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Calculating the environmental impact of the **Dutch healthcare sector**

Method report

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M. van Bodegraven et al.

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Synopsis

Calculating the environmental impact of the Dutch healthcare sector

Method report

The healthcare sector in the Netherlands emits greenhouse gases, for example, through energy use required to heat hospitals, the use of anaesthetic gases, and the production of medicines. Healthcare-related emissions account for approximately 7% of the total emission of greenhouse gases, both in the Netherlands and abroad. Reducing emissions in the healthcare sector contributes to achieving Dutch climate goals. To lower these emissions it is essential to identify which healthcare sectors have the greatest environmental impact.

For a more precise understanding the RIVM has enhanced its method for calculating the environmental footprint of healthcare. In addition to climate impact this method looks at wider environmental effects, relevant to the circular economy and biodiversity. The previous method (2022) provided useful insights but lacked details or granularity per healthcare sector and product group. Additionally, it could not be used for repeated calculations of environmental impact. The improved method addresses these limitations, offering policy makers and healthcare professionals better insights into the environmental burden of different healthcare sectors.

The new method consists of two models. The basic model can be used immediately and provides an overview of how different healthcare sectors contribute to the environmental impact. The specific model offers more detailed insights into the contributions of specific product groups and services. The data required for this model is highly fragmented and found across multiple organisations.
Close collaboration between healthcare organisations is crucial for obtaining and centralising the required data. Additionally, standardised data collection is essential to ensure comparability across different sources. The RIVM will work with healthcare professionals to discuss these challenges and will conduct pilot projects to refine data collection.

The RIVM developed the improved method at the request of the Ministry of Health, Welfare and Sports (VWS).

Keywords: environmental footprint, healthcare sector, sustainability and health, sustainable healthcare, climate change, circular economy, biodiversity

Publiekssamenvatting

De berekening van het effect van de Nederlandse zorg op het milieu

Methoderapport

De zorgsector in Nederland stoot broeikasgassen uit, onder meer door energieverbruik om ziekenhuizen te verwarmen, door het gebruik van narcosegas en door de productie van medicijnen. Van alle sectoren in Nederland draagt de zorgsector voor zo'n 7 procent bij aan de totale uitstoot van broeikasgassen. Om de uitstoot te kunnen verlagen, is het belangrijk om te weten welke onderdelen het milieu het meest belasten.

Het RIVM heeft een betere methode gemaakt om preciezer te berekenen hoe de zorg het milieu belast. Het RIVM kijkt hierbij niet alleen naar het effect van de zorg op het klimaat maar ook naar andere milieueffecten, zoals het gebruik van water, grondstoffen en land. Deze milieueffecten hebben invloed op bijvoorbeeld de biodiversiteit.

De oude methode (2022) gaf nuttige inzichten, maar te weinig details per sector in de zorg en per productgroep. Ook kon de methode de berekening van de impact op het milieu niet herhalen. De vernieuwde methode kan dit wel, en geeft beleidsmakers en zorgprofessionals zo meer inzicht in de milieubelasting van de zorg. Nationaal en internationaal, zoals vanuit de WHO, is er belangstelling in deze aanpak.

De nieuwe methode is in twee modellen opgedeeld: het basismodel en het gespecificeerde model. Het basismodel kan meteen worden gebruikt en geeft in een overzicht van hoeveel de sectoren in de zorg het milieu belasten. Meer informatie is nodig voor een gedetailleerder beeld van de milieueffecten door productgroepen en diensten. Dit kan met het gespecificeerde model. De informatie die daarover nodig is, is bij veel verschillende instanties beschikbaar en daardoor sterk versnipperd.

Het is daarom belangrijk dat zorginstellingen gaan samenwerken om de gewenste details te krijgen en centraal te verzamelen. Ook is het belangrijk dat gegevens op dezelfde manier worden vastgelegd, zodat ze beter met elkaar kunnen worden vergeleken. Het RIVM gaat in gesprek met zorgaanbieders en inkoop organisaties hoe dit zo efficiënt mogelijk kan worden gedaan en dat in pilots uitproberen.

Het RIVM heeft de methode in opdracht van het ministerie van VWS verbeterd.

Kernwoorden: milieuvoetafdruk, zorgsector, duurzaamheid en gezondheid, duurzame zorg, klimaatverandering, circulaire economie, biodiversiteit

Contents

Summary

Background

The Dutch care and welfare sector accounts for 7.3% of total greenhouse gas emissions (in carbon dioxide equivalents, CO2-eq) from the consumption of products and services in the Netherlands (Steenmeijer et al., 2022). Due to the international nature of supply chains, these emissions – and other environmental impacts – take place both within and outside the Netherlands. By reducing its environmental footprint, the care sector can make a significant contribution to achieving the national targets in the fields of climate, biodiversity and the circular economy (Ministry of Health, Welfare and Sport et al., 2022).
A good understanding of its footprint can help the sector maximise this contribution. To that end, it is important to identify environmental impact hotspots, prioritise sustainability measures and monitor the progress made. These calculations also help to strengthen communication on the urgency of sustainability measures, and they support existing sustainability initiatives.

In recent years, RIVM has built a knowledge base regarding the environmental footprint of the Dutch care sector and has developed a phased approach to calculate that impact (the '2022 method'; Steenmeijer et al., 2022). While this method offers valuable insights, it has certain limitations. These include a lack of detail or granularity per type of provider and product group, the use of non-current data and the absence of a clear methodological and model structure for periodic calculations and recalculations. To address these shortcomings, the Ministry of Health, Welfare and Sport asked RIVM to improve the method. This will help the healthcare sector and policymakers identify the specific product groups and services which, per type of healthcare provider, have the greatest environmental impact.

Approach

Efforts to reduce and quantify the environmental footprint of the Dutch care sector are impeded by the complexity and fragmentation of the associated data landscape. As a result, mapping out the environmental footprint for each type of healthcare provider (henceforth called sub-sector) calls for a substantial research effort.

For pragmatic reasons, the revised methodology (the '2024 method') has therefore been divided into a basic model and a specific model. Following some crucial improvements compared with the 2022 method, the basic model is able to periodically calculate the environmental footprint per sub-sector, but only at an aggregated level. For the desired granularity, such as the impacts of specific product and service categories, we need the specific model. This requires close collaboration with actors in the field to collect and process the required data. The basic model can be implemented almost immediately. The specific model takes more time, due to the level of collaboration required. Since the two model options are complementary, the additional research required

for the specific model can be carried out in parallel with calculations for the basic model.

The basic model and the specific model

The *basic* model calculates the environmental footprint of the care sector on the basis of data from national databases and monitoring initiatives, applying a combination of bottom-up and top-down methods. For direct environmental impacts, such as greenhouse gas emissions and waste generation, the model uses data measured at the level of individual organisations. Data originates from existing monitoring initiatives as much as possible, including theme-based monitoring of theme 3 of GDDZ 3.0 by the Centre of Expertise for Sustainability Measures in Healthcare (EVZ), the AMICE waste registration database of Rijkswaterstaat and mobility monitoring by the Netherlands Enterprise Agency (RVO). For indirect environmental impacts, such as emissions generated in the production and supply of care-related goods and services, the model uses financial data (operating costs) from the annual healthcare accountability report (Jaarverantwoording Zorg). Through input-output analysis (EE-IOA), these publications are linked to the key environmental indicators from the PBL-FIGARO MRIO database to calculate the environmental impact of the care supply chain. The PBL-FIGARO database contains accurate data that is updated regularly. This is an improvement compared with the previous EXIOBASE database, providing better insight into the environmental impacts of industry categories that are relevant to the care sector, such as the pharmaceutical industry.

Going beyond the aggregated insights produced by the basic model, the specific model focuses on a further breakdown of the environmental footprint into product groups and services. To that end, care providers' financial expenditures have to be linked to the corresponding environmental data of products and services, such as pharmaceutical products, medical aids and food supply, with a high level of detail. For that, we need data from the financial records and procurement systems of healthcare organisations. Obtaining such data is a complex exercise, given the absence of a standardised system for the classification of products and services in the care sector, and the considerable differences between care providers in terms of their operational management.
For this reason, the specific model comprises a study into the usability of existing data of sector associations and procurement organisations, such as the Dutch Federation of University Medical Centres (NFU) and Intrakoop. Additionally, the possibilities for a representative sample among care providers are being studied with a view to direct data collection. While this method provides more accurate insights, it also requires more intensive collaboration with the sector.

Limitations

Since input-output analysis is a top-down macroeconomic method, small-scale sustainability interventions are not always visible in the results. In a cost-based method, the often more expensive sustainable products, potentially result in a higher environmental impact, even if this effect is compensated in part in the specific model. Moreover, this

approach does not reflect the countless changes within and outside the care sector that can affect environmental impacts, such as an ageing population, staff shortages and digitalisation. This is why this and similar methods, are unsuitable to establish causal links between sustainability interventions and environmental impacts.
As a result, it is difficult to quantify the effect of specific policy interventions or sectoral agreements.

Execution and implementation

To address these limitations and enhance the reliability of the results, cooperation with healthcare organisations is essential. There is a growing need for environmental data, fuelled in part by new regulatory requirements and the increasing involvement of care providers in sustainability efforts. This is why RIVM aims to promote collaboration within a broad network of care and knowledge institutions so as to further refine the method and enhance data availability. To explore the availability and usability of data, a preliminary study will begin in Q1 2025 involving various parties, including sector associations and government agencies. A test phase in Q3 2025 will show us how data can be gathered, harmonised and processed. The final results will be published in 2026.

The revised methodology provides a solid base for monitoring the environmental footprint of the Dutch care sector. During implementation, the practice of not only retrieving data but also exploring ways of returning it to care organisations will help to further improve the methodology. Collaboration, improvement of data quality and data sharing are key ingredients of this approach. By working according to these principles, the methodology will promote the transition to a climate-neutral and circular care sector in the Netherlands.

