Master of Public Health

Master de Santé Publique

Sustainability of health systems

Environmental footprints & health systems' transition priorities.

Case study from the French context.

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Abstract

Background

Until recently, health systems' responsibility in the alteration, depletion or pollution of world resources was not much presented nor discussed. However, amidst vivid debates around the concept of *Planetary Health*, the precise role & responsibility of health systems to adapt to environmental needs, met the growing evidence that they are both part of the problem and the solution (Lenzen et al., 2020).

Methods

Mixed methods were used. A scoping review to assess how researchers present sustainability of health care system. A health-economic evaluation to understand how Carbon Footprint could be integrated into Health Technology Assessment. A qualitative analysis to analyze the determinants of political priority in France.

Findings

89% of scientific articles writing about environmental transition of health systems, between 2021 to 2023, didn't refer to any definition of sustainable healthcare. Only 33% of articles have a definition logically correlated with a foot-printing method. 61% of articles presenting primary data use Greenhouse Gases (GHGs) as the main measurement of environmental impact. This tends to show the preeminent use of the Carbon Footprint as a measurement of environmental impact over these last 2 years. Preliminary findings of the health economic assessment suggest that treatments of moderate depressive disorders in France amount 107 kg CO2 for one episode of a year per patient treated by pharmacotherapy, 184 kg CO2 for a psychotherapy, and 328 kgCO2 for a combined therapy. When it comes to decision making, the context in which political determinants are unfolding doesn't appear quite mature or aligned yet for a strong political ownership and action in favor of a more sustainable health system in France. However, a better convergence of top-down intentions to transition, with available resources, broader civil society participation, bottom-up initiatives and territorial dialogues could pave the way for a positive iterative process towards building a more sustainable system.

Interpretation

Public health advocates may tactically accept that carbon footprint, a proxy indicator, serves a short-term operational objective to limit global warming and embark decision makers on board. But if we want to make health systems environmentally sustainable, we will have to find a way to address all threats to planetary health, efficiently and concomitantly.

Introduction

First, do no harm. One of the cornerstones of medical ethics, probably discussed by health practitioners since Hippocrates. Does it encourage a renewed debate in the onsets of the XXI century? Until recently, health systems' responsibility in the alteration, depletion or pollution of world resources was not much presented nor discussed. However, amidst vivid debates around the concept of *Planetary Health*, the precise role & responsibility of health systems to adapt to environmental needs, met the growing evidence that they are both part of the problem and the solution (Lenzen et al., 2020).

When the Paris Agreement[1], signed in 2015, conceded a worldwide attempt to limit global warming to 1,5 degrees Celsius above pre-industrial levels, debates around sustainability were quickly by-passed by a crisis mode in which part of the world entered (Karliner et al., 2020). Addressing global warming through the reduction of Carbon Footprint appears to become a priority, even for health systems.

How to define sustainability in health care?

From the debate about the environmental impact of *health systems*, the concept of *sustainability* resurfaced. What is a sustainable health system? How to define it? What scope do we give to its definition? Does it apply to a limited perimeter like a "stock" of raw material to produce a drug? Does it apply to a limited "ecosystem" around a hospital? Does it apply to the entire planet and to all living beings?

"While the idea of natural resource constraints to human development dates back at least to Malthus, the concept of sustainability, as such, came into widespread popular usage relatively recently (i.e., during the 1960s as part of the environmental movement and during the 1980s as part of the political rhetoric." (Dixon & Fallon, 1989). Nevertheless, its widespread use doesn't mean the concept is unambiguous. Much the contrary. Sustainability's very different definitions fit "developers" nearly as well as "environmentalists".

Through the works of a dedicated commission lead by a former Norwegian Prime Minister, Mrs. Gro Harlem Bruntland, the United Nations proposed in 1987 a rather flexible definition of *sustainable development*: *"a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).* This definition - or its WHO variation - is broadly used and referred to in number of publications talking about sustainable health systems that *"improve, maintain or restore health, while minimizing negative impacts on the environment*

[1] https://www.un.org/en/climatechange/paris-agreement accessed June 16th 2023

and leveraging opportunities to restore and improve it, to the benefit of the health and well-being of current and future generations" (World Health Organization, 2017).
Concomitantly, from the 1970s to the 90s, the concept of *environmental footprint* was being refined. It introduced notions of *equity* in the debate, not only towards future generations, but towards other human and non-human inhabitants of the planet (Rees, 1996).

What is the environmental footprint of health care?

"If the health sector were a country, it would be the fifth-largest emitter [of CO2] on the planet" (*Health Care Climate Footprint Report*, 2019). Win-win strategies were hopped for, to get community support. *"Responsible for some 4–5% of global green-house gas emissions, the health-care sector has a vital role to play in climate change mitigation efforts, which will not only result in substantial reductions in emissions, but can often lead to enhanced patient care, staff satisfaction, and cost savings." (Watts et al., 2019).*
Debates around equity resurface. *"In OECD countries, China, and India, health care on average accounts for 5% of the national CO2 footprint making the sector comparable in importance to the food sector."* Developed countries' health systems may have a particular responsibility to adapt. Not only they set the worldwide standards in terms of best possible health care, but they also represent the biggest part of Co2 emissions per capita worldwide. *"The average per capita health carbon footprint across the country sample in 2014 was 0.6tCO2, varying between 1.51tCO2/cap in the US and 0.06tCO2/cap in India." (Pichler et al., 2019).*
"We can't mitigate what we don't monitor" (Smith et al., 2022). A wide range of publications propose to set baselines and start monitoring health systems environmental footprint at various levels. But calculating a carbon footprint highly depends on the method used, on the perimeter set, on countries energy profile, on where patients live… *"Study settings varied widely, as did the magnitude of reductions in travel-related emissions due to telehealth use, ranging from 22 kg CO2e per patient in Portugal to 123 kg CO2 per patient in rural Scotland."* (Purohit et al., 2021).

How to account for health care environmental footprint?

Different methods coexist. Systems tend to be evaluated using an economic lens through Environment Extended Input-Output (EEIO) analyses. *"EEIO is now widely used to evaluate the upstream, consumption-based drivers of downstream environmental impacts and to evaluate the environmental impacts embodied in goods and services that are traded between nations." (Kitzes, 2013)*

While environmental criteria could be part of Health Technologies Assessments, “considerable work is needed to track decision makers’ demands, augment the environmental evidence base, and develop robust methods for capturing and incorporating environmental data as part of HTA”. (Marsh et al., 2016). Until now, it did not yet become a standard for WHO (Bertram et al., 2021) even if it already integrated the HTA process in a few countries (Sweden, UK).

On the other end of the spectrum, when it comes to products, since the 1960s, industries developed Life Cycle Assessment (LCA) & Life Cycle Inventory (LCI) methods. First accounting for energy impact, later for wider environmental impacts of a product from cradle to grave (Guinée et al., 2011). LCAs are now supported by two ISO standard. ISO 14040 detailing the 'principles and framework' of the Standard, ISO 14044 providing an outline of the 'requirements and guidelines’. Concomitantly, academia continued to work on refining the method to best account for multiple environmental impacts (Jolliet et al., 2003). Researchers also developed Life cycle impact assessment tools (LCIA), to support the interpretation of LCA studies. By translating emissions and resource extractions into a limited number of environmental impact scores, at midpoint level and endpoint level, some methods like ReCIPE[2] try to harmonize and simplify the understanding of environmental impacts through LCAs (Huijbregts et al., 2017).

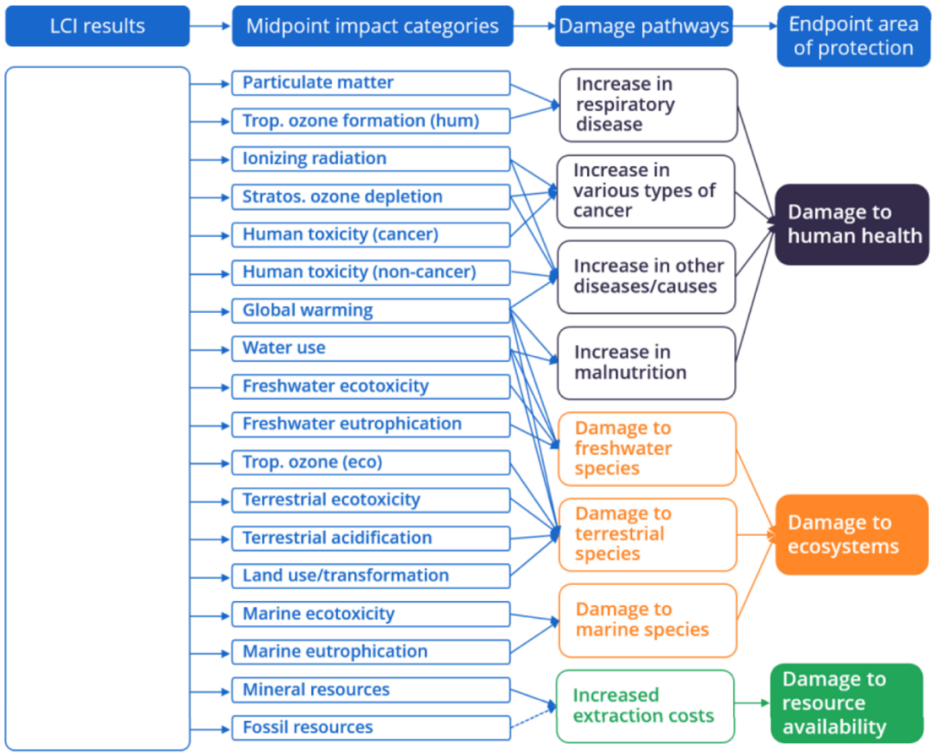

Figure 1 - Overview of the impact categories that are covered in the ReCiPe 2016 method

[2] https://ec.europa.eu/environment/biodiversity/business/assets/pdf/tool-descriptions/RECiPe%20and%20BioScope%20summary%20description.pdf accessed June 16th 2023

What are the main limitations of environmental footprint methods?

Life Cycle Assessments are built within boundaries or perimeters. The system boundaries define what covers the life cycle assessment, and what stays out, according to the ISO standard *"from raw material extraction to production, packaging, transport, use and reprocessing until final disposal"*. Comparison in products or processes should use the same system boundaries (van Straten et al., 2021). This is often the first limitation encountered when comparing two LCAs.

But many other limitations could be mentioned like the "*type of impacts typically included, quality of inventory data, methodological choices in relation to time aspects, allocation, characterisation and weighting methods"* (Finnveden, 2000) Consequently, LCA methodologies are still being debated, under development, or even disputed between private providers, and standardization is still not yet achieved despite an ISO standard setting the overall rules of the exercise.

On the other hand, Environment Extended Input/Output analysis also suffer from some limitations. First, its assumption of homogeneity within a sector: 1$ of good produced by an industry will be equivalent to 1$ of good produced by another industry in the same sector. While production conditions between different industrial plants may vary in terms of environmental impact. Second, input/output tables may not capture all activities in an economy, like the important informal work in Low-Middle-Income-Countries, or the data provided by governmental agencies may be unreliable. Third, and this particularly applies to so called hybrid methods *"inventories of environmental impacts, especially at large spatial scales, such as nations, often reflect a mix of empirically measured data and modeled estimates, both of which can introduce biases and uncertainties into EEIO analyses" (Kitzes, 2013).*

With these limitations, comparisons remain a difficult exercise. However, with more and more publications on the matter, we may see a certain standardization of the methods, at least by methodological replication. From one publication to another, one country to another, the interest to compare a result, may lead to streams of articles using the same methodology. And by doing so, a bottom-up standardization of the methods could happen. But already, comparison is made possible by using available methods within homogenous environments. And this is enough to make change desirable versus status quo. *"It is difficult to analyse the reasons for the large variation in cataract package content and weight. It appears as if the large packages used in numerous eye departments have historical reasons and were never changed since they have not caused problems." (Winklmair et al., 2023)*

How could a transition towards a more sustainable system happen?

Throughout the global warming urgency, the debate around sustainability, and planetary boundaries is not over (Steffen et al., 2015). But with climate change, public health issues meet public interest into the crisis. The urge to act, the intention to change a threat into something positive, both for the climate and the planet, creates an opportunity to leverage public opinions, professionals, financial interests, decision makers… *"Awareness has to be raised among politicians and the general public (problem advice) on the one hand, and a targeted expertise on the content of public policies has to be provided to governmental agencies on the other hand (policy advice)."* (Sager et al., 2020)

One journal captured remarkably well the opportunity to help set the agenda. *"The Lancet Countdown was established following the 2015 Lancet Commission on Health and Climate Change. (…) Published annually, it is an international, multidisciplinary collaboration, dedicated to monitoring the evolving health profile of climate change, and providing an independent assessment of the delivery of commitments made by governments worldwide under the Paris Agreement*[3]*."*

Some health systems took a leadership position in setting the norms, the practice and show first results, like the National Health Service in the UK. *"The Sustainable Development Unit was created by the NHS in 2008 to meet the government's commitments under the UK Climate Change Act, conducting its first assessment of the NHS's carbon footprint that year.(..) In 2019, the health service's emissions totalled 25 megatonnes of carbon dioxide equivalent, a reduction of 26% since 1990"* (Tennison et al., 2021)

But other health systems took a different direction and developed a more comprehensive objective towards addressing a wider range of environmental impacts, like in the Netherlands and its Green Deal on Sustainable Healthcare[4]. The interest of this political stand is to address simultaneously various environmental risks, as well as to offer the possibility to decision-makers to prevent trade-offs between different impacts. *"The health-care sector's share of the national footprint was highest for material extraction (13·0%), followed by blue water consumption (7·5%), climate change (7·3%), land use (7·2%), and waste generation (4·2%). Pharmaceuticals and other chemical products were the biggest contributors to all impacts."* (Steenmeijer et al., 2022)

France may still be at the onset of such transition. Many initiatives coming from professionals & professional associations promoted an adaptation of health structures to environmental constraints, all over the territory in the last decade[5]. However, surprisingly, it did not integrate

[3] https://www.thelancet.com/countdown-health-climate/about accessed June 18th 2023
[4] https://www.greendeals.nl/green-deals/duurzame-zorg-voor-gezonde-toekomst-green-deal-20 accessed June 18th 2023
[5] https://ceres-sante.fr/qui-sommes-nous/ accessed June 18th 2023

the latest strategic plans of the Ministry of Health[6]. In 2021, a year before 2022 presidential election, a series of reports by The Shift Project[7], aimed to quantify France's Carbon Footprint, inclusive of the health sector. The intention was to alert decision makers and citizens on the need to take more robust orientations towards the decarbonization objectives of the 2015 Paris Agreement. In its updated version of April 2023, emissions from the healthcare sector are evaluated to range *"from 40 to 61 MtCO2e, i.e. between 6.6% and 10% of France's carbon footprint" (SHIFT PROJECT, 2023).* Indeed, this range shows that the carbon footprint of the health sector, in France, as much as in other high-income countries takes a considerable place in the emissions of the country. This may as well give an indication of its broader environmental footprint (Lenzen et al., 2020)

In this research project, we would like to take the opportunity of having a closer look to the way the transition towards more sustainable health systems practically unfolds, with a review of the most recent publications on the matter, completed by a case study set in France to test the inclusion of an environmental parameters in health-economics and a qualitative research on determinants influencing decision makers in the health sector environment.

