of study, care service targeted by the contribution, type of team carrying out the study	Research question(s)/objective(s)	Pillar of SD studied			Measured results		
			Economic	Environment	Social	Environmental impact	Economic impact	Other results
								2- Dispensing stage - 95% of responding countries limit the quantity of medicines in stock. 3- Remaining stages - 77% of responding countries recover unused medicines. - 18% of responding countries donate unused medicines to associations. - No responding country dispenses medicines returned from healthcare services.
Abbasi *et al*., 2017 [21]	United States Hospital pharmacy Multidisciplinary medical team	Measure the impact on wastage of increasing the frequency of sterile preparation batch production.	X	X		Reduction in the number of sterile preparations discarded in one week: - 97 doses (2.2%) *vs.* 83 doses (1.8%)	Reduction in the total cost of wasted preparations in one week: - $4,585 vs. $4,454.	/
Furukawa *et al*., 2016 [22]	Brazil Hospital pharmacy/care unit Multidisciplinary medical team	Analyse environmental actions implemented concerning the healthcare products (HP) circuit.		X		Within the pharmacy: - 75% reduction in chemical, infectious and sharp waste. - 33% increase in common recyclable waste. - 20% increase in common non-recyclable waste. In the medical-surgical unit: - 23% reduction in chemical, infectious and sharp waste. - 23% increase in common recyclable waste. - 20% increase in common non-recyclable waste.	/	Implementation of 8 actions to improve the HP circuit.
Al-Shareef *et al*., 2016 [23]	Saudi Arabia Hospital pharmacy/care unit Pharmaceutical team	Evaluate patients' behaviour regarding the disposal of expired and unused medications. Identify the most relevant methods for educating patients on proper healthcare product disposal practices.		X		/	/	Most common method of elimination: - household waste (79%) - returned to pharmacies (2%) The most common therapeutic groups in the homes are: - cold, cough and flu medicines (18%).

Author, year of publication	Country of study, care service targeted by the contribution, type of team carrying out the study	Research question(s)/objective(s)	Pillar of SD studied			Measured results		
			Economic	Environment	Social	Environmental impact	Economic impact	Other results
								- vitamins and food supplements (18%) - antibiotics (17%) Preferred methods for teaching good disposal practices: - social networks (17%) - mobile applications (14%) - hospital pharmacists (14%)
Mosquera *et al.*, 2014 [24]	Spain Care unit Multidisciplinary medical team	Evaluate the impact of waste management training in various departments of a university hospital centre.	X	X		Within the hospital pharmacy, a non-significant decrease in the weight of waste was observed in the following categories: - Infectious waste (45 kg/month *vs.* 42 kg/month) - Genotoxic and pharmaceutical waste (610 kg/month *vs.* 423 kg/month) - Chemical waste (23 kg/month *vs.* 15 kg/month)	Annual savings from reducing the weight of waste: - 125 205 € (26%)	Optimization of disposal pathways: - Dialysis filters that were initially discarded with infectious/biological waste are now disposed of as household waste (with the exception of filters with a risk of HIV, hepatitis B, and C).
Toerper *et al.*, 2014 [25]	United States Hospital pharmacy/Care unit Pharmaceutical team	Using an algorithm to determine the optimum frequency, timing and preparation time for paediatric pharmaceutical compounding.	X	X		Increase in production frequency from 1 batch to 3 batches per day: - 31% reduction in annual waste	Increase in production frequency from 1 batch to 3 batches per day: - Net annual savings of $97,970	Frequency of preparation: - Reduction in the number of dispensed doses wasted from 2 batches/day onwards Preparation time: - Minimisation of waste when batches are prepared outside the times when doctors are on duty, and as close as possible to the times when medicines are administered. Preparation time: - Reduce waste by cutting preparation time.

OR: Operating Room

***SUPPLEMENTARY TABLE 2**: description of contributions*

Author, year of publication	Description of the contributions	Role of the pharmacist		Method used					Targeted health product		Targeted stage in the pharmaceutical circuit				
		Pilot	Support	Survey	Waste collection	Quality management method	LCA	Theoretical/Practical training	Medications	Medical device	Purchasing/ procurement	Prescription*	Preparation**	Dispensing***	Elimination
Rouvière *et al*., 2022 [9]	Implementation of monthly working group meetings Monthly bulletin for raising awareness about eco-health. Execution of: - 7 waste reduction actions - 5 waste sorting actions - 1 action on eco-responsible purchasing - Evaluation of cost differences associated with these interventions.	X		X	X		X	X		X	X				X
Giraud *et al*., 2022 [10]	Identification of 30 regulatory and non-regulatory criteria related to the procurement of healthcare products and SD. Creation of a questionnaire for healthcare product suppliers to assess their level of environmental "maturity." Creation of a questionnaire for healthcare product buyers to assess the integration of SD criteria into their procurement procedures.	X		X					X	X	X				
Singleton *et al*., 2022 [11]	Semi-structured interviews with hospital pharmacists conducted by a pharmacist. Topic of the questions: awareness of the existence of NHS SD working groups; barriers to the integration of SD into their decision-making; the pharmacist's role in overcoming these barriers and incorporating SD into clinical decisions.	X		X					X	X	X	X		X	X
Mouarbes *et al*., 2022 [12]	Creation of a custom pack for anterior cruciate ligament reconstruction surgery. Study of the three pillars of SD:	X		X	X					X	X				X