1 Introduction

The Dutch care and welfare sector accounts for 7.3% of all greenhouse gas emissions (CO_2-eq) from the consumption of products and services in the Netherlands (Steenmeijer et al., 2022). These emissions, as well as other environmental impacts (see Table 1), occur both within and outside the Netherlands, since part of the care products and services are produced abroad. By reducing its environmental footprint (in other words, all environmental impacts combined), the care sector can make a significant contribution to achieving the national targets in the fields of climate, biodiversity and the circular economy (Ministry of Health, Welfare and Sport et al., 2022).

Table 1 Environmental footprint of the Dutch care sector in 2016 (Steenmeijer et al., 2022).

Environmental impact category	Share of care sector in national consumption footprint
Climate change (kt CO_2-eq)	7.3%
Abiotic use of raw materials (kt)	13.0%
Freshwater consumption (mm^3)	7.5%
Land use (km^2)	7.2%
Waste generation (kt)	4.2%

Under the leadership of the Ministry of Health, Welfare and Sport, various parties within and representatives of the Dutch care sector joined forces and signed agreements on making the sector more sustainable. This resulted in the first *Green Deal – Working Together for a Sustainable Healthcare Sector*, in 2015. The third Green Deal Sustainable Care (GDDZ 3.0) was launched on 4 November 2022 (Ministry of Health, Welfare and Sport et al., 2022). This third version of the deal contains the following targets, focused on reducing the environmental footprint of the Dutch care sector:

1. Reducing CO_2-eq emissions. Targets: a 55% reduction by 2030 (relative to 2018) and climate neutrality in 2050 as regards energy consumption in the sub-sectors real estate and transport. Interim target: 30% reduction in CO_2-eq by late 2026 relative to 2018.
2. Reducing the use of primary materials. Targets: 50% reduction by 2030 and 100% circular working processes in the care sector by 2050. Interim target: at least 20% of all medical aids to be reusable by 2026.
3. Reducing the environmental burden caused by (the use of) medicines.

Furthermore, during the international UN climate summit in Glasgow in 2021 (the *conference of parties* or COP26), the Ministry of Health, Welfare and Sport pledged to develop initiatives promoting a resilient and sustainable healthcare sector (WHO, 2021). Those initiatives include the regular monitoring of the environmental footprint and supporting the development of sustainable and low-emission supply chains for the care sector (National government, 2021).

Environmental footprint method for the care sector

Since 2019, on behalf of the Ministry of Health, Welfare and Sport, RIVM has worked on building up a knowledge base regarding the environmental footprint of the Dutch care sector. RIVM has developed a method for the step-by-step calculation of various environmental impacts of the care sector (Steenmeijer et al., 2022). The results of the study in 2022 (hereinafter referred to as the '2022 method') have improved our understanding of the environmental impacts of the care sector and have generated key indicators that are often quoted in support of sustainability initiatives in this sector.

Even so, the 2022 method involves several limitations that reduce its potential to support sustainability interventions in the care sector. The problem is that the results are general and aggregated. At the present stage, it is not yet possible to map out the environmental impacts of specific types of providers, such as hospitals and medical practices, or of specific product groups, including food, chemicals and pharmaceuticals. This makes it difficult to prioritise specific sustainability interventions. Additionally, the environmental impact calculations rely on a database that includes estimates based on historical data. For these reasons, this method is not deemed suitable for calculating an up-to-date sectoral footprint. What is also lacking, moreover, is a methodological structure to enable periodic calculations.

Assignment

This is why the Ministry of Health, Welfare and Sport asked RIVM to update and improve the environmental footprint calculation method. According to RIVM, the method should have the following objectives:

1. identifying environmental hotspots within the care sector with the greatest potential for sustainability measures;
2. supporting the effort to prioritise sustainability measures;
3. developing key environmental indicators for the care sector; and
4. contributing to monitoring progress towards a more sustainable care sector.

To help achieve these main objectives, several secondary objectives have been formulated that establish the preconditions for the method:

1. The data used must reflect specific time periods so as to make it possible to monitor developments between the various reporting periods.
2. Additionally, the continuity of the method must be guaranteed to enable consistent evaluations over time.
3. Also, the results should reflect sector trends, which calls for a sufficient level of detail in both the data and results (i.e. improving granularity of the data).

The end result of this development process is a revised method, known as the 2024 method, which should preferably be implemented every two years in alignment with other monitoring activities within the GDDZ 3.0 framework and the overarching monitoring task of the Sustainability and Health programme (Ministry of Health, Welfare and Sport, Directorate for Macro-economic Issues and the Labour Market (MEVA)).

Approach

To arrive at the environmental footprint measurement method introduced in this document, we explored several paths of improvement on the basis of the recommendations in the 2022 method (Steenmeijer et al., 2022) and held a series of interviews with experts and data administrators. These include research teams of Statistics Netherlands (CBS), the PBL Netherlands Environmental Assessment Agency and Rijkswaterstaat (RWS), as well as individual researchers from the Leiden Institute of Environmental Studies (CML) and the Netherlands Association for Hospital Pharmacists (NVZA). Discussions were also scheduled with experts from centres of expertise in the field of care, including the Centre of Expertise on Sustainability Measures in the Care Sector (EVZ) and the Environment Platform for the Care Sector (MPZ), and with care procurement organisations such as Intrakoop and the Dutch Healthcare Procurement Network (ZINN). To verify opportunities, various care providers have been contacted, mostly during events and in the context of regular consultation between care providers. Knowledge and experiences have been shared with the Green Deal Sustainable Care 3.0 working group, and with representatives of international research teams via conferences and workshops at the World Health Organization (WHO) and the Organisation for Economic Cooperation and Development (OECD).

Reading guide

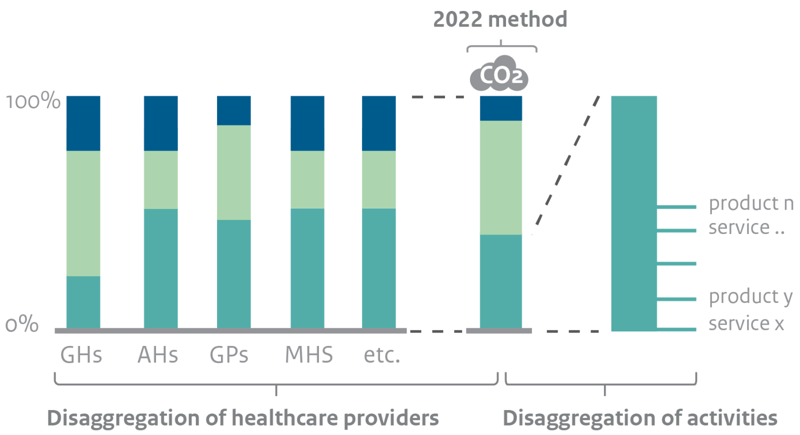
This report consists of four chapters, which together constitute the monitoring plan but also elaborate on the opportunities to improve the existing methodology. While the chapters build on one another, they can also be read independently. Chapter 2 is concerned with delineating the scope of the assignment. Next, chapter 3 presents an introduction on and an overview of the revised method. Chapter 4 contains a detailed description of the various components of the method. Chapter 5 discusses the limitations and challenges of the method and introduces initial mitigation strategies . The chapter ends with a discussion of plans for a follow-up and for the implementation of the method.

2 Scope of the assignment

This chapter explains the difference between the scope of the 2022 method and that of the revised 2024 method. This is important, as the new method, besides introducing substantive adaptations, also has broader ambitions, meaning that the definitions and scope formulated for the 2022 method no longer suffice. While the 2022 method provided insight into the environmental footprint at sectoral level, the 2024 method zooms in on a more detailed analysis per *sub-sector* (§ 2.1) and per *activity category* (§ 2.3). This enables an estimation of specific environmentally harmful processes, thus providing more valuable insights for the care sector. The objective of the 2024 method is illustrated in Figure 2.1.

The scope is determined at four levels: The organisational boundary, or the definition of the Dutch care sector and the included sub-sectors (§ 2.1), the impact boundary, or the chosen environmental themes and analysed environmental impacts (§ 2.2), the operational boundary, meaning the definitions and classification of environmentally harmful activities in the care sector (§ 2.3) and the process-related principles of the monitoring method (§ 2.4). In each case, the scope is explained in comparison with the choices made in the 2022 method.

Figure 2.1 Fictitious representation of outcomes of the 2024 method compared with the 2022 method.



2.1 Organisational boundary: Definition of the Dutch care sector

In the 2022 method, the calculation of the environmental footprint of the Dutch care sector was based on a broad definition of the sector, which included both care and welfare. This was a pragmatic choice, as it aligned with the databases used. However, this definition and the distinction between the care sector and the welfare sector in those databases meant that the environmental footprint results could not disaggregated further by classes or types of healthcare provider (henceforth called sub-sectors) – which is an objective of the 2024 method. Nor was it clear which types of care providers fell within the scope of the definition and which did not. In this section, therefore, the Dutch care sector and its various sub-sectors are each defined separately. The resulting scope is also used for the overarching monitoring task of GDDZ 3.0 assigned to RIVM by the Ministry of Health, Welfare and Sport.

The Dutch care sector comprises a wide variety of organisations focused on providing healthcare.
The sector can be subdivided in various ways, for example by using the classification based on Standard Industrial Classification (SBI) codes as established by Statistics Netherlands (CBS), and the classification according to the System of Health Accounts (SHA), coordinated by the World Health Organization (WHO). The SBI distinguishes between types of healthcare organisations in the Netherlands on the basis of their main (economic) activity. It for example separates organisations for disability care from general hospitals. The SBI is the most appropriate for the Dutch context and forms the basis for defining the healthcare sector as presented in Table 2. As can also be seen in the table, the SHA is used where necessary to further specify sub-sectors, for instance in the case of extramural use of pharmaceutical products. In addition, due to its broad international application, the SHA can be employed to enhance international comparability. The various databases consulted in this plan, such as StatLine and Eurostat, apply the SBI and SHA classifications respectively. With the revised method, the intention is to periodically calculate the environmental footprints of each of the following sub-sectors, see Table 2.