Problem statement and research question

Problem statement: 1) Health systems are making pledges to become "sustainable". 2) However, sustainability is not defined, is not well measured, and has no clear place in current decision-making structures. 3) Therefore, methods, measures, and tools may have a determinant influence in directing decision makers towards transition priorities. 4) Are these priorities safeguarding planetary health?

Research question: How can sustainability be integrated into health system policy and decision making?

[6] https://www.ars.sante.fr/la-strategie-nationale-de-sante-2018-2022-1 accessed June 18th 2023
[7] https://theshiftproject.org/ambition/ accessed June 15th 2023

Research in context

Evidence before this study

Health Systems & health care providers do contribute both positively and negatively to planetary health. Climate change is an immediate threat to human health and planetary health. Adaptation of health systems to mitigate global warming is necessary, if the objective to limit temperature raise in the range proposed by the Paris agreement is pursued. However, other environmental impacts than global warming are detrimental to planetary health. A proportion of these environmental impacts do come from the health system and health providers. In France, the health system is responsible of 6,6 to 10% of the whole country carbon emissions. Professionals did start to realize a transition needed to happen.

Added value of this study

In this study, we will shed light on the relative weight of the carbon footprint in recent publications about health system environmental footprint, as well as the limited results in producing a consensual definition of what could be considered a sustainable health system.
We will illustrate some of the challenges presented by introducing an environmental parameter in health economics, in the environment of mental health treatments. We will also present some of the diverging perspectives that French decision makers will have to deal with when engaging the transition of the system towards greater environmental sustainability.

Implications of all the available evidence

We aim to present the ambiguous nature of the carbon footprint in supporting decisions towards a more sustainable health system. On one hand it is a formidable tool to persuade human societies to act in favor of a greater sustainability, and to change the architecture of very complex systems. On the other hand, it risks focusing the attention of public opinions and policy makers on the sole problem of global warming, consequently diverting the efforts to mitigate wider environmental impacts.

Objectives

Environmental footprint: what to measure, how to measure?

From the literature available on the topic, what are the available definitions of *sustainability* referred to when applied to health systems? What are the most common methods & tools used to measure the environmental footprint of the health system at its various levels? Are the methodologic choices linked to the nature of what is being measured (example: the health system itself)? Are the tools available fit for purpose? What are the most common limitations reported? How do these limitations may impact on the results?

In this first part, we will aim to get an overview of the methods and tools commonly utilized in the literature to quality & quantify the environmental footprint of health systems. The objective is to 1. report what definitions of sustainable healthcare are proposed in most recent publications about the environmental footprint of health systems 2. report what are the main methods, tools & measures retrieved in original research for each level of the system.

How to integrate environmental parameters into health decision-making?

What are the practical constraints in integrating an environmental footprint within an existing decision-making tool commonly used in public health? How can this integration be articulated with other parameters? How is the tool built? What are the limitations faced? What could be its potential use?

In this second part, we will explore the practicalities of integrating an environmental dimension into a widely used public-health decision-making tool. The objective is to 1. describe the context in which the health-economic & environmental evaluation was developed 2. describe the tool itself 3. describe which parameters were chosen to be inputted and why 4. present the results obtained, and their possible use into public-health decision making.

How is the agenda towards a more sustainable health system set?

Which environmental impacts decision makers in the French health system do recognize as a source of concern? What are the methods and tools useful to highlight these impacts? Which expertise and key actors do they recognize? What are the main levers identified to support the environmental transition? What are the key opportunities and challenges perceived?

In this third part, we will explore the perception of a few influencers and decision makers part of the health system in France. The objective is to 1. Identify their concerns in terms of environmental impacts within the perimeter of the health system 2. Describe the environment in which these concerns could be addressed 3. Identify the main levers, opportunities and challenges perceived.

Methods

Mixed Methods

Mixed methods were used, in order to address the different dimensions of the research question. First, **a scoping review** into the mainstream scientific literature published in major biomedical and environmental journals was conducted to assess how researchers introduced debates arounds sustainability of health care system, and which environmental impacts methods, measures and tools were preeminently used at different levels of the health system worldwide. Second, **a health-economic evaluation** integrating both cost and carbon footprint was elaborated based on a Markov model, in order to practically evaluate how the integration of Carbon Footprint measures could support decision making in the context of a future Health Technology Assessment. Third, **a qualitative analysis** was conducted based on the Shiffman & Smith framework, in order to analyze the determinants of political priority in France. Actors' power, political context, ideas and issues at stake were scrutinized during an academic workshop specifically addressing the issue of Decarbonizing the Health System in France held in Science-Politiques in May 2023. To complement the information collected and address possible gaps in the analysis, additional interviews were held with a few key participants of the workshop in May/June 2023.

Scoping Review

The scoping review was built on a previously completed review covering the period 2010-2020 by the same lead author, Michael Padget[8]. Despite the scoping review and data extraction was achieved, the paper was not finalized in 2021 due to conflicting publication priorities. This is why I was asked to update the scoping review with the latest publications, using the same search strategy. 226 articles were selected for review for the period 2010-2020 (23 articles per year on average), while another 114 were later selected for the period 2021-2023, suggesting an important increase in the number of publications on the topic over the last two years (57 per year on average). The method we used followed the PRISMA-ScR recommendations (Preferred Reporting Items for Systematic Reviews and meta-Analyses, extended for Scoping Reviews)[9].

[8] Michael Padget, Program Coordinator at the Centre for Environment & Health of Boston Mass General Hospital in the United States, supported by a team of researchers: Dr Dionne Kringos, Associate professor, and Vice-Director of Amsterdam Public Health research institute (APH), Dr. Iris Blom, PHD Candidate from the London School of Tropical Medicine and Anitha Devadason, from John Hopkins Bloomberg School of Public Health

[9] http://prisma-statement.org/Extensions/ScopingReviews accessed on 2nd June 2023

Review Objective & databases searched

The review searched published articles and grey literature written in English from January 2021 to March 2023 on the topic of environmental sustainability of healthcare systems and services (last search on March 9th 2023). The objective was to identify which definition of sustainability they refer to and to identify original research including methods & measures to report an environmental footprint, at any level of the health system. Reviews were included on the assumption they would provide a definition of sustainability. Four databases were searched: **PubMed** – A free access 35 million citations and abstracts database in the field of biomedical and life sciences[10] hosted by the National Institutes of Health (NIH) in the US. **Embase** – Owned by Elsevier, a 41 million records database in the biomedical & pharmacological field[11], integrating under license Medline (92% of PubMed). **Web of Science (WoS)** – Owned by Clarivate, a paid-access database giving access to 79 million records in the field of science, social sciences, and humanities[12]. **Google Scholar** – A free access online database of scholarly documents, including as well grey literature from non-academic origin (reports, working papers from NGOs, governments, companies…)[13].

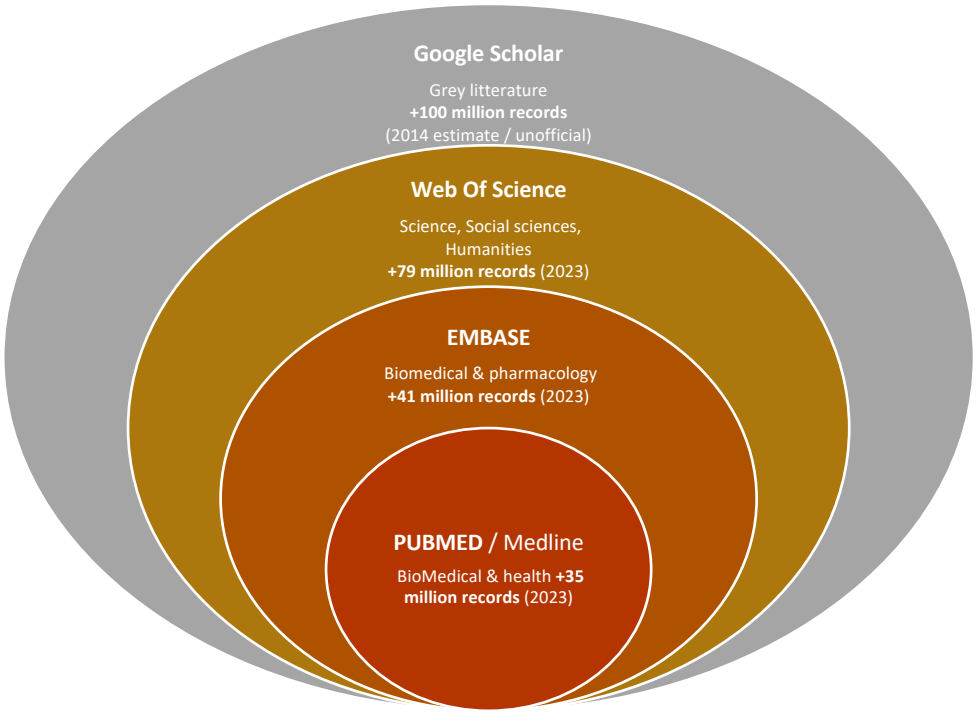

Figure 2 - Databases searched in the scoping review

[10] https://pubmed.ncbi.nlm.nih.gov/about accessed May 10th 2023.
[11] https://www.elsevier.com/solutions/embase-biomedical-research/coverage-and-content accessed May 10th 2023
[12] https://en.wikipedia.org/wiki/Web_of_Science in lieu of https://clarivate.com/products/scientific-and-academic-research/research-discovery-and-workflow-solutions/webofscience-platform/ not providing clear information & metrics
[13] https://en.wikipedia.org/wiki/Google_Scholar accessed May 10th 2023 accessed May 10th 2023 in lieu of https://scholar.google.com/intl/en/scholar/about.html not providing clear information & metrics about the database

Search strategy

The search strategy included a combination of text words relating to health care and environmental sustainability, searched in titles and abstracts of studies. The health care related search terms were: *Health care system, health system, health care, healthcare, and health sector*. These terms were combined with text words relating to environmental sustainability: *environmental footprint, environmental sustainability* (searched in all its variants as "*environmental sustainab**"), *environmental impact, climate change, carbon footprint, carbon emission, greenhouse gas, energy use* (searched in all its variants as "*energy us**"). The search strategy was originally tested on PubMed. It followed a Boolean structure (AND, OR), repeated for each associated term, applied on publications' Titles & Abstracts, filtered for English papers in the selected time range[14]. The same strategy was then adapted for Embase, Web of Science. On Google Scholar, due to a very high number of publications retrieved, a slight adaptation was applied: only the first 20 entries for each associated term were kept.

SEARCH	**Terms**	**Associated terms**	**Filters**
Date	OR	AND	AND
22/02/2023	Health care system, Health system, Health care, Healthcare health sector	Environmental Footprint	English, Jan 2021 to Feb 2023

Table 1- Search strategy

Publications screening, eligibility & inclusion

From a total of **3434 publications identified** with the search strategy, 1037 duplicates were removed, and **2661 selected for screening**. One researcher (myself, GM) scanned the titles to ascertain that the publication was matching the keywords & the context of the review. Titles related to the impact on human health of environmental changes, like climate change, were excluded at this stage (2033 articles removed). From the **628 articles remaining**, two researchers (GM&MP) read the abstracts, in double blind, and excluded further unrelated articles (423 removed). Divergence in interpretation was resolved through discussion and consensus. **205 articles remained to be fully read**, in double blind (GM&MP), and a further 91 were excluded. 5 because the full article was unavailable, 86 because of various reasons: the article was more an opinion paper or an editorial, or it was the proceeding of a conference, a comment on a previous article published or in some cases, because the method used in original research was not clearly explained. Divergence in interpretation was resolved through

[14] All results were collected and sent in a collection in RAYYAN, an AI powered online tool designed for systematic reviews

discussion and consensus. **114 publications were eventually selected for data extraction**, 95 original research, and 19 reviews.

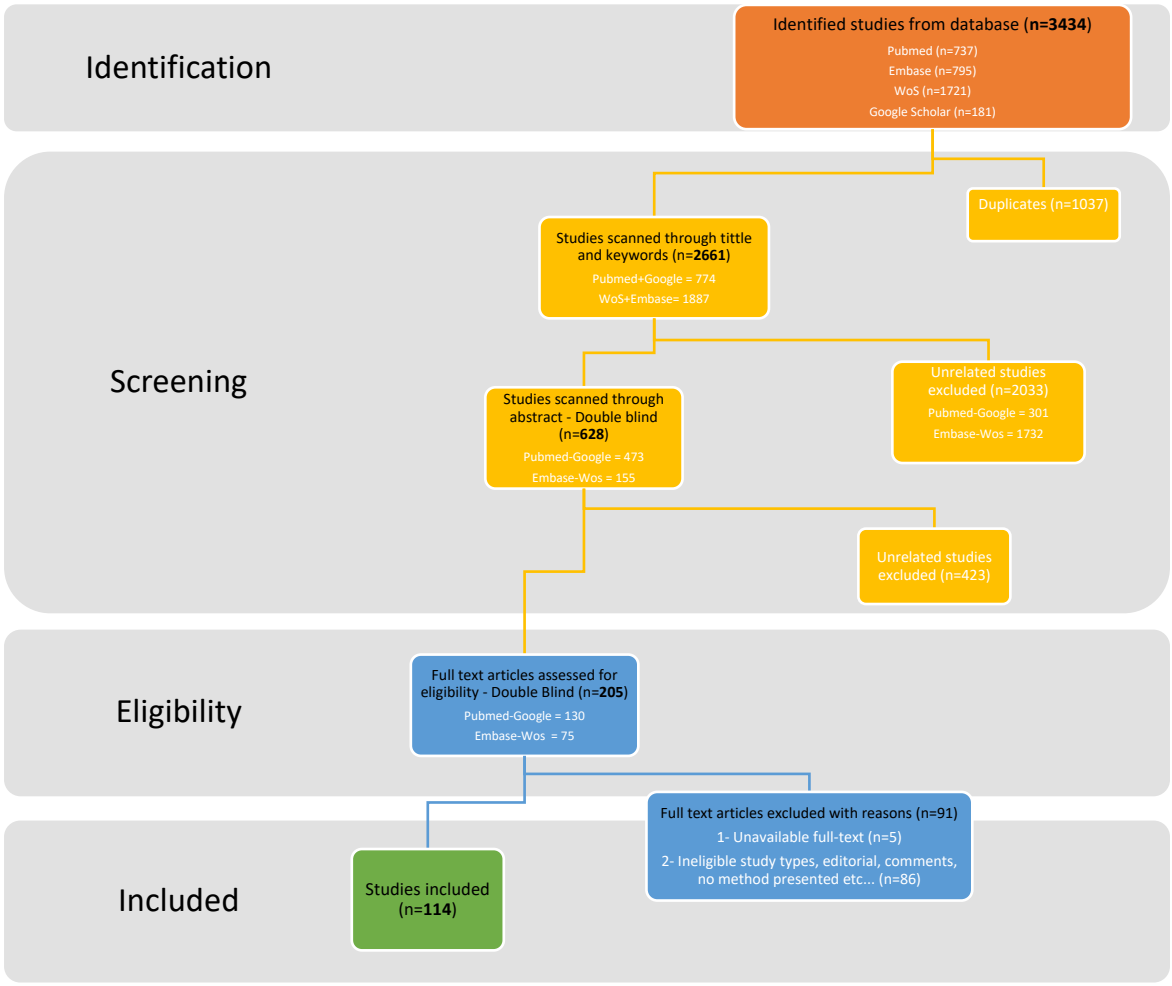

Figure 3 Diagram Flow Scoping Review 2021-2023

Health-economic evaluation

The second objective of this research project was to test the integration of an environmental dimension into an existing public health decision-making tool. The research team was composed by Dr Kevin Zarka[15], Dr Matthias Brunn[16], and myself. We followed the recommendations of the guideline from the Health Authority which supports health-economic evaluations (Haute Autorite de Sante (FRANCE), 2020). Programming a Markov model coupled with a Monte-Carlo simulation in an automated program based on R[17], a statistical computing software, was the specific objective of the lead researcher Dr Zarka, while the