Author, year of publication	Description of the contributions	Role of the pharmacist		Method used					Targeted health product		Targeted stage in the pharmaceutical circuit				
		Pilot	Support	Survey	Waste collection	Quality management method	LCA	Theoretical/Practical training	Medications	Medical device	Purchasing/ procurement	Prescription*	Preparation**	Dispensing***	Elimination
	1- Environmental: assessment of the difference in weight and the quantity of waste related to the surgical equipment. 2- Social: calculation of the difference in equipment preparation time; analysis of musculoskeletal disorder factors; surgeon satisfaction survey regarding the implementation of the custom pack. 3- Economic: evaluation of the cost difference of the instruments used.														
Leraut *et al.*, 2022 [13]	Qualitative and quantitative analysis of medications administered through an inhaler in urban and HF. Literature review to extract the carbon footprints per inhaler-administered medication box.	X					X		X					X	
Mohammed *et al.*, 2021 [14]	Inventory of returned/wasted healthcare products in HF. Creation of a questionnaire for pharmacy staff, divided into two parts: 1- Sociodemographic data 2- Pharmaceutical waste disposal methods.	X		X					X	X					X
Barbariol *et al.*, 2021 [15]	Literature review and preliminary study to select the most wasted medications (selection of 11 medications). Recording of the preparation and administration time of medication syringes by nurses. Inventory of the number of wasted syringes (prepared but ultimately not administered). Estimating the cost of wastage.		X		X				X				X		X
Gidey *et al.*, 2020 [16]	A pharmacy student conducted interviews with patients collecting treatments from the hospital pharmacy.	X		X					X						X

Author, year of publication	Description of the contributions	Role of the pharmacist		Method used					Targeted health product		Targeted stage in the pharmaceutical circuit					
		Pilot	Support	Survey	Waste collection	Quality management method	LCA	Theoretical/Practical training	Medications	Medical device	Purchasing/ procurement	Prescription*	Preparation**	Dispensing***	Elimination
	Creation of a 2-part questionnaire: 1- Sociodemographic data 2- Knowledge of how to dispose of unused and out-of-date medicines.														
Alhomoud, 2020 [17]	Creation of a questionnaire assessing the feasibility and importance of activities that could be implemented by pharmacists to reduce drug wastage.	X		X					X		X	X	X	X	X
Tsang *et al.*, 2019 [18]	Overview of the most commonly used refrigerated medicines in the OR. Twice-weekly reminders of the procedure for returning unused medicines to the pharmacy by e-mail and verbally. Provision of the most commonly used refrigerated medicines directly in mini-fridges in the ORs. Collection by pharmacy assistants of medicines intended for disposal and calculation of associated costs. Collected before and after the operation.	X			X			X	X					X	X
Lin *et al.*, 2018 [19]	Mapping of intravenous pharmaceutical compounding production flows to identify non- value-added tasks. Increasing the production frequency of pharmaceutical compounding batches from 3 to 5 batches per day. Increased use of already reconstituted medicines. Identify the number of doses wasted (dispensed but not administered) and calculate the associated costs.	X			X	X			X				X		

Author, year of publication	Description of the contributions	Role of the pharmacist		Method used					Targeted health product		Targeted stage in the pharmaceutical circuit				
		Pilot	Support	Survey	Waste collection	Quality management method	LCA	Theoretical/Practical training	Medications	Medical device	Purchasing/ procurement	Prescription*	Preparation**	Dispensing***	Elimination
Bekker *et al*., 2018 [20]	Creation of an open online questionnaire to list waste reduction activities implemented by pharmacists.			X					X		X	X	X	X	X
	Creation of a second questionnaire to assess the importance and feasibility of these activities.	X													
Abbasi *et al*., 2017 [21]	Counting the number of sterile pharmaceutical compounding returned to the pharmacy because they were not administered to patients within the allotted time.														
	Increase in the frequency of production of batches of pharmaceutical compounding, from 2 batches to 4 batches per day.	X				X			X				X		
Furukawa *et al*., 2016 [22]	Using quality tools to analyse the healthcare product distribution circuit: process mapping with problem identification, brainstorming, the five whys, impact/effort matrix.														
	Applying the Lean Six Sigma method to leverage the results of quality tools.	X			X	X		X	X	X		X		X	X
	Developing an action plan describing the actions to be implemented, the stakeholders, and the completion deadlines.														
Al-Shareef *et al*., 2016 [23]	Creation of a questionnaire in three parts: 1- Demographic data 2- Quantification and characterisation of expired and unused medications at home 3- Attitude and method of disposing of these medications	X		X					X						X

Author, year of publication	Description of the contributions	Role of the pharmacist		Method used					Targeted health product		Targeted stage in the pharmaceutical circuit				
		Pilot	Support	Survey	Waste collection	Quality management method	LCA	Theoretical/Practical training	Medications	Medical device	Purchasing/ procurement	Prescription*	Preparation**	Dispensing***	Elimination
Mosquera *et al*., 2014 [24]	Theoretical training sessions on the disposal of healthcare waste in various areas, including pharmacy. Pre-training assessment of healthcare waste management in each department. Weighing of care waste before and after the operation. Sending an improvement report to each department with waste sorting recommendations		X		X			X	X	X					X
Toerper *et al*., 2014 [25]	Creation of 108 different production schedules varying the preparation frequency, preparation schedules, and preparation times. Implementation of the ideal calendar.	X				X			X				X		
Total	**n=**	**15 (88%)**	**2 (11%)**	**9 (52%)**	**7 (41%)**	**4 (23%)**	**2 (11%)**	**4 (23%)**	**15 (88%)**	**7 (41%)**	**6 (35%)**	**4 (23%)**	**5 (29%)**	**6 (35%)**	**12 (70%)**

* Prescription (prescription receipt, prescription validation)

** Preparation: pharmaceutical compounding, dosage form *on demand*

*** Dispensing/distribution of care services