Table 2 Organisational boundary:sub-sectors in the Dutch care sector for measuring and monitoring environmental footprints. In accordance with the SBI, unless specified otherwise.

Sub-sector	Classification according to SBI and/or SHA code
Healthcare	University medical centres (86.10.1)
	General hospitals (86.10.2)
	Specialist hospitals (86.10.3)
	Residential mental healthcare and addiction services (86.10.4, 86.10.6 and 87.10.7)
	GP practices (86.21), medical specialist practices and medical day treatment centres (86.22), and dental practices (86.23)
	Practices of midwives and paramedics (86.91)*
	Other providers of non-residential healthcare services (86.92.1-3 and 86.92.9)
	Pharmacists (47.73)
Nursing, care and home care	Nursing homes (87.10.1), residential care homes (87.30.2) and home care (88.10.1)
	Disability care (87.20.0 and 87.30.1)
	Other residential nursing, care or counselling (87.10.4 and 87.10.8)*
Support	Medical laboratories, thrombosis services and other treatment support services (86.92.4, SHA HC[1]/HP[2]41, HC/HP42 and HP49)*
	Ambulance services and central clinics (86.92.5, SHA HC/HP43)
	Pharmaceuticals and other medical non-durable goods (SHA: HC 51)

Sub-sector	Classification according to SBI and/or SHA code
Outpatient use of pharmaceutical products	Therapeutic appliances and other medical goods (SHA: HC 52).

1: HP means 'healthcare provider', 2: HC means 'healthcare function'
* Due to a lack of data, the environmental footprint of these sub-sectors will be presented with a lower level of detail.

For certain sub-sectors, more specific (expenditure or activity) data than that used in the 2022 method could not be found. For these sub-sectors, which are marked with an asterisk (*) in the table, the level of detail in the calculation of the environmental footprint will be comparable to that of the 2022 method.

Depending on data availability, the possibility of aggregating other sectors into a single sector is being considered, for example nursing homes, residential care homes and home care. As such, this sub-sector (identified with the Dutch abbreviation 'VVT') contains multiple SBI and/or SHA codes. While aggregating sub-sectors saves time, it reduces the level of detail.

(Partial) exclusion of sub-sectors
In the new method, the use of SBI and SHA classifications makes it possible to distinguish more clearly between healthcare and welfare services. In the 2024 method, the scope is limited to medical and long-term care. This means that welfare services, youth care, child care and informal and community-based care (including preventive care) are excluded (Table 3). The reason for this exclusion is the limited availability and lower level of detail of data for those sub-sectors. Additionally, it is necessary to set priorities and focus research activities on those sub-sectors which, based on the 2022 method, are likely to generate the greatest environmental benefits. However, as the environmental footprint of preventive healthcare is expected to be considerable, the Ministry of Health, Welfare and Sport commissioned RIVM to study this particular contribution in a separate assignment (RIVM, n.d.).

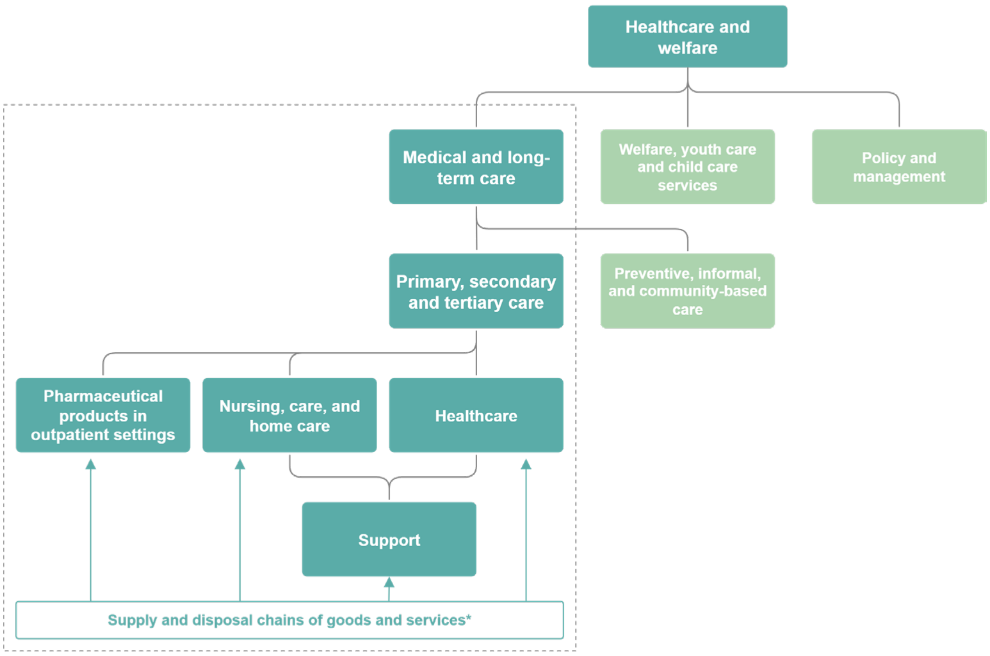
Due to the exclusion of sub-sectors shown in Table 3, the results of the new method will not be directly comparable to those of the 2022 method. For a visual overview of Table 2 and Table 3, see Figure 2.2.

Table 3 Organisational boundary: sub-sectors whose environmental footprint is not measured. In accordance with the SBI, unless specified otherwise.

Sub-sector	Classification according to SBI and/or SHA code
Welfare, youth care and child care services	Youth care and emergency accommodation, residential (87.9)
	Non-residential social services, not specifically aimed at older people and the disabled (88.9)
	Child care and playgroup services (88.91)
	Outpatient youth care, social work and advice, and local outreach services (88.99)
Preventive healthcare	(86.92.3)
Organisational management and funding	Government health administration agencies (HP71)
	Social health insurance agencies (HP72)
	Private health insurance administration agencies (HP73)
	Other administration agencies (HP79)
Other sectors	Households as providers of home healthcare (HP81)
	All other industries as secondary providers of healthcare (HP82)

1: HP means 'healthcare provider', 2: HC means 'healthcare function'

Figure 2.2 Sub-sectors in the Dutch care sector included for measuring and monitoring environmental footprints, derived from the Dutch 'nulde-derdelijnszorg' healthcare classification.



2.2 Impact boundary: Environmental themes and footprint

To calculate the environmental footprint, the 2022 method focused on three environmental themes: climate change, the circular economy and biodiversity. These themes comprise various environmental impact indicators and units, such as greenhouse gas emissions in CO_2-equivalents and the extraction of abiotic raw materials in kilotonnes (Table 4). Compared with the 2022 method, the environmental impact categories in the 2024 method have remained largely unchanged, but raw materials consumption will be extended to include the use of fossil fuels and biotic resources. This provides insight into the potential substitutions of abiotic with biotic raw materials and the environmental impacts that may result from this (Hanemaaijer et al., 2023).

Key indicators in assessing the environmental theme of biodiversity, in addition to land use and freshwater consumption, include ecotoxicity, terrestrial acidification and eutrophication (Steenmeijer et al., 2022). This applies in particular to the supply industries, such as the chemical and pharmaceutical industries and the food industry. However, owing to the absence of reliable data, it has been decided to keep these factors out of scope until more research on large-scale ecotoxicity data becomes available.

Table 4 Environmental impact indicators included in the 2022 method and the revised method.

Environmental theme	**Environmental impact indicator**	**Unit**	
		2022 method	***Adapted method***
Climate change	Greenhouse gases	CO_2-eq	CO_2-eq
Circular economy	Extraction of abiotic raw materials	kt	kt
	Extraction of biotic raw materials	x	kt
	Waste generation	kt	kt
	Waste disposal	x	kt
	Freshwater consumption	mm^3	mm^3
Biodiversity	Land use	km^2	km^2
	Freshwater consumption	mm^3	mm^3

Shift in footprint perspective
Another methodological adaptation is the shift in the analysis perspective used to calculate the environmental footprint. This has consequences for the range of data used in the analysis, and ultimately also for the level of detail of the results.

This is because, on a sectoral level, the environmental footprint can be calculated from a production or a consumption perspective (Schoenaker and Steenmeijer, 2024). A production footprint is a calculation of the environmental impacts arising from the production of goods and services, including direct impacts from the sector itself and indirect impacts from suppliers (upstream) and buyers (downstream).
A consumption footprint, on the other hand, concerns environmental impacts from the end user perspective. Itincludes both direct

environmental impacts from consumption and indirect impacts from the chain required for the supply of goods and services.

The 2022 method calculated the environmental footprint from the consumption perspective, thus reasoning from the viewpoint of care consumers and the environmental impacts driven by care spending (i.e. healthcare expenditure) and consumption. The drawback of this perspective is that spending data is only available at a highly aggregated level, making it impossible, for instance, to identify the exact products and services consumed in the provision of care. For this reason, in the revised method, the perspective has shifted from the care consumer to the care provider. This makes it possible to use the more detailed data held by care providers and other parties in the care sector, enhancing the alignment of the results with the sector perspective.

The consequences of the new production perspective in the 2024 method for the care sector's total environmental impact results are probably minor. This is because the care sector, unlike many other Dutch industries, produces almost exclusively for Dutch care consumers, who in turn almost exclusively consume care services provided by the Dutch care sector. Even so, the care sector generates types of value – for example, in the fields of academic research and education – that are not consumed directly by care consumers. Given the sustainability objectives and the scope of GDDZ 3.0, it is useful to also include those types of value in the analysis. This means that the analysis perspective of the 2024 method can be defined as follows: 'The upstream production footprint of medical and long-term care in the Netherlands'.