[15] from AP-HP (Assistance Publique – Hopitaux de Paris)
[16] psychiatrist-researcher from the LIEPP (Laboratoire Interdisciplinaire D'Etudes des Politiques Publiques) at SciencesPo Paris
[17] https://www.r-project.org/about.html accessed June 4, 2023

construction of a realistic scenario based on existing practices combining economic and environmental data was a team effort lead by Dr Brunn. My specific contribution was:

1- to find the relevant data available from the scientific literature on mental health & health-economic models to support the construction of our own model,
2- to calculate the ground parameters related to the cost & the environmental footprint according to the scenario defined.

Research scenario

Based on knowledge gaps identified in the field of health-economic research on mental health in France (Chevreul et al., 2013), in comparison to its important public health impact (Morvan et al., 2007), and the paucity of environmental footprint information available (Maughan & Davison, 2015), we decided to choose mental health as field of research. Our objective was to propose a framework to compare the cost effectiveness and the environmental footprint of two different treatment courses for a similar outcome: **moderate depressive disorders treated by psychotherapy (Cognitive-Based therapy) or by pharmacotherapy** (through a Selective Serotonine Reuptake Inhibitor, a molecule called Escitalopram). Both treatments selected were documented to have a similar outcome (Cuijpers et al., 2020). We eventually added the combination of these two therapy as a third comparision, since we eventually had produced all the ground parameters to consider as well this treatment course. In terms of environmental impact, we decided to focus for this project on carbon footprint, not to complexify the exercise with multiple environmental impacts in the experimentation of a tool.

Pharmacotherapy, our first clinical scenario, hypothesizes 9 visits to the GP (initiation of a treatment for moderate depression and follow-up of probable co-morbidities during the course of the treatment), and 4 visits to the psychiatrist to follow-up the treatment every quarter. 13 boxes of Escitalopram will be needed to cover a full year of treatment. Hospitalization happening only in 1,2% of patients. While a chronic condition may lead only to one more visit to both GP and Psychiatrist, but hospitalization happening in 7,5% of patients.

Psychotherapy, our second clinical scenario hypothesizes only 4 visits to the GP (initiation of a treatment for moderate depression and follow-up of probable co-morbidities during the treatment), accompanied by 18 psychotherapy sessions run by a psychotherapist (NICE recommendations: 16 for a mild episode, 24 for a severe episode). Hospitalization happening only in 1,2% of patients. While a chronic condition may lead only to one more visit to the GP and 2 visits to the Psychiatrist, but hospitalization happening in 7,5% of patients.

Combined therapy, our third clinical scenario hypothesizes 4 visits to the GP (initiation of a treatment for moderate depression and follow-up of probable co-morbidities during the treatment), accompanied by 18 psychotherapy sessions run by a psychotherapist (NICE recommendations: 16 for a mild episode, 24 for a severe episode) and 4 psychiatrist

consultations (one per trimester). Hospitalization happening only in 1,2% of patients. While a chronic condition may lead to double the visits to the GP and double the consultations with the Psychiatrist, but hospitalization happening in 7,5% of patients.

Gathering evidence

In comparison to the disease burden, **research on mental health issues appears limited in France**. Prior to this work, Dr Brunn had already pre-selected a few key publications from which we could get some further important citations (Dezetter & Briffault, 2016)(Morvan et al., 2007)(Chevreul et al., 2013). However, we needed more **epidemiological mental health related economic data**. Through a rapid review from PubMed/Medline database only, publications in English with the MESH terms “Depressive disorders / Economics” associated with “Cost-Effectiveness” were retrieved. From 358 results, after title and abstract screening, 42 were included (methods including formal analytical decision model or Markov model), 11 were eventually selected for full reading (Markov model) and 2 retained as key publications from which we could whether extract a considerable amount of valuable data, whether follow-up most relevant citations (Yamada et al., 2021) (Lokkerbol et al., 2021).
On the **environmental impact**, we could not access yet publications on the carbon footprint of a private practice in France, however it was available for Switzerland (Nicolet et al., 2022).

Markov model & Monte-Carlo simulation

The health-economic evaluation was developed on a **Markov chain**: a sequence of events for which each state in the chain depends strictly on a transition probability from a prior state. In mental health, for example, if the starting point state is “Well-being” (or “Sub-threshold depressive status” on a scoring scale measuring depression), this initial state will lead to 3 possible states in the next cycle: Well-being (continued), Depressed (new state) or Death (new state). Death needs to be factored-in by default, as a probable event in any state, but its probability will be adjusted to the excess mortality linked to a specific condition. For each state, we need to adjust a *transition probability* to a new state over a period of time, defined as a cycle. The *duration of a cycle* will be adjusted depending the scenario chosen, while *transition probabilities* need to be introduced based on available evidence. In our scenario, the probability of transition from one state to another is based on published evidence from cohort of people suffering from moderate depressive disorders (observational/longitudinal studies) or from the analysis of the aggregation of multiple cohorts (meta-analyses). A Markov model is described as a chain because each state links up to a prior state. Note that some states/outcomes are irreversible (like death), while others are dynamic and continue to evolve, for example, after being diagnosed depressed, the next states will be “cured” (back to well-

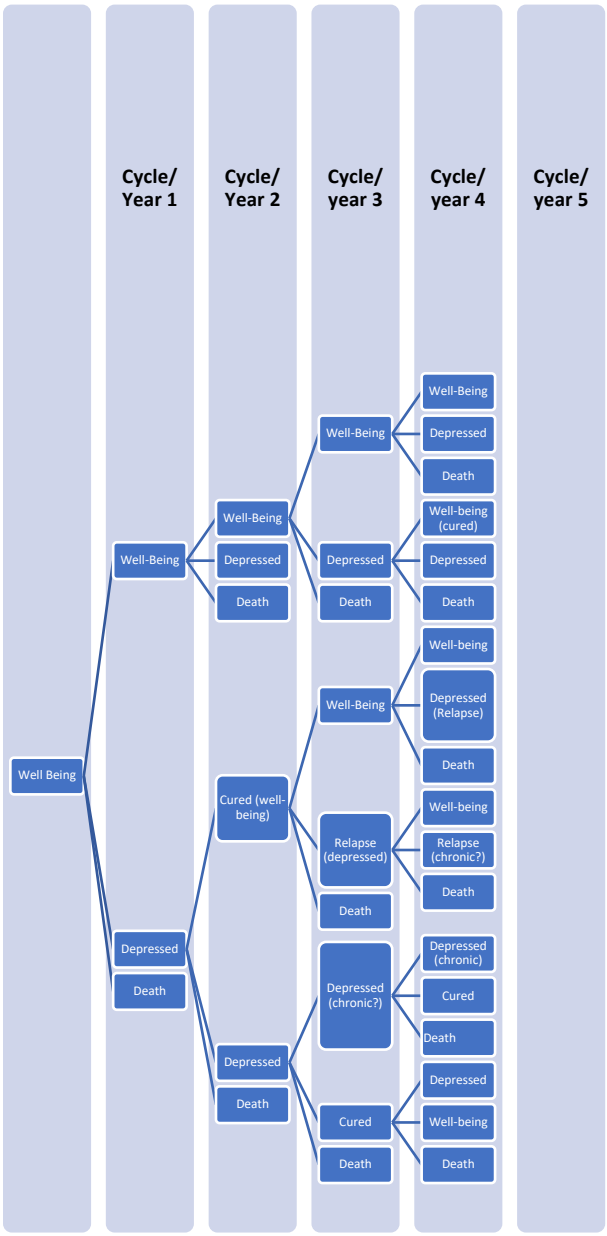

Figure 4 - Sequential representation of a Markov chain

being), still "depressed" (continuation of the symptoms or chronicity) or "death". For each state of the model a cost could be associated on the basis of the costs incurred in all prior states through different cycles before the considered state. The relative novelty of our model was to associate a Carbon footprint to the cost of each state (very few publications reported). Then, using a **Monte Carlo probabilistic simulation**[18], the outcomes of different treatment courses we want to assess can be simulated and compared in terms of cost and carbon footprint for a population based on its epidemiological profile. Cycles can be run for a duration according to the needs:1 year, 2 years, 5 years etc. Eventually, this model allows decision makers to select the best available treatment: which treatment is the most cost & Carbone effective, not only for one depressive episode, but for a given population over time. [Note: this part was outside of my research perimeter].

[18] *"The program that we elaborated simulates 10,000 different patients from the target population for each of the strategies evaluated. With each new simulated patient, cost and effectiveness are reset to zero and the values of all the most uncertain variables in the model are drawn at random, according to a distribution fixed in advance. This random selection of values, according to a distribution, makes it possible to take into account the effect of uncertainty and inter-individual variability within the model. Moreover, it allows a detailed interpretation of the model by indicating the probability that one strategy is superior to the other, according to the willingness to pay of the decision maker. This type of analysis is called second order Monte Carlo simulation, or probabilistic sensitivity analysis. At the end of each cycle, the cost and effectiveness variables are incremented according to the events that occurred during the simulation, which allows us to calculate for each patient, the cost and the total effectiveness at the end of the simulation. We can therefore obtain an average of costs and effectiveness for each strategy, which we may compare to know the most effective strategy."* (ZARCA Kevin, 2012)

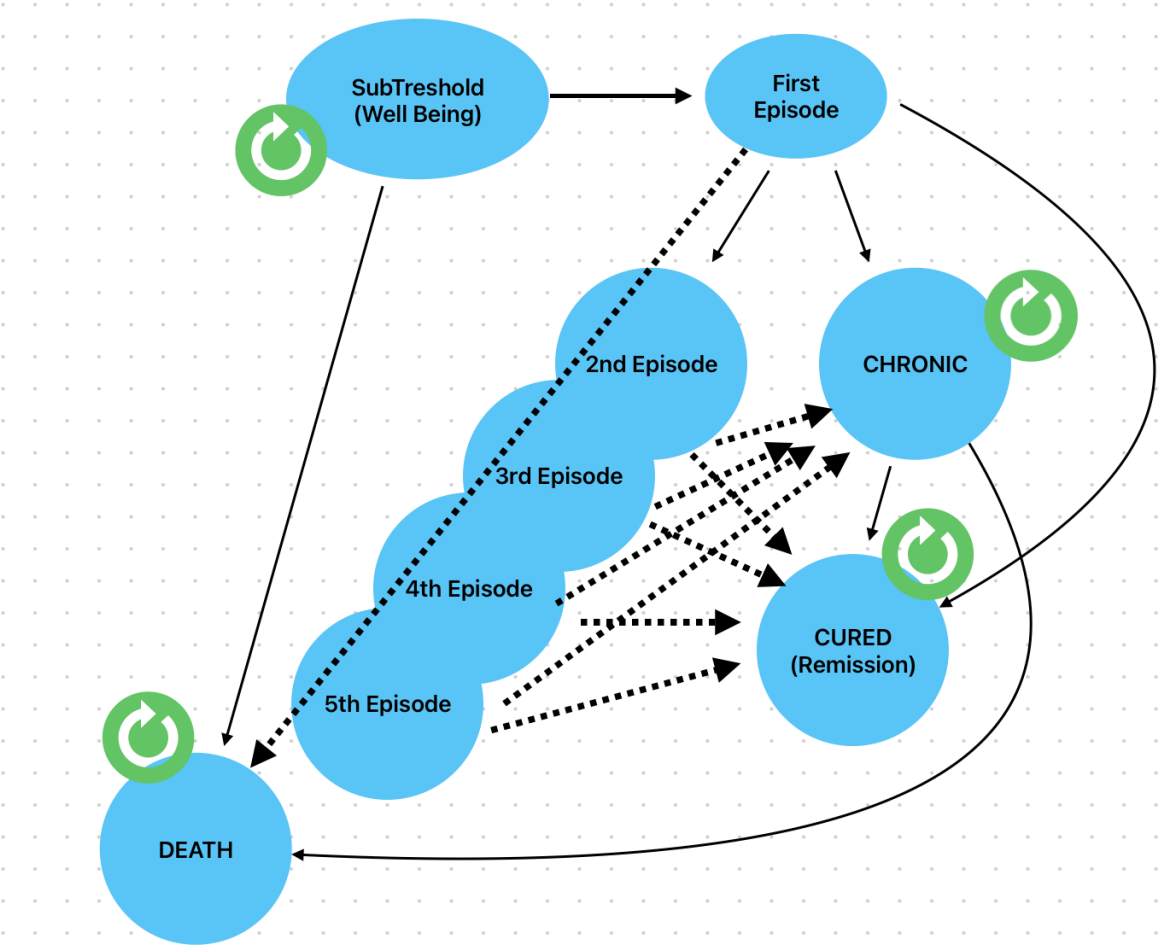

Figure 5 - Markov model (circles = states, arrows represent transition probabilities)

Calibration of the model & key assumptions

While in France 12.5% of people aged 18-85 experienced a depressive disorder episode in the last 12 months in 2021 (Christophe Léon et al., 2023), we did not manage to find any population level data giving an **incidence rate** (occurrence of a first episode within the year). We had to use data from a cohort study in Nederlands (NEMESIS-II), assuming, in alignment with OECD reports pre-Covid[19], that France mental health epidemiological profile would be similar to Nederland's. **Mean duration of major depressive disorders** (moderate to severe) is reported to amount 10,7 months (Ten Have et al., 2017), we assumed a delay in accessing care and added an extra 1,3 month per cycle, in order to simplify the model in its experimental phase (1 cycle = 1 year). We aimed to run the simulation for 5 cycles. In light with methodological limitations mentioned above, we did not find **excess mortality rates** for France, and used a longitudinal study from Canada/US (Gilman et al., 2017). The **probability**

[19] "By country, the estimated prevalence of mental health disorders is highest in Finland, the Netherlands, France and Ireland (with rates of 18.5% or more of the population with at least one disorder), and lowest in Romania, Bulgaria and Poland (with rates of less than 15% of the population)." https://www.oecd-ilibrary.org/sites/health_glance_eur-2018-4-en/index.html?itemId=/content/component/health_glance_eur-2018-4-en accessed June 10th 2023

of recurrence was also a challenge to find: many longitudinal studies follow small cohorts of a few dozen of patients, which provokes a low confidence interval. During my internship, I was not able to access the expertise needed to translate a standard deviation (SD) between different treatments compared in meta-analyses into a probability of transition. Based on this limitation, we inelegantly used different published controlled trials to match what the most recent meta-analyses suggest (Cuijpers et al., 2020): different treatments have a similar outcome in terms of recurrence (25% in this case), while their combination may be more efficient, at least in the short term (21% of recurrence). However, the slight difference in these percentages is eventually pondered by low confidence intervals.