One exception is the outpatient use of pharmaceutical products and medical aids. This is a type of care which is consumed by care consumers, but is not produced exclusively by Dutch care providers. As regards this component, denoted by the SHA codes HC-51 and HC-52 (section 2.1), the analysis perspective from the 2022 method remains unchanged, i.e. the consumption perspective is used.

2.3 Operational boundary: classification of environmentally harmful activities

Many processes in the healthcare sector are environmentally harmful and contribute to its overall footprint. To identify and group those processes, the 2022 method used the definitions and classification of the databases consulted. However, those databases do not provide the level of detail required to specifically identify the wide variety of environmentally harmful processes in the care sector. This is why the 2024 method introduces a definition of environmentally harmful processes and uses the broader term 'activities' to clarify the role of the actors involved. The definition and classification will be further refined during the implementation of the method.

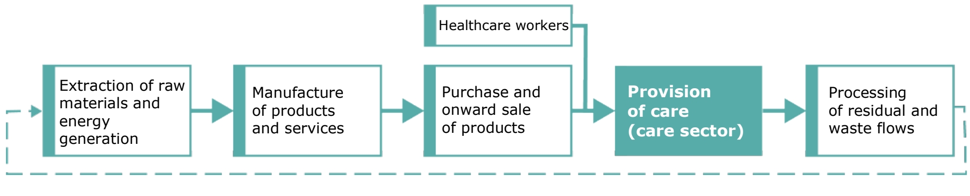
Examples of environmentally harmful activities are the extraction of raw materials and the production, supply, utilisation and processing of numerous products that are essential in the care sector. Additionally, services such as mobility, ventilation and heating contribute to the overall environmental burden. The revised method aims to identify the environmental burden of each activity as accurately as possible. The first step in this process is to define each activity and determine whether it falls within the scope of the analysis method. In this section, we discuss this process in further detail.

Direct and indirect environmental impacts
In the 2024 method, activities are subdivided into activities with direct environmental impacts and those with indirect impacts. This classification is based on definitions from previous studies (HCWH and Arup, 2019) and the Green House Gas Protocol (WRI & WBCSD, 2004). Direct environmental impacts are the impacts from activities associated with the core tasks of the care sector. Examples include emissions of anaesthetics during surgery, emissions from the combustion of gas for heating in care facilities and emissions from travel related to outpatient care. To execute its core tasks, the care sector uses products and services supplied by other sectors and/or industry categories.
The environmental impacts associated with those supply and disposal chains are in the group of indirect impacts. Indirect environmental impacts also include other activities which are crucial but do not qualify as core tasks, such as commuting and real estate maintenance.

Furthermore, within the group of indirect impacts, a distinction is made between upstream and downstream impacts. Upstream impacts occur in the supply chain of goods and services. Downstream impacts concern activities by care consumers (patients) and include, for example, the disposal of medical products or medicines in the patients' home situation. Due to methodological and practical limitations, indirect downstream impacts are largely excluded from the analysis.
One exception is the emission of propellants used in inhalers, considering their high greenhouse gas potential and the prevention options available. These emissions are included because data on their use is available (Wichers & Pieters, 2022).

System boundaries
When mapping out indirect upstream environmentally harmful impacts, the 2024 method takes account of the full life cycle of the products and services used in the care sector. This means that the environmental impacts are calculated across the entire chain, from raw material extraction to disposal of the products at the end of their life cycle (cradle to grave and cradle to cradle), as shown in Figure 2.3.

Figure 2.3 Simplified diagram of the healthcare sector and its supply chain.



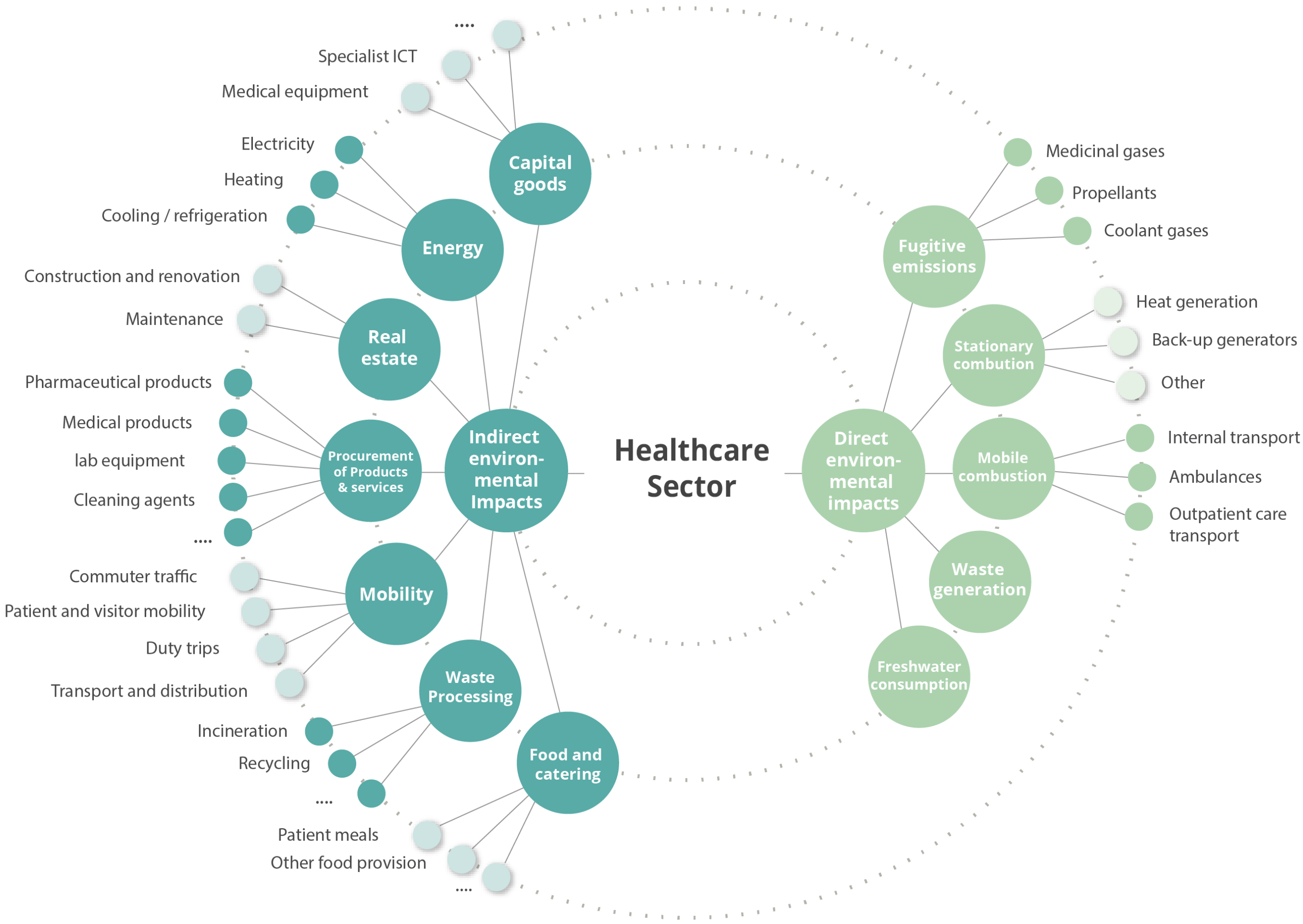
Activity categories
One challenge in footprint analysis at the organisational or sectoral level, is identifying and categorising the environmentally harmful activities (UNEP, 2014; Cimprich & Young, 2023). Identifying and

categorising those activities is necessary for the purpose of both gathering data and presenting the results in a way that is consistent with previous studies and the Dutch care landscape. Existing protocols, such as the Greenhouse Gas Protocol (GHG Protocol, n.d.) and methods from previous studies, such as those by Healthcare Without Harm (HCWH) and Arup (2019), offer only limited guidance in this regard. This is because those protocols are limited to the climate footprint, so they only concern greenhouse gas emissions. Methodological issues arise when transferring these to other environmental themes such as water consumption, waste generation and land use.

As a result, the 2024 method uses a provisional classification that is to be further developed over time. The first version of the classification of activity categories as shown in Figure 2.3 is based in part on the results and considerations from the 2022 method, plus input from interviews with experts and identified activities and categories from previous footprint analyses of UMC Utrecht (CE Delft, 2018), Erasmus MC (Metabolic, 2021) and Healthcare Without Harm (HCWH & Arup, 2019). This classification is an initial guide for data collection and presentation of the results. However, due to the complexity of the care sector and the absence of earlier studies into suitable protocols for environmental footprint analysis in the sector, it is likely that the classification will be further adapted and expanded even after implementation of the methodological improvements. This iterative process continues as the method is implemented and is carried out in collaboration with parties in the care sector (care providers and knowledge organisations, see also 5.3).

As shown in Figure 2.3, the activities are first classified on the basis of their contribution to indirect or direct environmental impacts. The ‘scales’ represent the various levels of aggregation of the activities. Level 4 (not shown) further subdivides the categories into sub-product categories (e.g. cytostatics as a medicine category), level 5 includes the individual products and services.

Figure 2.4 Non-exhaustive illustrative overview of activities that contribute to the environmental footprint of the care sector, per category.



2.4 Starting principles

Due to the complexity of the care sector, it is impossible to map out its environmental footprint in a comprehensive and detailed manner. This is why a large number of choices and assumptions have to be made. These relate to the following four starting principles:

- *Administrative burden and synergies* – To map out an environmental footprint for the sector, we need a considerable amount of data. In order to minimise the administrative burden for care providers, we aim to tap existing flows of information. Where possible, existing administrative processes are extended to serve multiple purposes.
- *Transparency and support base* – We explore opportunities in collaboration with parties in the field and are transparent about methodological choices and the possibilities and impossibilities of the approach.
- *Bottom-up versus top-down methods* – Where possible, specific activity- or spend-data from the care sector (bottom-up) is preferred over spend-data from national statistical offices (top-down). This is because bottom-up data provides a better picture

of the actual situation, which makes it more suitable as a basis for monitoring progress.

- *System perspective* – By developing an environmental footprint model for the entire care sector, we ensure that the methodology can be used to support future sector-wide agreements.

3 Introduction to the methodology

For a detailed calculation of the healthcare sector's environmental footprint, it is necessary to combine several datasets using a variety of methods. This was previously known as the 'hybrid approach' (Steenmeijer et al., 2022). The scope and complexity of this new method depends on the availability of the necessary datasets, the choice of calculation method and the parties involved.
To provide structure to the various activities involved in the development and implementation of the method, these elements are grouped according to the calculation method used and/or the parties involved. The result is a distinction within the method between a part that can be implemented in the short term (the 'basic model') and a part that requires additional coordination and collaboration with the healthcare sector (the 'specific model'). Both models calculate the environmental footprint of the Dutch healthcare sector and are an update of the 2022 method. However, only the specific model offers the higher level of granularity required.

This chapter introduces the resulting methodology and the overarching structure. The chapter is structured as follows. Section 3.1 provides a brief explanation of the environmental footprint methods used in the overarching methodology. Section 3.2 discusses the input of the environmental footprint calculation and how the results depend on the level of detail of the input data. Section 3.3 presents the steps in the implementation of the monitor. Section 3.4, finally, gives an overview of the model structure and the associated research activities. For a more extensive description of specific components of the method, see chapter 4.

3.1 Environmental impact calculation methods

To calculate the total environmental footprint of the healthcare sector, the input data for the environmental footprint methodology is processed mainly using two quantitative methods: Life Cycle Analysis (LCA) and Environmentally Extended Input-Output Analysis (EE-IOA). Life Cycle Analysis is used in the bottom-up part of the methodology and is the preferred method when detailed input data and suitable LCA datasets are available. The required data for these calculations is hereinafter called 'activity-data', and refers to the quantitative data that is often collected at the level of individual organisations for specific activities.
EE-IOA is used for the top-down part of the methodology. This enables us to calculate the environmental footprint on the basis of less detailed input data and for a wider range of activities (Weidema & Heijungs, 2009; Suh & Huppes, 2005). The required data for EE-IOA is referred to as 'spend-data', which in the case of the 2024 method mostly originates from the national statistical office, though it can also be collected at the level of individual organisations for additional specificity, as is the case for the specific model.
Both LCA and EE-IOA were also used in the 2022 methodology. However, the revised methodology has introduced several new methodological choices and expands the

bottom-up part. Below is a brief explanation of the methods and choices.

3.1.1 *Life Cycle Analysis*

LCA is a method that is frequently used for quantifying and evaluating the environmental impacts of a process, product or service over its entire life cycle (ISO 2006a; ISO 2006b). In LCA, the calculations tend to be based on physical characteristics (mass, volume).
To conduct an LCA large volumes of data need to be collected, which prevents its large-scale application. One alternative is to use existing, controlled LCA datasets from LCA databases or relevant literature. In practice, those datasets tend to be available mainly for the more common products, processes and services. The healthcare sector, in contrast, has many ‘unique’ products and services, for which in many cases no LCA-data has yet become available. What is lacking, moreover, is a comprehensive overview of all products and services used within the Dutch healthcare sector, which makes it impossible to calculate the full environmental footprint via LCA.

As pointed out in the guiding principles, where possible a bottom-up approach is used for data collection and for quantifying environmental impacts. Using LCA, this approach is used for calculating direct greenhouse gas emissions (see 3.2). No new LCAs need to be performed for these calculations; instead, existing LCA datasets and literature are used. The ecoinvent v3 database (Wernet et al., 2016) has been selected as the principal source. If possible, these existing datasets are adapted to reflect the Dutch situation, for example for the calculation of the environmental impacts of energy.

Compared with the 2022 method, the share of LCA in the environmental footprint method has increased because this yields more detailed results. Moreover, in addition to using the results already known (key environmental indicators) from the LCA databases, the calculation of the LCAs is integrated with the other environmental impact calculations in the model. By integrating LCA, the model becomes suitable for more extensive analyses of the quality of the model itself and for in-depth analysis of the results. For more information, see section 3.4, Implementation of the methodology.

3.1.2 *Environmentally Extended Input-Output Analysis*

An Environmentally Extended Multi-Regional Input-Output (EE-MRIO) table is a matrix that models the global economy by mapping the interrelationships between industry sectors. It enables the calculation of how much input from various industries is required to produce a specific output. In addition to containing data on income and expenditure (‘monetary data’ below), an EE-MRIO table also includes information on the environmental stressors caused by each industry. This allows not only for quantification of the economic activities contributing to a given output, but also for the calculation of the total environmental stressors associated with the involved industries. In an EE-IOA, monetary data therefore forms the basis for calculating environmental footprints.

Several databases provide EE-MRIO tables, each differing in their consistency with national accounts, international comparability, data

timeliness, industry detail, and the range of environmental indicators covered (see Table 5 in Appendix 9.1). For this analysis, we chose the PBL-FIGARO database, which is based on institutionally embedded monetary data and extensive environmental data (in 't Veld, personal communication, 16 September 2024). The PBL-FIGARO database is regularly updated and provides appropriate industry coverage for healthcare-related analyses.
Using PBL-FIGARO also reduces the 'aggregation issue' (see Section 5.3) that is inherent to EE-IOA. Compared to the EXIOBASE database used in the 2022 method, this issue is less pronounced in PBL-FIGARO, as it aligns more closely with the specific industries relevant to the healthcare sector. This enables a more detailed specification of the environmental impacts.

Like EXIOBASE, PBL-FIGARO includes a separate industry sector for health services ("human health activities") and offers sufficient industry-level specificity to distinguish medical devices where necessary (e.g. "manufacture of computer, electronic and optical products," "manufacture of fabricated metal products," etc.). What makes PBL-FIGARO more suitable, however, is the presence of a distinct industry for pharmaceutical products ("manufacture of basic pharmaceutical products and pharmaceutical preparations"). In contrast, EXIOBASE classifies pharmaceuticals under a broader, more aggregated industry ("chemicals not elsewhere classified"). This distinction is important given the substantial contribution of chemical products to the environmental footprint of the healthcare sector.

3.1.3 Hybrid approach to IOA-LCA

Our guiding principle is to use LCA as much as possible, but this is only realistic for a small part of all activities in the healthcare sector.
This is due to the wide range of products and services that are unique to the healthcare sector, such as pharmaceutical products and surgical instruments, for which no LCA data is currently available. Additionally, the available physical data on the consumption of products (numbers, mass, volume) in the healthcare sector is not sufficient to link those products to the key environmental indicators from the LCA. Input-Output Analysis may fill those data gaps, especially as regards indirect impacts and supply chains that resist direct modelling (Nakamura & Nansai, 2016).

Despite the advantages, combining IOA and LCA comes with several methodological challenges. Combining these two different types of data calls for accurate data management to prevent double counting or inconsistencies on their interfaces (Crawford et al., 2018; Agez et al., 2023). Given the differences in terms of units and data quality between the monetary data from IOA and the physical data from LCA, we also need to address the issue of data integration (Suh & Huppes, 2005; Crawford, 2009). Additionally, the macro-economic focus of IOA and the micro-level details of LCA potentially give rise to differences in scale (Nakamura & Nansai, 2016). It is also difficult to develop a uniform systematic approach that allows alignment of the functional unit (LCA) and the sectoral matrix (IOA) (Suh & Kagawa, 2023).

The combination of IOA and LCA would enable a higher-resolution analysis. Unfortunately, the challenges mentioned above currently prevent the hybrid application of the two methods within activity categories such as procurement of products and services. To still make use of the strengths of both methods, each component is assessed to determine whether LCA is feasible. If not, IOA is used. The results of the methods are subsequently harmonised and aggregated. For an overview of methods per activity category, see section 3.3 in Figure 3.2.

3.1.4 Environmental impact assessment

Both the LCA and the EE-IOA first generate an 'inventory of substances', as an intermediate step. This list presents the results at environmental stressor level. The impact of those stressors on the environment is calculated using an environmental impact assessment model. Such models translate stressors such as emissions and raw material consumption into impact categories, usually at two levels: midpoints, which measure environmental impacts such as greenhouse gas emissions, and endpoints, which represent broader impact areas such as human health, ecosystem quality and resource availability. The results of the environmental footprint method will be provided at midpoint level.

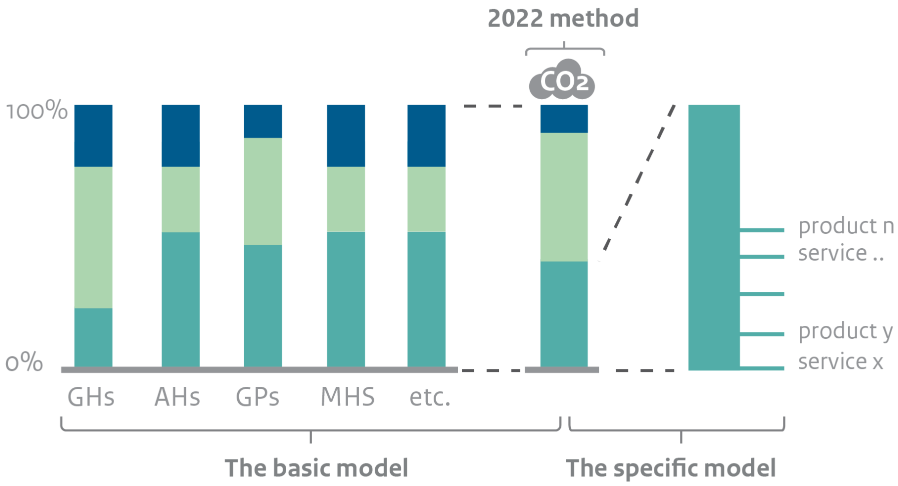
In the environmental impact assessment, it is important for the interim results from the LCA and the EE-IOA to be assessed in the same way. In this methodology, the environmental impact assessment model used for this purpose is ReCiPe (Huijbregts et al., 2016). ReCiPe was co-developed by RIVM and is frequently used in life cycle analyses. This means its results are comparable to those of other studies.