From a web interface of the Technical Agency on Hospitalization Information (ATIH)[20], we accessed the average days of hospitalization in 2022 for depressive disorders[21]:

- in general hospitals for all patients (30,846 patients for an average of 3,23 day)
- in psychiatric hospitals – episodic patients (81,542 patients for 22,03 day)
- in psychiatric hospitals – chronic patients (27,840 patients for 26,39 day)

This allowed us to calculate an average of **18,76 day** stay per patient hospitalized for depressive disorders in France, 2022.

$$\frac{3{,}23 \text{ day} * 30846 \text{ patients} \quad 81542 \text{ day} * 81542 \text{ patients} \quad 26{,}39 \text{ day} * 27840 \text{ patients}}{140{,}228 \text{ Total Patients } (30{,}846+81{,}542+27{,}840)} = 18{,}76 \text{ days per patient}$$

Cost parameters

Key parameters of cost include outpatient medicine: General Practitioner, Psychiatrist & Psychotherapist visits. For a visit or consultation, we took the **official cost of a practitioner in the first sector** (maximum reimbursement), as determined by the payer's (Assurance Maladie): 25 euros for a GP, reimbursed 17,5 euros, 43,7euros for a psychiatrist, reimbursed 29,59[22]. From the works of Dezetter, France's mental health patients tend to consult psychiatrists to conduct psychotherapies, since these sessions get partially reimbursed. As a consequence, an overwhelming majority of psychotherapies happen in the private sector (84%), where 69% are conducted by psychiatrists (Dezetter, 2012). In order to calculate the cost for the payer - Social Insurance - we took this last percentage as a % of recourse: which means we made the assumption that not 100% of patients did follow a psychotherapy reimbursed by the insurance system, but only 69% of them which tends to increase slightly the payer's cost (in reality, we should take 69% of 84% and add the remainder of psychotherapies followed in the public sector, 16%). The other assumptions used to build the

[20] https://www.scansante.fr/ accessed June 10th 2023
[21] Respectively codes 19M11, F33 and F32
[22] https://www.service-public.fr/particuliers/vosdroits/F34917 accessed on June 10th 2023

scenarios according to each treatment (number of visits to the GP or to psychiatrists) were drawn from Dr Brunn's clinical experience.

A second parameter we applied from a payer's perspective was the **recourse to hospitalization**. From available French cohort studies, we extracted the data that hospitalization of patients experiencing a moderate depressive episode happens to 1,5% patients, while it is a recourse to 7,5% chronic patients (Morvan et al., 2007).

From the payer's perspective (Assurance Maladie), we retrieved the total costs of "neurotic disorders"[23] which amount to 6,233 million euros, 3,7% of total expenses. 50% of this cost, is covering hospitalization: 3,124 million euros for a total of 1,408,700 patients suffering for neurotic disorders in France, 2020. This equals to **2,224 euros per hospitalized patient** per episode.

$$\frac{\text{3,124,000 euros}}{\text{1,408,700 patients}} = \text{2,224 euros}$$

Carbon Footprint parameters

For pharmacotherapy, we used the LCA provided by ECOVAMED[24], a company specialized in analyzing & comparing medicines' carbon footprints. Escitalopram by Biogaran[25], a generic from the original molecule (Seroplex), the most prescribed of this class of drugs in France, accounted for 0,68kgCo2 per box.

In order to attribute a Carbon footprint both to private practitioners' consultations (GPs, Psychiatrists) and to the hospitalization linked to neurotic disorders, we had to make 3 important assumptions. The **first assumption** was the distance patients have to make to visit a health practitioner. In the 2023 Technical Report from the SHIFT PROJECT, the assumption used for a visit indiscriminately to a GP or a psychiatrist is 10km average per patient per visit (SHIFT PROJECT, 2023). However, the hybrid methodology proposed aims to give a macro perspective on the carbon footprint of the health system as a whole. In our study, a bottom-up methodology would allow a closer look at Carbon emissions linked to a different spatial repartition of generalists and specialist practitioners on the territory. We found in an IRDES publication that on average a citizen in France stands at an average bird distance of 0,609km for GPs against 6,516km for psychiatrists (Coldefy et al., 2011). This distance had not increased significantly between 1990 and 2006 (around 6% for both practitioners). Thus, we chose to use this reference, for a unique visit (back-and-forth,

[23] Referred to as « Troubles nevrotiques et de l'humeur » in the French codification, including bipolar disorders, reported in to account for less than 10% of the total neurotic disorders. L'Assurance Maladie - Personnes prises en charge pour troubles névrotiques et de l'humeur en 2020. Fiche pathologie mise à jour le 18/01/2023 - Cnam/DSES/DEPP

[24] https://www.ecovamed.com/ accessed June 12th 2023

[25] https://base-donnees-publique.medicaments.gouv.fr/extrait.php?specid=65502004 accessed June 12th 2023

doubled distance), translating it into road distance from bird distance, by applying a factor 1,4 as recommended by ADEME (French Environment & Energy Management Agency[26]).

Average distance to practitioners	Bird Distance	Road Distance	**Back & forth**
GP	0,6km	0,85km	**1,7km**
Psychiatrist	6,5km	9,1km	**18,2km**

Figure 6 – Average distance to practitioners in France, 2006 (IRDES)

Second assumption: the average carbon footprint for primary services, a visit to a general practitioner or a specialist consultation may vary greatly from countries to countries depending on the method used, between top-down Input/Output analyses and bottom-up Life Cycle Assessments but also between rural/urban context, organization of the primary service (private practice in a cabinet or health centre with pooled resources) and obviously the perimeter chosen to calibrate a LCA (for example, does it include medicines prescribed or not to the patients?). Very few Life Cycle Assessments of primary care & private practices were available in the literature until early 2023. We referred ourselves to a recent Life Cycle Assessment conducted in Switzerland on 10 primary care practices: *"They were located in sub-urban (five practices), urban (four) or rural (one) or domains. Their surfaces ranged between 107 and 180 m2 except for two practices of 600 m2. The practices employed between 0.8 and 4.0 full-time equivalent non-physician staff and from 0.8–3.5 full-time equivalent physicians."* (Nicolet et al., 2022). The footprint retrieved for a primary service was 4,8kg CO2e per patient/visit, excluding drug prescription. We removed 33,2% of the footprint, the share corresponding to patients' mobility (1,6kgCO2 equivalent to an average of 5,5km for a patient to access primary health services, which suggest all patients came by car in this study). At the exception of patient mobility, we hypothesized a **similar Carbon footprint profile between a primary care practice in western Switzerland (Lausanne area) and France: 3,2kgCO2e** (4,8kgCO2 – 1,6 kgCO2) accounting for 66,8% of a private practice Carbon Footprint (thus not accounting for 33,2% patients' mobility). This hypothesis will be commented later in the discussion part.

From this initial hypothesis, we calculated both the Carbon equivalent for a visit to the GP and for a consultation to the psychiatrist in France, based on a transport by a medium sized car (0,2176kgCO2 per km as recommended by ADEME). We assumed all patients would be using a car, as primary transport mean, at this stage of our work, in order not to over-complexify the calculations, but also to model the highest possible transport footprint.

FRANCE	Practice Footprint (kgCO2e)	Transport footprint	**Total Footprint per visit**

[26] https://www.ademe.fr/en/frontpage/ accessed June 10th 2023

Formula	*From Nicolet et al (2022)*	*Distance (km) * kgCO2 per km*	*Practice + patient mobility (kgCO2e)*
GP	3,21kgCO2	1,70 * 0,2176 = 0,37 kgCO2	3,2 + 0,37 = **3,58kgCO2e**
Psychiatrist	3,21kgCO2	18,52 * 0,2176 = 4,03 kg CO2	3,2 + 4,03 = **7,18kgCO2e**

Table 2 – Carbon Footprint calculation for a visit to the GP/Psychiatrist in France based on Nicolet et al. (2022)

Third assumption, we used as reference the Carbon footprint of a hospital per bed/day from on a recent Life-Cycle Assessment published by AP-HP (Assistance Publique – Hopitaux de Paris). *"In 2019, the carbon footprint of the AP-HP amounted to 1.1 million tonnes of CO2e, i.e. an average of **182 kgCO2e per day of hospitalization** and 173 kgCO2e per thousand euros of budget operating costs, consistent with industry estimates."*[27] The Carbon footprint of a hospitalization for a depressive disorder could then be calculated by multiplying the average stay (18,76 days) by the average Carbon Footprint per day (182kgCO2) which equals to **3414 kgCO2 e per episode of hospitalization per patient**.

Qualitative study

Participation to a dedicated workshop

On May 3rd 2023, a workshop gathered in Sciences-Po, Paris, 29 researchers and health system key stakeholders from universities, think tanks, agencies and the government, to dialogue on the topic of "Decarbonizing the Health System, what is at stake for public policy making?" 4 distinct sessions took place[28]:

1- Situation point & Carbon Footprint
2- Reorganizing to decarbonize the health system
3- Local experimentations
4- Perspectives for public policy making

Double note taking (from the workshop organizers and myself) allowed to capture the main themes and discussions. All participants agreed that ideas presented and discussed could be disseminated, yet without making mention of participant's identity nor institution. The intention of this format was to allow for the free expression of view without formal institutional engagements or constraints.

[27] https://www.aphp.fr/contenu/premiers-resultats-du-bilan-carboner-de-lap-hp-sur-lensemble-de-ses-activites accessed June 12th 2023
[28] https://www.sciencespo.fr/liepp/fr/content/decarboner-le-systeme-de-sante-quels-enjeux-pour-les-politiques-publiques.html accessed June 19th 2023

Semi-directed interviews

Five semi-directed interviews of 45 minutes each were organized between May and June 2023, with 4 organizations participating in the workshop (a think tank, a public insurance scheme, a central regulation body, a provider association) as well as an additional participant representing an agency. Questions covered attitudes towards environmental impact of the health system, key stakeholders in this field, availability of methods and tools, availability of expertise, main levers, as well as main opportunities and challenges. The interviews were recorded, transcribed, controlled by the interviewer against the recording, sent for approval to the interviewee, and finally treated in a spreadsheet software to extract key themes per topic & highlight related citations[29].

Analysis Framework

I chose to apply the framework of Shiffman & Smith determinants of political priority (Shiffman & Smith, 2007), by taking into consideration some recent proposed additions to the model (Walt & Gilson, 2014). It appeared particularly relevant to analyze a situation in the making, through its determinants, as compared to frameworks such as Kingdon's windows of change, better suited to retrospectively analyze a change that happened, when trying to understand what made it happen (Hoefer, 2022). Figure 7 below provides an overview of the framework.

Category	Description	Factors shaping political priority
Actor power	The strength of the individuals and organizations concerned with the issue	1. *Policy community cohesion*: The degree of coalescence among the network of individuals and organizations centrally involved with the issue at the global level
		2. *Leadership*: The presence of individuals capable of uniting the policy community and acknowledged as particularly strong champions for the cause
		3. *Guiding institutions*: The effectiveness of organizations or coordinating mechanisms with a mandate to lead the initiative
		4. *Civil society mobilization*: The extent to which grassroots organizations have mobilized to press international and national political authorities to address the issue at the global level
Ideas	The ways in which actors understand and portray the issue	5. *Internal frame*: The degree to which the policy community agrees on the definition of, causes of and solutions to the problem
		6. *External frame*: Public portrayals of the issue in ways that resonate with external audiences, especially the political leaders who control resources
Political contexts	The environments in which actors operate	7. *Policy windows*: Political moments when global conditions align favorably for an issue, presenting opportunities for advocates to influence decision-makers
		8. *Global governance structure:* The degree to which norms and institutions operating in a sector provide a platform for effective collective action
Issue characteristics	Features of the problem	9. *Credible indicators*: Clear measures that demonstrate the severity of the problem and that can be used to monitor progress
		10. *Severity*: The size of the burden relative to other problems, as indicated by objective measures such as mortality levels
		11. *Effective interventions*: The extent to which proposed means of addressing the problem are clearly explained, cost-effective, backed by scientific evidence, simple to implement, and inexpensive

Figure 7 - Shiffman & Smith framework (2007)

[29] Confer Sample Interview Guide in Appendix

Results

1. Environmental footprint: what to measure, how to measure?

Definition of sustainable healthcare

Over 114 articles screened between 2021 to 2023, **89% (n=102) didn't refer to any definition of sustainable healthcare**. 4% (n=5) referred to an original definition, assembled or created by the authors. 3% referred to an *operational definition* created or assembled by a governmental body (Dutch government, NHS in UK). 2% (n=2) referred to "the triple bottom line", a business concept integrating environmental, social and financial impacts to define sustainability. 2% (n=2) referred to a UN definition like the SDGs or WHO framework for sustainable healthcare.

Over 12 articles integrating a definition of sustainable healthcare, **only 33% (n=4) have a definition logically correlated with a foot-printing method**. By logically correlated, we mean that the scope of the definition reflects in the scope of the method associated. For instance, a definition of sustainability integrating multiple impacts on the environment correlates with a multiple impact method to account environmental footprints. In 58% of articles (n=7), the definition is not specific enough or could be associated with any impact.

What is measured as an environmental impact?

		Environmental Impacts	Partial **(Greenhouse Gases & related)**	Partial **(Other then GHG)**
System/Macro	Total	4	15	6
	%	*16%*	*60%*	*24%*
Facility/Unit/Community	Total	3	25	9
	%	*8%*	*68%*	*24%*
Procedure/product	Total	12	17	3
	%	*38%*	*53%*	*9%*
Total research	Articles n=	**19**	**57**	**18**
	% of articles	**20%**	**61%**	**19%**

Table 3 - What is measured at which level from a total of 93 original research screened from 2021 to 2023

Over 93 articles presenting primary data (out of 114 articles), 61% (n=57) use Greenhouse Gases (GHGs) as the main measurement of environmental impact within the health system. 20% (n=19) use multiple environmental impacts like LCAs. 19% (n=18) focus on a specific impact, other than Greenhouse Gases. This tends to show the **prominent use of GHGs or the Carbon Footprint as a measurement of environmental impact** in the literature over these last 2 years. The carbon footprint measure is even more prominent at facility or unit level, where 68% (n=25) articles measure GHGs, while only 8% (n=3) use multiple environmental impacts as a measure. When it comes to measuring products or procedures'

impact, we can observe a more balanced result in the methods utilized. When 53% (n=17) focus on greenhouse gases, 38% (n=12) use multiple impacts.

2. How to integrate environmental parameters into health decision-making?

Pharmacotherapy to treat a moderate depressive episode

Total cost for the payer will amount 324 euros per year, for a carbon footprint of 107 kgCO2 for one episode of a year. Total cost for the payer will amount 511 euros per year, for a carbon footprint of 333 kgCO2 for a chronic condition.

Moderate Depressive Episode / 1 patient-year	**Direct care (Patient's choice)**			**System care (likelihood)**	**Total / Episode**
	Outpatient		Medicines	Hospitalization	
Resources	GP	Psychiatrist	Escitalopram	Emergency Dept + Psy	
Unit	Visit	Visit	Box (28 comp)	Bed/day per episode	
Quantity	**8**	**4**	**13**	**18.76**	
Price (euros)	25	43.7	4.63	2,224.75	
% healthcare use	100%	100%	100%	**1.2%**	
% reimbursement	70%	70%	65%	100%	
Social Cost (euros)	200.00	174.80	60.19	26.70	462
Patient's cost	*60.00*	*56.44*	*21.07*	0.00	*138*
Payer's cost	*140.00*	*118.36*	*39.12*	26.70	***324***
kg Co2e/unit	3.58	7.18	0.68	3,414.35	
Carbon Footprint kgCO2 (Social)	**28.62**	**28.71**	**8.84**	**40.97**	**107**
Chronic Depressive Disorder / 1 patient-year	**Direct care (Patient's choice)**			**System care (likelihood)**	**Total / year**
	Outpatient		Medicines	Hospitalization	
Resources	GP	Psychiatrist	Escitalopram	Emergency Dept + Psy	
Unit	Visit	Visit	Box (28 comp)	Bed/day per episode	
Quantity	**9**	**5**	**13**	**18.76**	
% healthcare use				**7.5%**	
Payer's cost	*157.50*	*147.95*	*39.12*	166.86	***511***
Carbon Footprint kgCO2 (Social)	**32.20**	**35.88**	**8.84**	**256.08**	**333**

Table 4 - Pharmacotherapy to treat moderate depressive disorder (cost in Euros)

Psychotherapy to treat a moderate depressive episode

Total cost for the payer will amount 463 euros per year, for a carbon footprint of 184 kgCO2 for one episode of a year. Total cost for the payer will amount 620 euros per year, for a carbon footprint of 417 kgCO2 for a chronic condition.

Moderate Depressive Episode / 1 patient-year	**Direct care (Patient's choice)**			**System care (likelihood)**	**Total / Episode**
	Outpatient			Hospitalization	
Resources	GP	Psychotherapist	Psychiatrist	Emergency Dept + Psy	
Unit	Visit	Session	Visit	Bed/day per episode	
Quantity	**4**	**18**	**0**	**18.76**	
Price (euros)	25	43.7	43.7	2,224.75	
% healthcare use	100%	69%	100%	**1.20%**	
% reimbursement	*70%*	*70%*	*70%*		
Patient's cost	*30.00*	*253.98*	*0.00*		*284*
Social Cost (euros)	100.00	541.18	0.00	26.70	668
Payer's cost	*70.00*	*366.44*	*0.00*	26.70	***463***
kg Co2e/unit	3.58	7.18	7.18	3,414.35	
Carbon Footprint kgCO2 (Social)	**14.31**	**129.18**	**0.00**	**40.97**	**184**
Chronic Depressive Disorder / 1 patient-year	**Direct care (Patient's choice)**			**System care (likelihood)**	**Total / year**
	Outpatient			Hospitalization	
Resources	GP	Psychotherapist	Psychiatrist	Emergency Dept + Psy	
Unit	Visit	Session	Visit	Bed/day per episode	
Quantity	**5**	**18**	**2**	**18.76**	
% healthcare use		69%	69%	**7.50%**	
Payer's cost	*87.50*	*532.62*	*40.72*	166.86	***620***
Carbon Footprint kgCO2 (Social)	**17.89**	**129.18**	**14.35**	**256.08**	**417**

Table 5 - Psychotherapy to treat a moderate depressive disorder (cost in Euros)

Combined therapy to treat a moderate depressive episode

Total cost for the payer will amount 502 euros per year, for a carbon footprint of 328 kgCO2 for one episode of a year. Total cost for the payer will amount 673 euros per year, for a carbon footprint of 480 kgCO2 for a chronic condition.

Moderate Depressive Episode / 1 patient-year	Direct care (Patient's choice)				System care (likelihood)	Total / Episode
	Outpatient			Medicines	Hospitalization	
Resources	GP	Psychotherapist	Psychiatrist	Escitalopram	Emergency Dept + Psy	
Unit	Visit	Session	Visit	Box (28 pills)	Bed/day per episode	
Quantity	**4**	**18**	**4**	**13**	18.76	
Price (euros)	25	43.7	43.7	4.63	2,224.75	
% healthcare use		69%			**1.20%**	
% reimbursement	*70%*	*70%*	*70%*	*65%*		
Patient's cost	*30.00*	*253.98*	*56.44*	*21.07*		361
Social Cost (euros)	100.00	541.18	174.80	60.19	26.70	903
Payer's cost	*70.00*	*366.44*	*0.00*	39.12	26.70	***502***
kg Co2e/unit	3.58	7.18	7.18	8.84	3,414.35	
Carbon Footprint kgCO2 (Social)	**14.31**	**129.18**	**28.71**	**114.92**	**40.97**	**328**
Chronic Moderate Depressive Disorder / 1 patient-year	**Direct care (Patient's choice)**				**System care (likelihood)**	**Total / year**
	Outpatient			Medicines	Hospitalization	
Resources	GP	Psychotherapist	Psychiatrist	Escitalopram	Emergency Dept + Psy	
Unit	Visit	Session	Visit	Box (28 pills)	Bed/day per episode	
Quantity	**8**	**18**	**8**	**13**	18.76	
% healthcare use		69%	69%		**7.50%**	
Payer's cost	*140.00*	*532.62*	*162.86*	39.12	166.86	**673**
Carbon Footprint kgCO2 (Social)	**28.62**	**129.18**	**57.41**	**8.84**	**256.08**	**480**

Table 6 - Combined therapy (pharmaco + psychotherapy) to treat a moderate depressive disorder

Comparing costs & Carbon footprint across all treatments

COMPARATIVE RESULTS	Pharmacotherapy	Psychotherapy	Combined
1 episode / year (Payer's perspective Euros)	324	463	502
%	*65%*	*92%*	*100%*
CHRONIC / year (Payer's perspective Euros)	511	620	673
%	76%	92%	100%

Pharmacotherapy is the least expensive treatment for the payer (65% of combined therapy for one episode), while Psychotherapy & Combined therapy are in a close range.

COMPARATIVE RESULTS	Pharmacotherapy	Psychotherapy	Combined
CO2 / 1 episode / year (kgCo2)	*107*	*184*	*328*
%	33%	56%	100%
CO2 / Chronic / year (kgCo2)	*333*	*417*	*480*
%	69%	87%	100%

Pharmacotherapy also has the lowest Carbon footprint to treat an episode of moderate depressive disorder (33% of combined therapy for one episode), Psychotherapy is the second best with 56% of the footprint of combined therapy. For the treatments of chronic depressive disorders, Pharmacotherapy still perform best (only 69% of combined therapy), but psychotherapy gets closer to combined therapy with 87% of its Carbon footprint. However, those results cannot be conclusive at population level, before running a Markov model and a Monte-Carlo simulation on a larger population submitted to real life epidemiological parameters, as well as introducing a measure of sensitivity.

3. How is the agenda towards a more sustainable health system set?

Through the lenses of an analytical framework adapted from social sciences, the material extracted from a dedicated workshop and a series of interviews is presented to highlight the multifaceted perspectives on the issue: how to make the health system in France more sustainable?

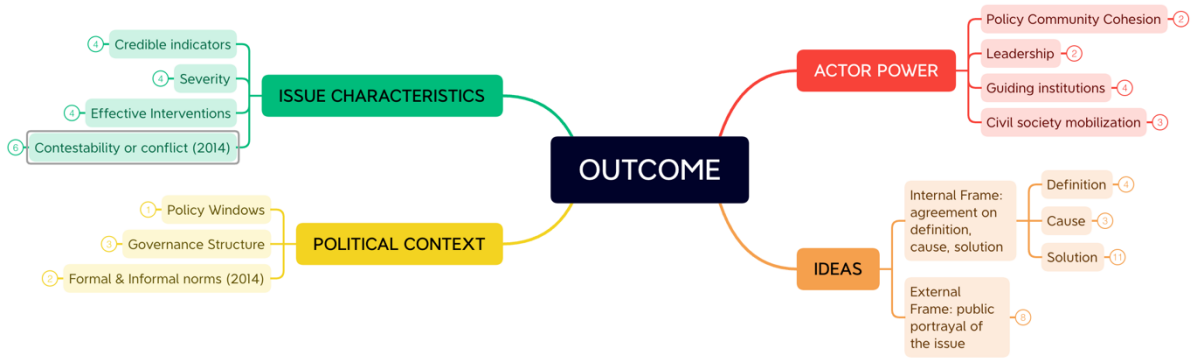

Figure 8 - Shiffman & Smith Framework (2007) - Revised 2014

Actor power: Strength of individuals and organizations concerned with the issue.

Policy community cohesion - The degree of coalescence among the network of individuals and organizations centrally involved with the issue.

During the workshop, the decentralized organization of the health system in France appeared as a key factor explaining the difficulty to establish benchmarks, unlike the NHS in the UK. This may be counter-intuitive when looking at the centralized tradition of France. If a central actor in the system like the Ministry of Health (MoH) has an influential role, its impact on the system takes its roots in the tools it uses. In the case of the MoH, regulations over the past 10-15 years did not prove to be effective in making a change. Piling-up regulations only made the legal environment more complicated to navigate for poorly equipped health actors.

The reality of the system is that recurrent negotiations are needed to keep all actors on board. Power resides in the financial equation managed by the main payers, different social insurances branches.

Absence of benchmark may explain the difficulty to ascertain the reality of the environmental footprint of the system, but not only. It also explains the difficulty to perceive and display the system as a whole, or to kick start the initial phase of a change process: all stakeholders recognizing an issue and forming a consensus on an initial diagnostic.

Therefore, in the words of a staff from a technical governmental agency: *"Today, the healthcare system is not on any of the radars. When the sobriety plan [from the government,*

during the fall of 2022] came out, there was no mention of the healthcare system. Even though it's one of the biggest consumer sectors. It's just not taken into consideration."

Leadership - The presence of individuals or bodies capable of uniting the policy community and acknowledged as particularly strong champions for the cause

Despite its influential role, the ministry of health itself did not appear to exert a strong leadership until now to drive a transition towards a more sustainable health system. Much the contrary, its silence stood out, until it eventually released a roadmap in May 2023 (*Planification ecologique du systeme de sante. Feuille de route.*, 2023). In the words of a MoH staff *"For a long time, I don't think we've had anything very coordinated or clear outside the Ministry".* This staff explains it by the many consultations which took place with other administrations, politicians, industrial partners, including pharmaceutical companies.

This lack of leadership came from a lack of priorisation at government level, during the first term of the actual president's administration, which in the words of several participants of the workshop had other priorities with several major crises in the last 5 years (Yellow jackets, Covid19).

The consequence today, described by a payer's senior staff is that is that a compass is missing. There is no ecological planning. "*We're in a race against time, and we're also in a race to make the best use of public money. So we need to know where we're going. We need to know where the main issues are, where we need to move as quickly as possible in a given area, where the second-order issues are, and where the false good ideas may be."*

Guiding institutions & organizations - The effectiveness of organizations or coordinating mechanisms with a mandate to lead an initiative

However, some guiding institutions or organizations are well recognized in the health care ecosystem. At field level, a certain number of flagship healthcare establishments are recognized, like Bordeaux regional hospital, the reanimation service of Marseille-North hospital, or a few other hospitals (Niort, Lille, Strasbourg). Those hospitals propose models to follow or develop practical methods and guides for any establishment wishing to embark on an ecological transition.

Almost all participants of the workshop recognize the particularly positive role of the ANAP[30], a governmental agency providing not only technical support to medical and medical-social establishments, but as well acting as a network coordinator and adviser. Main payers like the CNSA[31] are also reported to play an important role in structuring territorial dialogue with

[30] *Agence nationale d'appui à la performance des établissements sanitaires et médico sociaux*
[31] Caisse Nationale de Solidarité pour l'Autonomie

decentralized key stakeholders: departmental councils, cities & territorial networks, as well as government decentralized agencies. Their determinant role is to frame the financial equation to be expected, as well as giving a multiyear horizon. Through these dialogues, the expectation is to have a multiplying effect, to get on board citizens, local businesses, notably around solutions to be put together to achieve objectives linked with the ecological transition of the health system.

Interestingly, the National Health System in the UK is continuously referred to as an example by many workshop participants. Although its fundamental difference with the way the health system is organized in France is recognized. The exemplarity of the NHS resides in the fact its approach to sustainability is very systematic & very well organized. But in the words of a participant mostly "very well communicated". Nevertheless, the NHS results are broadly recognized by all participants. "*It starts from an observation with a quantification of the various sources of greenhouse gas emissions. It then identifies effective levers for tackling these main sources, prioritizing them and providing establishments with the tools they need to do so. It also implements policies at national level, such as purchasing policies, with work on calculating the carbon footprint of healthcare products, which will then be integrated into public procurement policies."*

Civil Society mobilization *- The extent to which grassroots organizations have mobilized to press international and national political authorities to address the issue*

"Since 2020/2021, there has been a major shift in awareness and action, with an ecological awareness and a "green wave" in the hospital, although some colleagues remain climate sceptics". (Participant of the Workshop). The role of the Shift Project and its publications assessing for the first time in France the Carbon Footprint of the health & social care sector in 2021 (and later 2023) was quasi unanimously recognized by the workshop participants. Indeed, having a correct vision of the industry's carbon footprint is recognized as the right first step to make.