3.2 Basic model and specific model

To guide the research activities, the model structure is divided into a 'basic model' and a 'specific model'. The basic model comprises the improvements relative to the previous method that are required at minimum for calculating the environmental footprint of the healthcare sector at a high level, such as updating the data and ensuring continuity. The specific model adds steps to the basic model in the form of additional data collection and calculations so as to generate results at a higher level of detail, as indicated in the introduction to chapter 2. This offers more perspective for healthcare providers and healthcare professionals. As such, the specific model is more ambitious, but it also presents extra implementation challenges.

Figure 3.1 presents an overview of the implications of the model options for the objectives and results of the method, as described in Figure 2.1.

Figure 3.1 Fictitious intended results of the basic model and the specific model relative to the 2022 method.



The basic model consists of three steps, which are aimed to improve the method for calculating the direct (step 1) and indirect environmental impacts (steps 2 and 3):

1. **Adding greenhouse gas emissions per type of healthcare provider**
   In the new methodology, the calculation of direct greenhouse gas emissions no longer relies on data from top-down environmental accounts of Statistics Netherlands (CBS). Instead, a bottom-up approach is used, in which the direct greenhouse gas emissions are determined at sub-sector level and calculated on the basis of data from a combination of existing initiatives and regulations. In this regard, we seek alignment with the ongoing monitoring activities for Theme 3 of GDDZ 3.0. Additionally, several specific parties are asked to supply data. This improvement effort is described in further detail in section 4.1.1.
2. **Creating a dataset with general operating costs per type of healthcare provider**
   At sub-sector level, spending on six aggregated cost categories is compiled using data from the Annual Healthcare Accountability Report, from hereon called 'Annual Healthcare Report' (CiBG, n.d.). This concerns the spending by healthcare providers on such things as food, rents and leases, and raw materials and auxiliary materials. Compared with the previous method, which was based solely on total healthcare expenditure, this initial breakdown provides more up-to-date and specific results. For a further explanation of compiling general operating costs, see section 4.2.2.1.
3. **Linking these operating costs with annually updated and more suitable key environmental indicators**
   An EE-IOA based on general operating costs makes it possible to identify the indirect environmental impacts. The IOA database known as EXIOBASE used in the 2022 methodology will be replaced by the PBL-FIGARO database, which – unlike EXIOBASE – is updated twice a year and contains industry sectors that are relevant to the healthcare sector. See Appendix 9.1 (overview of IOA databases).

The second layer, the ‘specific’ model, aims to break down the general spending-data from the basic model into costs specific to certain product groups and services. Once it is known what sub-sectors spend on products and services in delivering healthcare, these costs can be linked to more appropriate environmental data to provide more detailed insights. This concerns an estimate of the costs per product group and service group, and not the spending for individual products.
To implement the specific model, we need data from, among other things, the accounts payable records and procurement systems of healthcare providers. This calls for collaboration with parties in the healthcare sector, for which two routes are available:

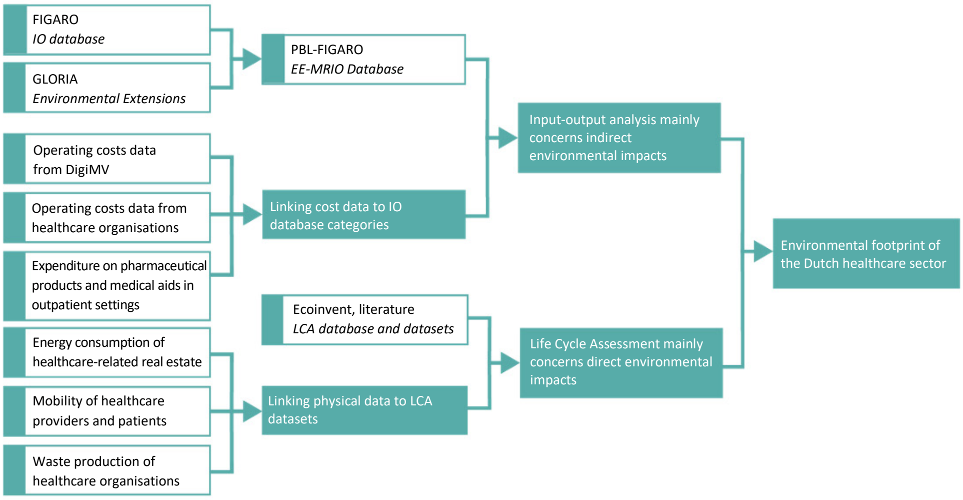
1. **Data request via existing partnerships**
   This concerns data that has already been collected through initiatives and projects of procurement organisations, sector associations and other partnerships within the healthcare sector. Examples include the environmental barometer for the healthcare sector of the Environment Platform for the Care Sector (MPZ) and the sustainability programmes of Intrakoop and of Zorginkoop Netwerk Nederland (ZiNN). However, due to the focus of these organisations on certain types of healthcare providers, this option is sensitive to selection bias, which could distort the results and lead to inconsistencies between periodic calculations. Furthermore, we only have limited insight into the quantity and coverage of the data that can be collected in this way.
2. **Direct request for data from a random sample of healthcare providers**
   This route provides for the direct collection of data from a range of healthcare providers so as to obtain a representative picture of the sector. The healthcare providers supply us with data from their records and, if necessary, ask their suppliers for additional information. The samples are based on the number of healthcare organisations per sub-sector and their size. The advantage of a random sample is that it provides a representative picture of the sector, free from selection bias. However, this approach is less practical: gathering data in this way is time-consuming, and the non-response rate may be high. This appears, for example, form the Socially Responsible Contracting and Procurement Monitor (MVOI), which RIVM has conducted since 2016 (Hollander et al., 2023).

To minimise the additional administrative burden for the healthcare sector, we need to find out whether existing information flows and systems of healthcare providers and partnerships are sufficient to meet the data needs of the 2024 method. Additionally, smaller healthcare organisations may not be able to supply the required data. In that case, we may decide to use a combination of the routes outlined above. However, combining routes may undermine the reliability and validity of the random sample, because in that case the selection procedure is no longer fully random. One solution might be to assign specific weights to the data of organisations that are able to supply data. In such a weighted sample, there would then be no distinction between small and large organisations, which would benefit the validity of the sample.

3.3 Input data

The data needed for the model are derived from a variety of sources. In Figure 3.2, these sources have been aggregated in a simplified representation of the model. See chapter 4 for further explanations of the input data and calculation methods.

Figure 3.2 Simplified representation of the method. PBL-FIGARO is derived from more datasets than represented in the figure.

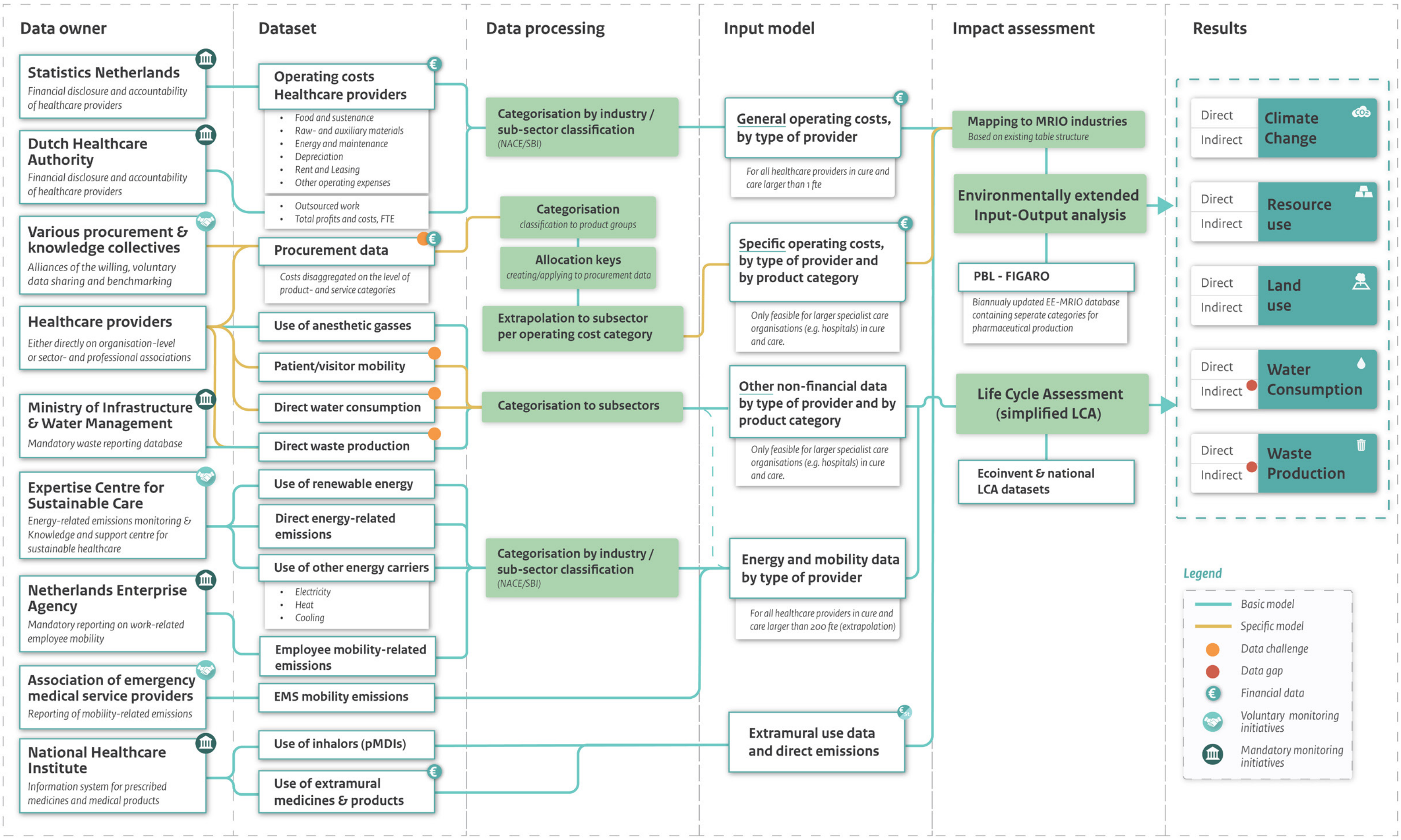


In Figure 3.3, the previous overview has been expanded to include a data flow diagram including the source of the data (data owners), the individual datasets, the intermediary steps of the environmental footprint model and the difference between the basic model and the specific model. In addition, it shows the dependencies of the approach on current voluntary and mandatory monitoring initiatives in the Netherlands. This relates to the previously mentioned collaboration with existing partnerships, and should give an insight into the preconditions for the current approach.

For each of the environmental impact categories, the diagram makes a distinction between the direct and indirect components to better represent the difference between activities within and outside the healthcare sector. This breakdown also helps to highlight the limitations of the method more clearly. For example, while no suitable data sources have been found for calculating indirect waste generation and indirect freshwater consumption, the *direct* component of these environmental impact categories can still be calculated.

The data flow diagram (Figure 3.3) also shows the intermediary steps that produce the input for the environmental impact assessment. These intermediary datasets already contain relevant information and can be used as a benchmark for healthcare institutions and sub-sectors. In the diagram, the euro symbol denotes the data flows that consist of monetary values. Due to a lack of physical data, this accounts for the majority of the model in the chosen method.

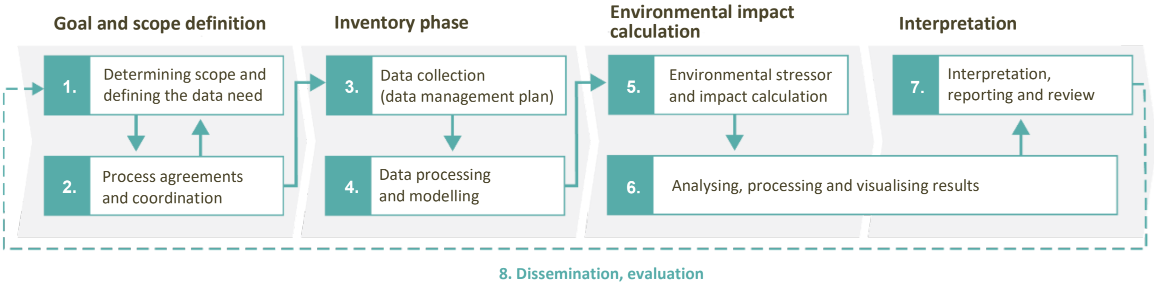
Figure 3.3 Data flow diagram showing the method in detail, including dependencies on voluntary and mandatory monitoring initiatives. A larger image can be found in Appendix 9.3.



3.4 Implementation of the methodology

The methodology consists of one part that can be implemented directly (the basic model) and another part that requires more coordination and research (the specific model). This means that, while the methodology is certain to yield results, the level of detail or granularity of the results will depend on the success of the specific model.
The two parts can be implemented alongside each other, using a phased, iterative approach comprising eight separate steps, as shown in Figure 3.4. As the methodology is implemented (steps 1–7), the iterative approach is used to prioritise and steer the data collection effort. With a view to improving the method over the course of several years, the iterative steps are intended to produce a better methodology with more functionalities (step 8).

Figure 3.4 Process overview of the 2024 method. Each arrow represents an interim result.



To implement the method, stakeholders are consulted at various stages. This consultation has the dual purpose of collecting data and discussing the results, so that the method can be improved and perspectives for action can be developed based on the findings (PBL & Radboud University Nijmegen, 2007). Key actors include the signatories to the Green Deal Sustainable Care 3.0 and all sector associations. Additionally, knowledge institutions such as Statistics Netherlands (CBS), PBL Netherland Environmental Assessment Agency, Rijkswaterstaat (RWS) and the Leiden Institute of Environmental Studies (CML), and procurement organisations and experts from the Centre of Expertise for Sustainable Healthcare (EVZ), the Environment Platform for the Care Sector (MPZ), the Dutch Healthcare Procurement Network (ZINN) and Intrakoop, all play a role in the implementation of the monitor and evaluation of the results.

Step 1 Determining the scope and defining the data requirement
The iterative process begins with an evaluation of the scope, as defined in chapter 2, in relation to the assignment, the needs of parties in the field and developments in the relevant literature. To this end, appointments are scheduled with the client and stakeholders, with this method document serving as the basis for an initial environmental footprint calculation. It may be the case that sector developments require a focus on a specific sub-sector or product category. As this will influence the methodology, it will also determine the scope.
Given that the methodology results in a simplified model of the actual healthcare sector, this step also includes an assessment of the influence of assumptions and simplifications on the results and their interpretation. This first step yields a document setting out the scope and the resulting data requirement (input) for the model.

Step 2 Process agreements and preparations with data suppliers
While step 1 is about the data requirement and is implemented in conjunction with the target group, step 2 will see consultation with (representatives of) stakeholders supplying data. During this consultation, we will assess the extent to which those parties are able to meet the data requirement and how they might be supported in this. If the sample-based approach is used in full or in part, the sample is set up during this phase in preparation for the inventory phase. For each sub-sector, the healthcare providers are further divided (stratified) according to several criteria (FTE, turnover), in order to minimise the variation within the sub-sectors as much as possible. Next, the required

size of each stratum is determined, after which a list of healthcare providers to be contacted is generated.
The agreements made in step 2 are laid down in a data management plan.

Step 3 Data collection
The inventory phase is the most labour-intensive period in the environmental footprint calculation. Based on the data management plan, the data owners will be asked to supply the required data.
If necessary, sessions are scheduled to answer questions and assist parties in gathering the right data.
When contacting data owners, priority is assigned to the parties that supply data for the basic model (Figure 3.3). This will help to ensure that the minimum requirements for environmental footprint calculation according to the basic model methodology are fulfilled. At the same time, data owners supplying data for the specific model are contacted as well. Given the large number of data owners, this process will take considerably more time.

This third step will yield a database of unprocessed datasets, in accordance with the data management plan.

Step 4 Data processing and modelling
As shown in Figure 3.3, data processing for the basic model involves categorising the collected data by SBI sector. This is necessary because this data has not been categorised, or has been categorised in a different manner. This sector-based categorisation for the 'general operating costs' and 'energy consumption' datasets is performed by CBS and EVZ, respectively. As regards the datasets on waste production and water consumption, the organisation responsible for carrying out the environmental footprint calculation will need to categorise the data.
The division of the sector categorisation effort between three parties may result in inconsistencies. This limitation is clarified further in section 5.2.

The data for the specific model is processed in three sub-steps: categorisation by product group, creation of apportionment keys by sub-sector and extrapolation to SBI sector level. In particular, the monetary data from the healthcare providers' own records will include significant differences. This is why this data needs to be categorised according to a uniform classification system into product groups that enable effective environmental footprint calculation. Exploratory talks with knowledge institutes and researchers in the healthcare sector have shown that the harmonisation of the highly heterogeneous data from care providers is an issue in multiple research projects. For this reason, this method document does not yet include a detailed categorisation step; there are opportunities to further develop this step in a co-creation process with players in the field in the period ahead. Based on the collected and categorised data, for each sub-sector, a number of apportionment keys are developed to break down the general operating costs into the costs of specific products and services.

As in the 2022 methodology, data processing and modelling are carried out using Python scripts. This approach has the benefit of being scalable, efficient and reliable in processing large datasets and performing extensive analyses. In addition, it enables the process to be automated and repeated, thus reducing the risk of errors. Python also provides flexibility for integrating additional data sources and calculation methods, facilitates transparent procedures and enables them to be shared with other researchers in the Netherlands and abroad.

The outcome of this step is an interim model that can be used to assess a variety of attributes, including the energy consumption, mobility use, waste generation and costs of purchased products and services per sub-sector (see 'input monitor' in Figure 3.3).

Step 5 Environmental stressor and impact calculation
For the bottom-up part of the model, the physical data known up to that point in time is linked to LCA key environmental indicators and datasets from LCA databases (Ecoinvent v3.10) and literature. Once all data flows have been linked to the corresponding datasets, a list of environmental stressors is calculated. These will include all greenhouse gas emissions, as well as land use and extraction of raw materials. In LCA terms, this is known as the Life Cycle Inventory. Next, the environmental stressors are converted into the desired environmental impact categories. This impact assessment (Life Cycle Impact Assessment) is conducted using the ReCiPe method (Huijbregts et al., 2016).

For the top-down part of the model, the monetary data flows are linked to the corresponding industry categories from an MRIO table, as explained in section 4.2.2.3. Once the environmental stressors of all monetary data have been calculated, they are converted – as is the case with non-monetary data – into environmental impact categories using the ReCiPe method.