On another scale, at local level, the role of some municipalities like Paris in politically addressing climate change, is recognized has having positive side effects on the agenda setting towards a more sustainable health system. However, the political nature of this commitment may also constitute its fragility in the long term, amidst ambiguous relationship with public health objectives. Some objectives may be converging at times, some may be just contradictory, like the multiplication of health structures, noted a participant, member of a local administration.

Internal frame - The internal frame displays a complex interaction of causes, and ideas about potential solutions.

One of the participants of the workshop underlined the need to **agree first on the objectives** and shared values of a sustainable health system, before agreeing on indicators. Otherwise, there would be dissensus around what the indicators aim to show, and a posteriori argument on what the objectives should achieve. The need to agree upon not only quantitative, but as well qualitative objectives is mentioned, with the "*absolute objective of ensuring good health for all"* in the own words of a MoH senior staff.

The complexity in addressing the causes of the problem is well anticipated by participants, particularly in front of **numerous environmental impacts**. Environment and health should be a top priority of all policies, a participant recognize, and in the medium-long term, the health care community is expected to work on all environmental impacts, not just on carbon footprint.

A consensus emerged on the **complex architecture of the health system**, made of many flows of patients, users, and professionals, synonym of massive transport emissions. This leads the practice of care itself, as it is structured today, to be recognized has having a negative environmental impact. With pollution generated before (upstream production), during care, and downstream (discharge of pollutants in the environment), the considerable emission of the sector is obvious to the participants, no dissensus was expressed.

Food waste and the question of nutrition in health structures like hospitals is a topic of concern, with a fairly meat-based diet generating carbon emissions. More broadly, **hospitals are recognized as major polluters**.

The structure of **the medical-social sector also generates massive pollution**. In the own words of a participant, *"the DNA of the medical-social offer as it is conceived today, it's a carbon emitter, the very design of the branch generates emissions that are not independent of the care of the people".* This DNA is today promoting policies favoring home-based care, and an inclusive society where needs of each individual are met within the community they live. This is expected to generate more flows of professionals, spread-out services throughout a territory, and possibly more pollution.

The **practice of irrelevant care** by health providers, is reported as a complicated issue to address. It is not disconnected with the delegation of services to private providers. But participants recognize how challenging it will be to address this issue, not only harmful to the environment, but already harmful to the system, since it consumes unnecessarily financial resources.

Nevertheless, participants of the workshop recognized that there's a lot going on at provider level, across the sector, in favor of more sustainability. This is actually where things really started in France, a participant acknowledged. Several promising field driven initiatives were reported, with ongoing attempts to structure them at national level. **Encouraging & supporting local initiatives** with appropriate tools makes consensus, as well as calling-in local actors having an expertise not specifically related to health (like local businesses, industries). Only a few participants mentioned the risk to see a multiplication of initiatives that do not produce a real impact on the global system. "*Players must not exhaust themselves implementing policies that would have micro impacts. We all need to have a clear vision of the most effective levers, and to activate these levers as a matter of priority" a participant mentioned.*

All participants did recognize the urgent need to plan for **massive investments** to decarbonize the system. First because there are quick wins expected in rehabilitating and decarbonizing the numerous buildings of the sector, second because financial constraints are limiting factor to engage the transition. In the own words of an interviewee: "*in the field, as soon as there's time and resources, there's no real obstacle."*

Planning appeared as a key word during both the workshop and the interviews: ecological planning, land-use planning, new forms of planning with a centralized management that provides trajectory and tools. However, the principle of subsidiarity was also underlined: decision need to be taken at the right level, only when needed and requested at a higher level. This to protect the motivation and initiatives of local actors in favor of the transition.

The idea to introduce into **tariff equations** elements that promote correct carbon management was mentioned by a payer's senior staff, since the sector is highly regulated in terms of price. Since public money is involved, it would be a way to indirectly finance a more sustainable system.

In front of multiple tools and indicators, a participant calls for a **simplified reporting system**, where tools are aggregated. This is to facilitate the efforts to pilot the transition at health structure level. Similarly, there was a consensus from several workshop participants on the need to foster greater transparency from health products, in order to already make more responsible purchasing decisions.

External Frame - Public portrayals of the issue in ways that resonate with external audiences, especially the political leaders who control resources.

The **public recognition of the health sector as a major source of pollution**, is a first step. As well as the need to make it evolve towards a lesser environmental footprint, through its integration to all existing initiative to limit emissions and pollution.

Local stakeholders need to be recognized in their fundamental operational and decisional role. For that reason, a fine territory & actors mapping is a key step to plan the transition. Local actors know better their territory, their needs and resources, as well as their challenges and opportunities. This was a broad consensus among the participants. Local hospitals are an important element of the key players in the territories. They shouldn't be omitted in the actors' mapping, mostly because of the important resources they directly or indirectly manage (human, financial, material).

Positive communication about ongoing actions in favor a more sustainable system was clearly differentiated from green-washing. This objective of this public communication is to foster enthusiasm within a community about ways to address the ongoing environmental crisis, and to place health actors at the center of the action. This is expected not only to have a positive impact on patients & citizens' perception, but as well on health professionals themselves, making health & social-medical structures more attractive.

Interestingly, the **communication about carbon footprint** was questioned by a representative of health providers, since they may not speak to many people, unless translated into more practical real-life experiences like for instance journeys by plane or by car between cities. In the same logic, waste generated could be better translated in budget spent to treat the waste, which would literally show how much money is wasted.

"We must always bear in mind that we're talking about a sector that has been heavily, heavily impacted." The **human resource toll** health and medical-social structures have to pay, particularly post-Covid19 crisis, as well as the structural **lack of financial resources** to engage the transition, are described as important markers of the situation of the sector today. They both need to be framed in the public debate about the health sector transition. As an interviewee from a governmental agency simply puts it: *"Today, if we're not making progress on many issues, it's because we don't have the resources".*

Political context: The environments in which actors operate.

Policy windows – Political moments when conditions align favorably for an issue, presenting opportunities for advocates to influence decision-makers.

As a interviewee from a government administration concisely remarked *"in the interests of efficiency, and to tackle something quickly first,* ***decarbonizing is the angle that has been chosen*** *and that is supported by our industrial policy today".* However, the broader intention to tackle all sources of pollution also coexist. But decarbonizing simply appears as a priority, not only for the health sector, but to all industrial sectors. This was also reflected in the interventions of the workshop participants who did not question this priority. A few participants

only mentioned other sources of pollution to address concomitantly, like air pollution in its broader sense.

Governance structure - The degree to which norms and institutions operating in a sector provide a platform for effective collective action.

The recent creation of a General Secretariat for the Ecological Transition, as well as a High Commissioner for Sustainable Development are perceived by a few participants as a positive move from the French government. In their reasoning, those entities will help to coordinate public policies, to make sure that they're moving in the right direction, not duplicating the efforts of other administrations. At international level, the work of WHO through working groups, to achieve a kind of international harmonization of the environmental footprint indicators was noted. As well as the promotion of best practices and methods. However, this role was remarked by a minority of participants, in contrast with the leadership exerted by the NHS for instance.

Formal & informal norms & rules (add from Walt et al.) that make up judicial and legal institutions.

The piling up of environmental regulations in France was recognized as a semi-failure by a participant from an important health providers federation. From his experience, a majority of hospitals and health structure do not have the capacity to apply these regulations. They are simply partially or totally ignored, depending on the capacity of the structure. It is worth nevertheless to note, that the government seem not to have exerted its control capacity on this matter.

The real challenge in the years ahead, could be to support health professionals to implement and respect this environmental legal framework, which objectives are positively perceived in by a few participants. The existence and implementation of environmental labels could be instrumental to support the transition of health structures, because of their impact on team dynamics, sometimes through the work of dedicated consulting firms.

Issue characteristic: Features of the problem.

Credible indicators - Clear measures that demonstrate the severity of the problem and that can be used to monitor progress.

Workshop participants recognized the need to assess the **carbon footprint of health structures** including up to the scope 3. For some a broader footprint should also include other

key resources consumed like water, or pollutions like air pollution and waste. A major limitation of the system today is that it measures everything in financial flows, rather than physical flows that could be used to ascertain carbon emissions.
A member of a government administration remarked that professionals who work on **life cycle analyses of healthcare products** recognize that *it's much easier for them today to calculate a carbon footprint than to calculate a broad environmental impact, what we call 16-impact footprints".* This suggests that the industrial sector is keener to use simpler tools to report the environmental footprint than the tools that have been developed up to now.
While a representative of a professional federation admitted that some structures don't really track concrete indicators, since they have not enough human resources to follow them up.

Severity - The size of the burden relative to other problems, as indicated by objective measures such as mortality levels.

Both the assessment of the health sector's carbon footprint in France (8% of the country's emissions, mosty indirect) and the increased need for material and energy resources to face the growing pressure of climate change made consensus. The speed requested to transition the sector and the overall effort to be made as well. As one participant noted: *"The work of the Pisani-Mahfouz mission shows that we have a transformation to carry out on the scale of the industrial revolution, but that it needs to be carried out three times faster. We therefore need to coordinate, prioritize and plan our actions."*

Effective intervention - The extent to which proposed means of addressing the problem are explained, cost-effective, backed by scientific evidence, simple to implement, inexpensive.

At this stage, except the local numerous initiatives already mentioned, the only country wide visible intervention recognized by the participants of the workshop was the implementation since september 2022 of **151 positions of Ecological & Energy Transition in Healthcare Advisers** (CTES[32]). The expectation from one participant is that their role will be wider than for the hospitals they are based in, with a capacity to play an advisory role at local level for a broad spectrum of other health practitioners.
Other cost-effective or simple interventions were wished for, by more than one participant, like a broad training in environment and climate issue for the whole population, or gearing up multiple local actors towards a **more preventative & health promotion approach** to health. However, this proposition was welcomed by a cold realism by another participants, in

[32] Conseillers en transition écologique et énergétique en santé (CTEES)

reaffirming the challenges posed by key determinants of health, like poverty, in urban environments for instance. Nevertheless, the fact that the greatest quantity of services to be provided to the population was **outside the healthcare system**, as shown by the WHO pyramid of optimal care organization, made consensus.

Contestability or conflict (add from Walt et al.) - whether between actors, over how issues are framed, or over doubts about evidence or interventions.

A few conflictual elements also appeared in the workshop. First, some doubts about the numerous & scattered local initiatives who may not all have the expected systemic effect. The main reason being that they cannot be taken up by all the actors of the health and social & medical sector, often for simple resource constraints.
Second, the reluctance of some health professionals to recognize the urgency of the transition, whether because they are totally unaware of what's going on, whether because they think that *"decarbonization issues are to prevent prescribing"* in the own words of a participant.
Another participant noted the tendency of the sector to navel-gaze and wait for solutions to be tailor-made before implementing them, which would explain a certain level of immobilism.
But a greater challenge was eventually echoed by a few participants: the acceptability of private for-profit actors to assess the relevance of care provided in their practices, to go for more sober practices. While another participant mentioned the ethical dilemma posed by end-of-life care, when it comes to assess the opportunity to continue providing healthcare against sobriety principles.

ACTOR POWER	POLITICAL CONTEXT
Actor Power seems characterized by a **low coalescence** and a **fragmented policy community,** with a **weak leadership** until now. However, **civil society mobilization appears active** on the issue, and may **benefit from a few well recognized guiding organizations** and institutions.	**The political context offers a policy window**, with the direction taken by French industrial policy in favor of decarbonizing. Governance is supported at WHO level, nationally by several institutional players involved in the ecological transition, and at local level this window opens an opportunity for territorial dialogues. Formal and informal norms do exist already, but there may be a challenge of implementation.
IDEA	**ISSUE CHARACTERISTIC**
The idea **seems framed in its complexity, both internally and externally**. The definition - sustainability of health systems - appears mostly implicit to stakeholders, while the cause of unsustainability seems directly related to how care is practiced and organized. Solutions proposed encompass a large spectrum of actions: renewed planning, change in the tariffication, elimination of unnecessary care, massive investments, aggregation of tools, environmental footprint transparency. Externally, recognizing the need of resources, the emissions of the health sector, the role of local actors, and the particular toll the Covid pandemic took on the system, while avoiding greenwashing seem to be the key features.	While the severity of the issue seems recognized, it is **characterized by challenges at the level of the indicators**. A simplification may happen towards carbon footprint rather than environmental footprint. The accounting of financial flows rather than physical flows makes indicators inoperative, while some indicators are simply not tracked. **Effective interventions are already reported**, or some future simple evolutions recognized. But **some conflicts may already appear**, with health providers themselves questioning the intention behind the issue, through the systemic inefficiency of local experimentations, or with economic models in the private sector being at risk.

OUTCOME

- The use of Shiffman & Smith framework suggests that the context in which political determinants are unfolding doesn't appear quite mature or aligned yet for a strong political ownership and action in favor of supporting a more sustainable health system in France.
- Enthusiasm and opportunities exist. Change is supported at various levels. But major challenges remain on the way, starting from defining what a sustainable health system would look like, practically speaking.
- A risk is to run into some sort of action, without knowing exactly until which point change will be accepted, or to stay at the surface of things without reaching an impactful result.
- However, a better convergence of top-down intentions to transition, with available resources, a broader civil society participation, with bottom-up initiatives and territorial dialogues could pave the way to a positive iterative process towards building a more sustainable system

Limitations

Scoping review

Articles screened were only representing 2 years of publication (2021-2023). Over the last 5 years, climate crisis debates intensified around the term of President Trump in the US, it may have influenced further the scientific community to publish about it. Enlarging the scope of analysis to the whole scoping review period (2010-2023) may broaden the perspective and alter the interpretation of the results. Another limitation was the task repartition between researchers. Interpretation in the data extraction parameters may differ between researchers. For instance: extracting a *definition of sustainability* is not systematized enough since it is rarely introduced as: *"here is our definition of sustainability of health systems"*. Some articles were clearer about it than others. In some articles, the definition was implicitly introduced. However, we tried to limit individual bias by restricting the search to the introduction and making available previous examples of definitions retrieved. Ultimately, cross-checking the findings of one-other would increase reliability of this result.

Health-economic evaluation

Follow-up studies in psychiatry are notoriously difficult to conduct (Blackburn et al., 1986), this lead to a certain difficulty to retrieve data from longitudinal cohort studies on the long term (more than 1-2 years), at a few exceptions (Gilman et al., 2017). Some clinical terms suffer from a lack of definition across studies: "The definition of 'relapse' presents certain conceptual difficulties. Klerman (1978) suggested that the term relapse should be reserved for a return of symptoms within 6-9 months after the onset of the index episode and that recurrence should apply to a return of symptoms after that period. Thus, relapse would apply to the previous episode and recurrence to a new episode of illness." (Blackburn et al., 1986). Categorization of mental disorders between "mild to moderate" or "moderate to severe" may create a certain confusion, some studies group differently the severity of symptoms. Classifications of severity may also depend on various scales and denominations across countries guidelines and studies. Even if some scales are more often referred to, like the self-reported Beck Depression Inventory, (BDI), the Hamilton Rating Scale for Depression (HDRS, HRSD or HAM-D) to measures depression in individuals before, during and after treatment, or the EQ-5D, a non-disease specific instrument for describing and evaluating health-related quality of life.

Another limitation comes from the lack of a precise reference guideline in the French context to guide mental health practitioners in the treatment of depressive disorders, alike the UK National Institute for Health and Care Excellence (NICE) guidelines[33]. We had to palliate for

[33] https://www.nice.org.uk/search?q=Depression%20in%20adults:%20treatment%20and%20management accessed June 13th 2023

this by creating clinical scenarii under Dr Brunn's directions, based on existing care consumption databases (Morvan et al., 2007). These scenarii will be assessed by a peer panel before scientific publication.

One may ask about the number of outpatient visits (GP and Psychiatrists): would this scenario be applicable equally to patients in rural and urban areas? Expectedly, the further a health practitioner is from a patient, higher the chance that not all appointments be respected. In that sense, our scenarii may apply more swiftly to urban contexts, unless we would apply a lower percentage of recourse as well for GPs during a treatment, to account for it.

In the calculation of the average distance to a GP or a psychiatrist (Coldefy et al., 2011), postal codes were used as reference, not the actual patients who did consult, based on a Social Insurance database. This may modify considerably the average distance: patients may not always visit the closest practitioner. Health practitioners in the near distance may not be always available to potential patients. This is an important limitation. However, access to patients' databases, reasons of consultation and distance to a health provider would be most probably subject to ethical approval, which was not realistic in the context and timeframe of this project.

A last limitation comes from the use of Switzerland as a reference for a primary health care service: organization of services may differ with France, as well as sources of energy supply. Those variations are not accounted for until now in our work. We also did not account for the possible variation of transport means between rural and urban areas. As such our results, - based on 100% of private car use - are probably on the highest end of the spectrum.

Some data used in our calculations is not always aligned on the same year (2020, 2022…) which creates an internal heterogeneity that we should later correct. We could also ask ourselves if using indiscriminately Covid years in these calculations may not hamper the integrity of our results. For instance, the number of patients hospitalized in 2022 for a moderate depressive episode may be artificially inflated by the consequences of Covid pandemic.

Qualitative Research

One first important limitation is the selection of respondents. Since there was no search for exhaustivity, the panel of respondents is biased: a selection of people having a role in the health system in different positions and organizations, interested and involved in the debates about sustainability. A second limitation was the very limited proactive participation of a few key governmental institutions. The expected release of an important roadmap in the weeks following the workshop prevented several other actors to participate. A third limitation is related to the use of the analytical framework to analyze a situation still unfolding. If it helps to organize propositions from respondents, it lacks a methodology to analyze the outcome, particularly when the outcome is not yet an historical fact to analyze retrospectively.

Discussion

The contribution of this work was to investigate how sustainability can be integrated into health system decision making and policy. Through the introduction of an environmental parameter into health economics, we proposed - to our knowledge for the first time in France - a process-based calculation of the carbon footprint of 3 treatment options to address moderate depressive disorders. Finally, through social science lenses, we portrayed some of the issues at stake in 2023 when considering the transition towards a more sustainable health system in France, in the eyes of a group of decision makers, representatives of professional associations or members of the academia.

Could Carbon Footprint limit the scope of health systems' transition?

In most publications (89%), the absence of a clear definition of what is considered a sustainable healthcare system seem to allow the implicit choice of the measure and the method. The climate crisis is often presented as overwhelming evidence for the system to transition towards decarbonization. Decarbonizing meets growing civil society movements demands in high income countries.

However, if carbon footprint represents the tip of the iceberg of the overall pollution of the health system, why delaying actions to address its full environmental footprint? Several publications discuss the "Do no harm principle" in this context. How can we justify that the Pandora box be opened to address solely global warming? Several other impacts prove to be harmful to humans, and to all beings on the planet. Air pollution, water pollution, over consumption of raw resources, medical waste. Health systems have a clear responsibility in preserving planetary health (Lenzen et al., 2020).

This highlights two important issues. A first issue is about equality. Higher-income countries also have the largest health system Carbon Footprint, and the heavier per capita Carbon Footprint (Eckelman & Sherman, 2016). Are these systems ready to address their own excesses?

Second issue, when looking at wider environmental impacts, some health systems may have other top priorities. Netherlands report land use as the impact number one from the health system (Steenmeijer et al., 2022). With a clear deficit of publications coming from low- and middle-income countries (LMICs), the question of a worldwide priority of the Carbon Footprint for health systems is legitimate to ask. For instance, the public health impact of medical waste in some LMICs may be a top priority? Without measure, we may not see it.

However, a challenge may come from the complexity to measure wider environmental impacts, as well as to communicate about it, to steer a change. If already a 16 impacts measure is complicated to assemble for pharmaceutical companies using LCAs, how complex

it may be to calculate at the level of a system? How much resources are needed to do so? Is it affordable for all countries? To conclude this point, is there a risk that Carbon Footprinting would become a useful tool to do something without doing it all? Is there a risk that a priority would become the sole priority, while other sources of harmful - if not deadly - pollutions be left aside? This is what suggest the number of publications (61%) focusing on Carbon Footprint, living aside other sources of pollution, particularly at system level, when LCAs are far more complex to run. Alternatively, is Carbon Footprinting an occasion to address the urgency of curving human pollution, while linking this action with other actions to reduce health systems negative impacts on planetary health? This is what suggest the most recent publications alerting on this point (Lenzen et al., 2020) (Steenmeijer et al., 2022). We may expect new publications on the topic of sustainable health systems to stress this point, As well as the richest systems to promote wider measures than Carbon Footprint, while the global warming crisis is being addressed.

Could carbon footprint change the clinical decision tree?

Will the equation faced by health providers change, considering the introduction of an information about the Carbon Footprint of a treatment? If today a doctor may consider a simple balance between patient health benefits & treatment cost (or medical investigation cost), could we see tomorrow this equation be modified by environmental considerations? During May 3rd 2023 workshop this question was somehow avoided by reducing the equation to its simplest possibility: two treatments have equivalent efficacy (or even efficiency), and a health provider or regulator just needs to choose between the lowest Carbon Footprint of the two.

But what we started to see while working on the integration of the Carbon Footprint into a health-economic model is that there is a far more complex equation baseline:

- Treatments have different efficacy
- Treatments have different costs
- Treatments have different Carbon Footprint

The best-case scenario of an alignment between the three (highest efficacy, lowest price, lowest Carbon Footprint) may not always happen. If the equation was simple enough with two factors only (efficacy versus cost), adding a third dimension will make it only more complex. This could explain the reaction of some doctors, as mentioned by a workshop participant: "*decarbonization issues are to prevent prescribing".*

From the payer's perspective, the equation may be simpler to resolve with a population perspective. Calculations help to theoretically solve the equation: one treatment should be preferred because more efficient, less costly, less carbonized. This is what the works on the Markov model shall tell.

At individual level, in France, particularly in the context of the liberal practice of medicine, how will this equation be solved, if not embedded in the tariffication as proposed during the workshop? Will it be enough to promote a greater transparency of the environmental footprint of medical products, or to publish good practices guidelines in order to change the behavior of health practitioners? Will it be enough to self-regulate patients worried about their own health, not to require an additional investigation? Not only because of its price, but because of its environmental footprint? We may expect difficult negotiations in the field for frontline practitioners.

As a perspective, we could say that disclosure of the carbon footprint of products and services may be an easy initial step, since it's already requested by a number of health practitioners, as well as a few patients.

The next step will be to find a way to integrate the pollution generated in the equation patient-provider-payer. Putting unnecessary pressure on a patient to decide if a treatment is worth of, because of its carbon footprint would be ethically problematic. However, the same limit given to unnecessary investigations could be aimed for. Issues around end-of-life care may however be always problematic. Making sure a provider is managing reasonably its carbon footprint could be a legitimate expectation, as much as it is already implemented by the system, in terms of cost control. Will some pooling systems of carbon credits help to cater for individual situations, while keeping the overall balance of a chain of services? Most probably, the funding mechanisms already experienced in the health system will be of use, to integrate an environmental footprint compensation.

Conclusion & Recommendations

Throughout this work, we considered how environmental footprints of health systems could be accounted for, with sustainability as a goal. Despite a lack of consensual definition, decarbonization of the sector appears a converging objective, amidst growing global warming threat.

We saw the importance of Carbon Footprint methods to benchmark the health industry with other sectors. Carbon Footprint also allows comparisons of products, services, health structures and systems. However, standardization stays a work in progress. Without it, comparisons risk to be unreliable.

Other methods promote multi-impact indicators to assess the environmental sustainability of health systems. They capture more environmental threats, but their downside is to be complex to deploy, and to operationalize.

Carbon Footprints are more straightforward. While facing intense pressure to change fast, the probability is high that the simplest & most operational indicator will have a preeminent role to influence transition priorities.

It became evident when integrating an environmental parameter into a health-economic assessment: the exercise was complex enough with only one environmental dimension. The decision triangle seemed complex enough for patients and health providers (health benefit, cost, carbon footprint).

Our qualitative study in France gave an illustration of the multiple challenges that transitioning a health system creates. If the simplest available solutions are more likely to be adopted, it will not downsize these challenges at all. Decarbonizing will already by a very complex task.

A dimension we did not explore enough in this study is the plasticity of the Carbon Footprint indicator. CO_2 can account for a large span of activities involving energy consumption, beyond just Carbon. Several publications use a Carbon equivalent indicator (CO_2e). This could be a middle way to account for more sources of pollution or resources extracted.

However, there are strong reasons why public health & planetary health advocates should keep supporting wider environmental impacts to be accounted for. Particularly if the objective is to approximate as close as possible the real impacts of health systems on the planet. Advocates may tactically accept that a proxy indicator serves a short-term operational objective to limit global warming and embark decision makers on board, assuming this is the most urgent crisis. But if we want to make health systems environmentally sustainable, we will have to find a way to address all threats to planetary health, efficiently and concomitantly.

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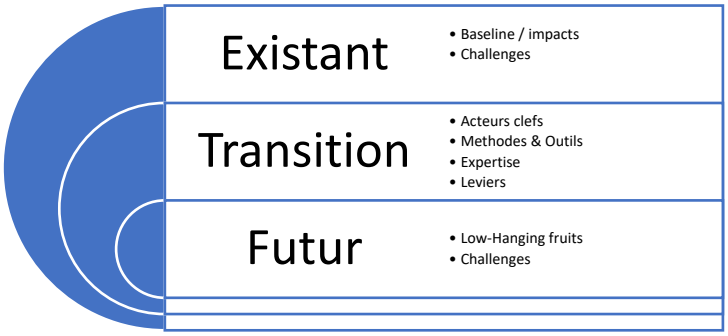
List of appendices

I. Sample Interview guide (Qualitative Study)

II. Shiffman & Smith Framework / Mind Map results.

I. Soutenabilité environnementale du système de soins français.

Recherche qualitative. INTERVIEWS Semi-structurés – EHESP – Mai 2023



EXISTANT	**Objectif**	**Question**
1	Identifier les impacts environnementaux problématiques, source de risque dans le système de soins	Quels impacts environnementaux vous semblent une source de risque à court, moyen et long terme dans le système de soins en France ?
TRANSITION	**Objectif**	**Question**
2	Identification des acteurs clefs	Quels sont les acteurs clefs qui jouent ou pourraient jouer un rôle dans la mitigation de ces risques liés à la dégradation de l'environnement?
3	Identification des méthodes et outils en place ou à mettre en place	Quelles méthodes, quels indicateurs, ou quels outils existants vous semblent les plus pertinents pour susciter un changement des pratiques en vue d'une plus grande soutenabilité environnementale ? Quels méthodes, indicateurs ou outils pourraient dans le futur aider à une accélération de la transition ?
4	Identification de l'expertise	Où trouver l'expertise nécessaire afin de faciliter la transition vers un système de soin plus environnementalement durable ?
5	Identification des leviers	Quels sont les leviers qui vous semblent les plus efficaces pour susciter une accélération de la transition vers un système de soins plus durable ?
FUTUR	**Objectif**	**Question**
6	Identification des "low-hanging fruits"	Quels sont, selon vous les changements bénéfiques à l'environnement les plus faciles et rapides à obtenir dans le système de soin actuel ?
7	Identification des principaux challenges	Quels sont au contraire les éléments du système de soin qui vous semblent les plus difficiles à changer, et pourquoi ?

II. Shiffman & Smith mindmap results

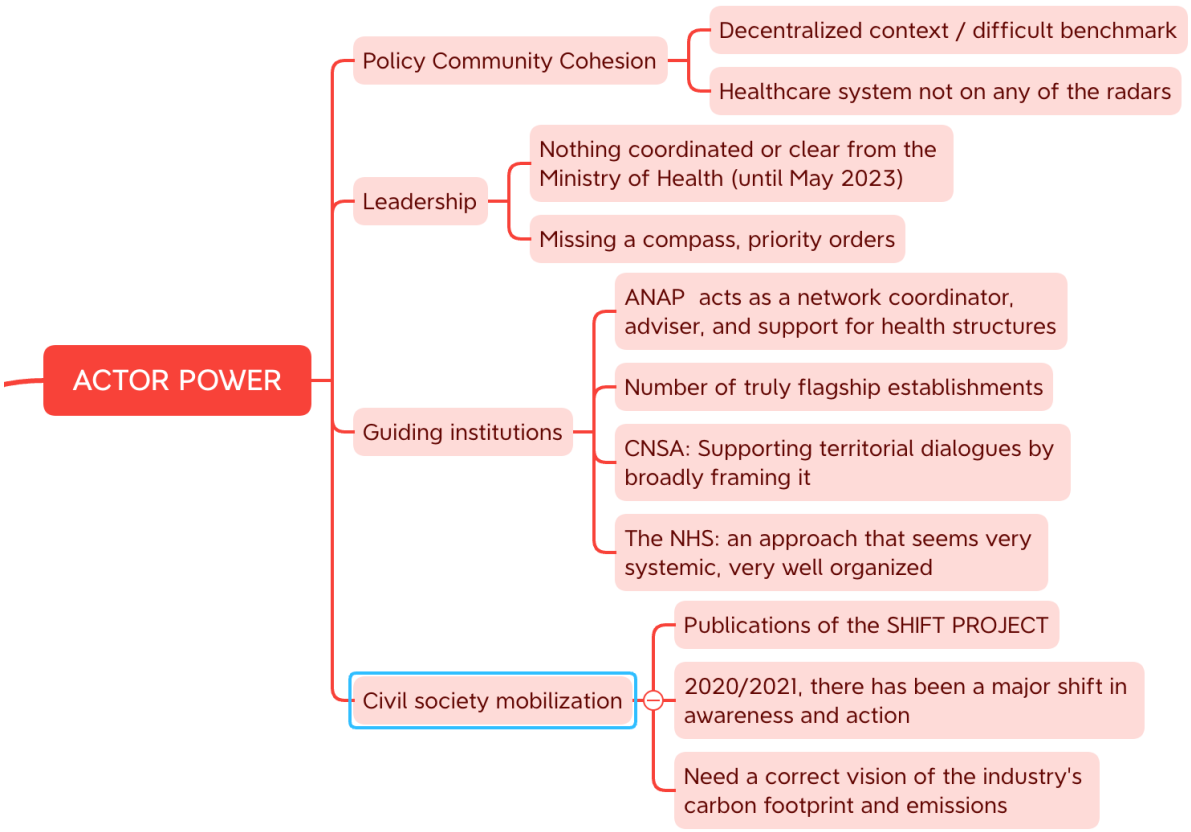


Figure 9 - Shiffman & Smith Framework Result - Zoom into Actor Power

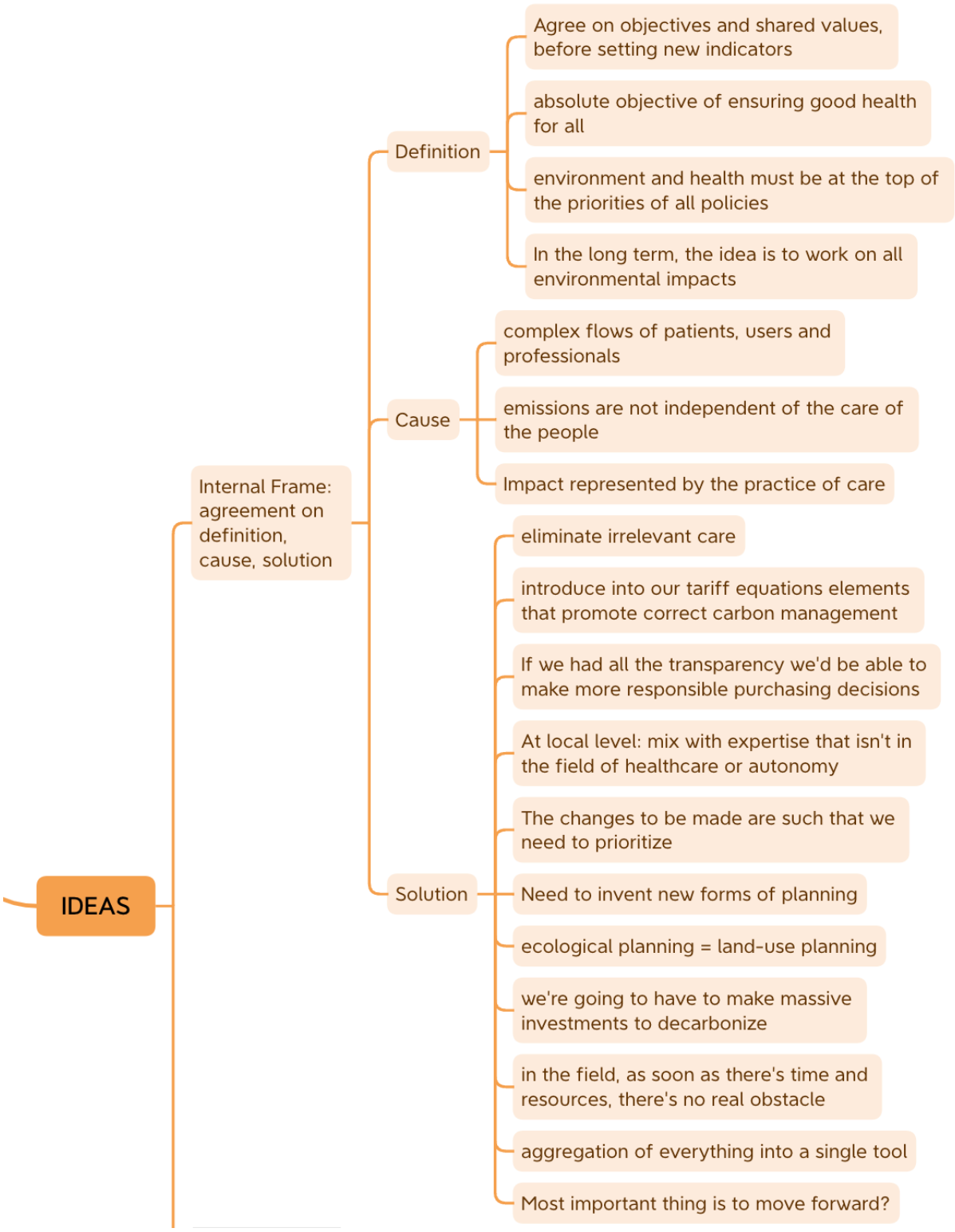


Figure 10 - Shiffman & Smith Framework Result - Zoom into Ideas (Internal Frame)

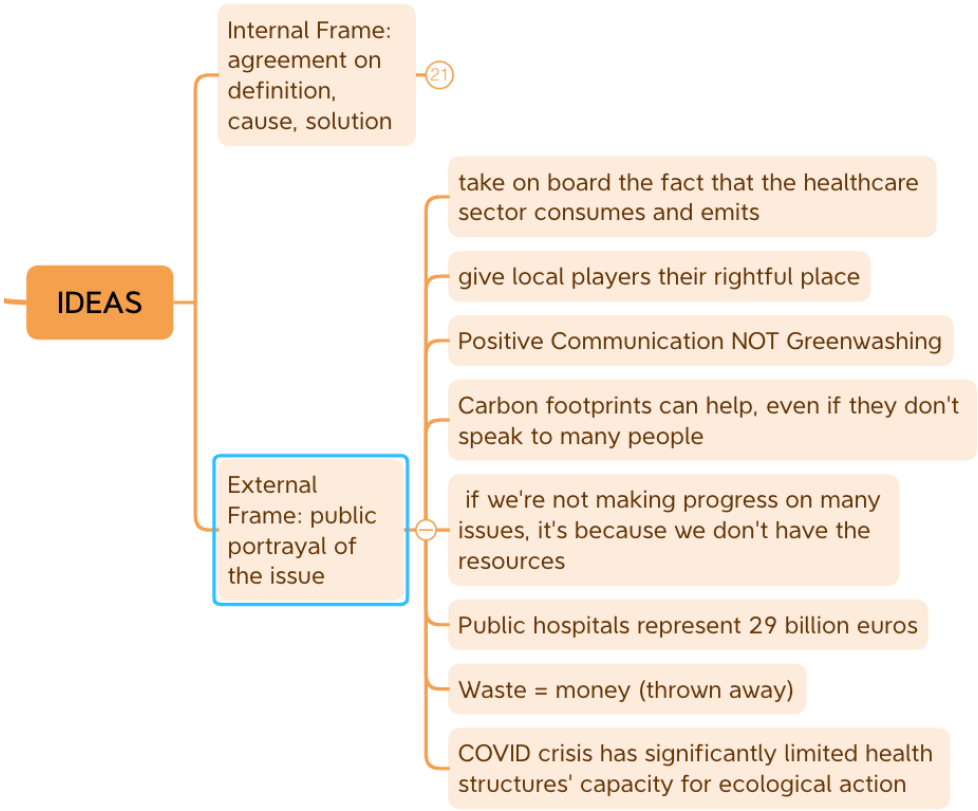


Figure 11 - Shiffman & Smith Framework Result - Zoom into Ideas (external Frame)

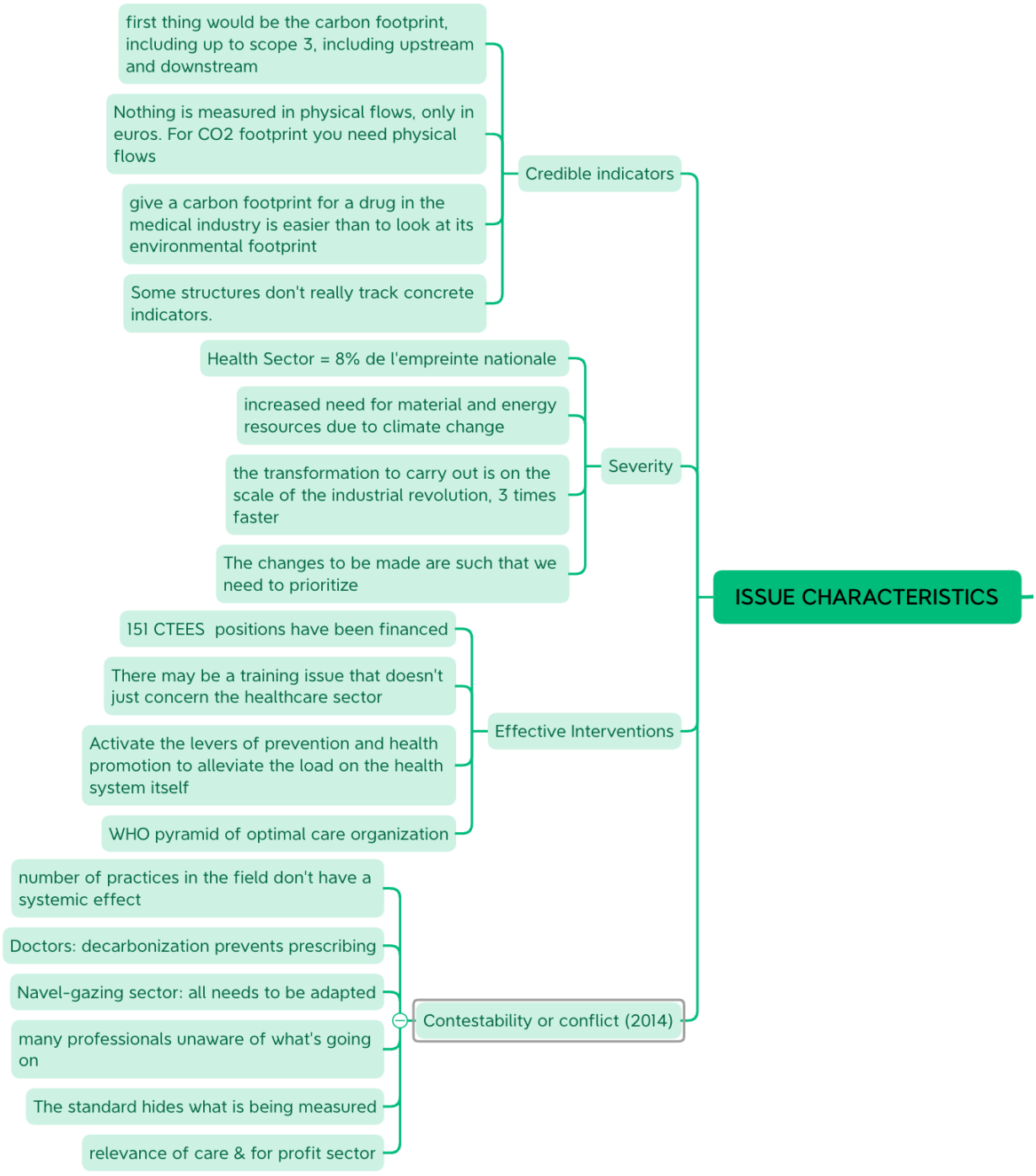


Figure 12 - Shiffman & Smith Framework Result - Zoom into Issue Characteristic

Abstract in French / Résumé

Contexte

Jusqu'à récemment, la responsabilité des systèmes de santé dans l'altération, l'épuisement ou la pollution des ressources mondiales n'était ni présentée ni discutée. Cependant, au travers des vifs débats autour du concept de santé planétaire, il a été démontré que les systèmes de sante santé font à la fois partie du problème et de la solution et qu'ils vont devoir s'adapter aux besoins environnementaux (Lenzen et al., 2020).

Méthodes utilisées

Une méthodes mixte a été utilisée. Un revue de littérature (Scoping) pour évaluer la manière dont les chercheurs présentent la durabilité du système de soins de santé. Une évaluation médico-économique pour comprendre comment l'empreinte carbone pourrait être intégrée dans l'évaluation des technologies de la santé. Une analyse qualitative pour analyser les déterminants de la priorité politique en France.

Résultats

89% des articles scientifiques traitant de la transition environnementale des systèmes de santé, entre 2021 et 2023, ne font référence à aucune définition des soins de santé durables. Seuls 33% des articles ont une définition logiquement corrélée à une méthode d'empreinte écologique. 61 % des articles présentant des données primaires utilisent les gaz à effet de serre (GES) comme principale mesure de l'impact environnemental. Cela tend à montrer l'utilisation prééminente de l'empreinte carbone comme mesure de l'impact environnemental au cours des deux dernières années. Les résultats préliminaires de l'évaluation économique de la santé suggèrent que les traitements des troubles dépressifs modérés en France représentent 107 kg de CO2 pour un épisode d'une année par patient traité par pharmacothérapie, 184 kg de CO2 pour une psychothérapie et 328 kg de CO2 pour une thérapie combinée. En ce qui concerne la prise de décision, le contexte dans lequel les déterminants politiques se déploient ne semble pas encore tout à fait mûr ou aligné pour une appropriation politique forte et une action en faveur d'un système de santé plus durable en France. Cependant, une meilleure convergence des intentions de transition du haut vers le bas, avec les ressources disponibles, une plus grande participation de la société civile, des initiatives du bas vers le haut et des dialogues territoriaux pourraient ouvrir la voie à un processus itératif positif vers la construction d'un système plus durable.

Interprétation

Les activistes de santé publique peuvent tactiquement accepter que l'empreinte carbone, un indicateur indirect, serve un objectif opérationnel à court terme visant à limiter le

réchauffement climatique et à convaincre ainsi les décideurs d'agir. Mais si nous voulons rendre les systèmes de santé écologiquement durables, nous devrons trouver un moyen de faire face à toutes les menaces qui pèsent sur la santé de la planète, de manière efficace et concomitante.