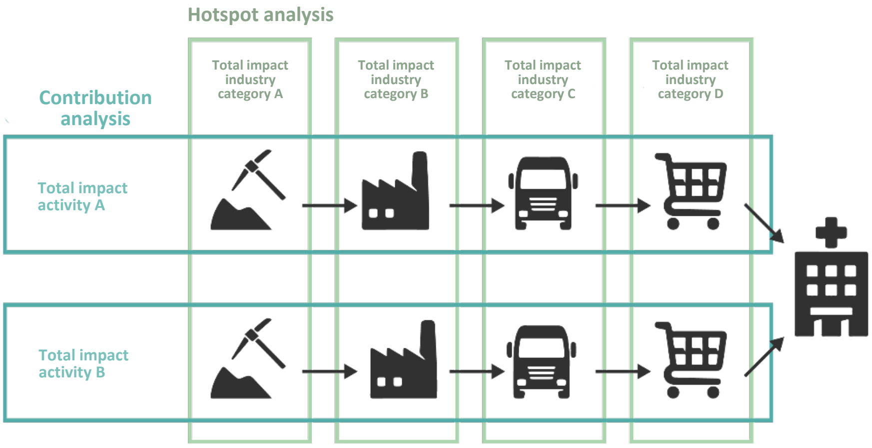
The interim result of step 5 is an initial overview of environmental footprint results per sub-sector.

Step 6 Analysing, processing and visualising results
Contribution and hotspot analysis
The environmental footprint results are studied in further detail using two types of analysis: contribution analysis and hotspot analysis, as shown in Figure 3.5. In a contribution analysis, we calculate the indirect impacts of purchased goods and services throughout the entire value chain (the embedded impact of the total value chain per product). This resembles the total results of a life cycle analysis of a product or service. The hotspot analysis focuses on the sector and location where the physical environmental impact occurs. This approach is similar to process-oriented contributions within an LCA.
This study uses both methods in order to gain a broader understanding of the structure of an environmental footprint, in terms of location and products. This makes it possible to identify trends and offer perspectives for action. It also helps to make results comparable to those of other studies that often use contribution analysis or hotspot analysis for their results analysis. Another option besides hotspot analysis and contribution analysis is the Structural Path Analysis (SPA),

which identifies the individual chains that contribute to the footprint analysis (Lenzen, 2007).

The hotspot and contribution analyses are visualised at the sub-sector level for each environmental impact category, providing insight into which activity categories (e.g. pharmaceutical products) and industry categories (e.g. transport) contribute most to the environmental footprint.

Figure 3.5 Difference between contribution analysis and hotspot analysis in IOA.



Uncertainties and sensitivity analysis

Due to the size of the model, the variety of data sources and the use of multiple methods alongside each other, the level of uncertainly of the results is likely to be high. To ensure reproducibility and effective communication of the results, it is important that these uncertainties are highlighted qualitatively or quantitatively. Uncertainty in environmental footprint models can arise at various levels. The types of uncertainty likely to predominate in the proposed method are uncertainty in terms of input data, model uncertainty and methodological uncertainty.
Data uncertainty includes measurement errors, representativeness and the temporality of data, while model uncertainty arises from simplifications such as the use of proxy data, data aggregation and choices regarding system boundaries. Methodological uncertainty arises from discrepancies between the methods used, such as double counts or differences in scale, as mentioned above. During implementation, we will explore various methods so as to identify the uncertainties and their effect on the results.

Step 7 Interpretation, reporting and review

In the second part of the interpretation phase, the results are related to the sector agreements and insights from previous environmental footprint studies. If, during implementation of the initial environmental footprint calculation, it proves possible to apply the methodology to multiple years, this phase will also comprise a trend analysis. A trend analysis studies changes in the hotspot and contribution analyses over several years. Where possible, these are linked to changes in or the introduction of sustainability measures, for instance, in the healthcare sector. However, due to the limitations of the methodology, it will not be possible to identify causal links.

The report presents results in the form of generic conclusions by sub-sector, including notes on how the methodological limitations may influence the conclusions and which aspects could benefit from additional research to provide further clarity.

Both the model and the report will be reviewed by at least two additional researchers.

Step 8 Dissemination and evaluation
Dissemination of the results includes delivery of the report to the client (the Ministry of Health, Welfare and Sport) and sharing it among the members of the Green Deal Sustainable Care 3.0 working group. Additionally, the findings will be shared with other relevant parties in the healthcare sector, including sector associations, procurement networks and environment-related initiatives. The evaluation will be conducted by the project team, with a focus on assessment of the methodology, data collection and results. As part of this effort, the project team will identify lessons learnt for incorporation in future iterations of the monitor.

Monitoring frequency
Our ambition is to calculate the environmental footprint every two years, in accordance with the overarching monitoring assignment of GDDZ 3.0. This has been taken into account as much as possible when exploring data sources. However, data from several less influential data sources will probably not be able to be updated every two years, making it likely that older data will also be used and possibly extrapolated. The effect of these choices on the results will be taken into account in the uncertainty analysis.

The year 2022 is the first period for which the environmental footprint will be calculated using the new method. At the same time, we will investigate whether preceding periods dating back to 2018 can also be calculated in this manner.

4 Methodology in detail

Chapter 4 discusses the working methodology of the environmental footprint calculation in detail. This includes the data collection effort, data processing, the chosen calculation methods and integration in the environmental footprint method. Next, the required research effort is determined based on the datasets and methods used and an estimate of the workload involved. In this chapter, each sub-section represents one research activity. All the activities add up to the total environmental footprint methodology.

Practically all research activities apply to both the basic model and the specific model. However, some research activities are more extensive for the specific model. This is discussed in the relevant sections.

As the differences in working methodology are largely determined by the type of environmentally harmful activity, the research activities – and therefore the sections in this chapter – are structured accordingly.
First, section 4.1 sets out the considerations and method for calculating the direct environmental impacts. Next, section 4.2 discusses the method for calculating the indirect environmental impacts. Section 4.1 is divided into sub-sections on the method for direct greenhouse gas emissions (4.1.1), direct freshwater consumption and land use (4.1.2) and direct waste generation and processing (4.1.3).
Section 4.2 first describes the data collection effort for the activity categories of energy and mobility (4.2.1) and then goes on to discuss data collection and implementation of the input-output analysis for purchased products and services (4.2.2). This is followed by a discussion of the limited coverage of waste generation in the chain (4.2.3).

4.1 Working method for calculating direct environmental impacts

The calculation of the direct environmental impacts of the healthcare sector is based largely on bottom-up data and key indicators from LCA and environmental databases. Since the environmental footprint methods use existing key environmental indictors and no new LCAs are going to be conducted, the focus of this chapter is on identifying data sources, the necessary steps to include that data in the environmental footprint and the associated opportunities and challenges.

4.1.1 Direct greenhouse gas emissions

The provision of healthcare services generates greenhouse gas emissions. As long as those emissions are the result of the healthcare providers’ core activities, they qualify as direct environmental impacts. These are known as ‘operational greenhouse gas emissions’.

There are various ways to classify greenhouse gas emissions, based on the characteristics of the processes in which they occur. For example, the Greenhouse Gas (GHG) protocol distinguishes between stationary combustion (usually through local energy generation), mobile combustion (mainly in transport), process emissions (emissions as a by-product) and volatile emissions (mostly from leaks) (WRI & WBCSD, 2006). This classification was also used in earlier environmental footprint studies, except for the process emissions, which qualify as indirect environmental impacts (HCWH & Arup, 2019). In its environmental accounts, CBS likewise distinguishes between stationary and mobile combustion sources (CBS, 2020).

In the 2024 method, a distinction is made between stationary and mobile combustion and volatile gases.
Stationary combustion mainly concerns processes for local energy generation, such as heat generation in boilers or electricity from emergency power units. This type of combustion is usually associated with care provision, such as a patient's stay in a healthcare institution, which is why it qualifies as a direct environmental impact. Emissions from mobile combustion are also classified as direct environmental impacts, provided the mobility is part of the core activity, i.e. providing care services. In contrast, transport movements for peripheral activities, such as the mobility of patients, visitors and employees (for commuting and official trips) classify as indirect environmental impacts.
Lastly, various gases are used during the provision of care – for example, in the operating theatre and when administering medication. These volatile gases are classified as direct environmental impacts, as their emission into the atmosphere contributes to climate change.

4.1.1.1 Stationary and mobile combustion

Direct greenhouse gas emissions in the 2022 method
In the 2022 environmental footprint calculation method, emissions from stationary and mobile combustion were calculated on the basis of data from environmental accounts supplied by CBS (CBS, 2020). CBS publishes annual overviews of air emissions from economic activities. These calculations are based on a variety of sources, including national emission registers, energy statistics, national economic accounts and government statistics, resulting in a table showing emissions in kg CO2 equivalents per main economic activity. In this system, the healthcare sector falls under sector Q, 'healthcare and welfare'. This approach was deemed preferable to the use of direct emissions from the IOA database (Exiobase) because CBS's environmental accounts are updated annually, thereby providing a more up-to-date representation of the Dutch healthcare sector.

However, following publication of the 2022 method, consultations with CBS revealed that the largely macro-economic methodology of the environmental accounts does not permit a further breakdown by sub-sector. Furthermore, doubts were expressed about the use of the results for sector-level monitoring. For these reasons, alternative sources were explored and a selection was made of data obtained in previous partnerships. The choices made for the 2024 method are explained in the following sub-sections.

Stationary combustion: Sustainability and Health Monitor Theme III of GDDZ 3.0 by EVZ
The Centre of Expertise for Sustainable Healthcare (EVZ) has been given responsibility for monitoring Theme 3 of the GDDZ 3.0: 'reducing CO_2 emissions from buildings, energy and transport (sectoral level)'.
EVZ supports the healthcare sector in its work on climate targets, for

example through the ‘portfolio roadmap’ approach. This approach consists of collecting energy use statistics of the real estate portfolio of care and cure providers, and relies on self-reporting through tools supplied by EVZ. The data is then used to gain insight into the current and projected CO_2 emissions associated with healthcare real estate. EVZ maintains an online database and a dashboard, and progress reports are published periodically (EVZ, 2022).

The first of these progress reports, in 2022, represented 62% of the floor area in the care sector and 95% in the cure sector. The current target set by EVZ and the GDDZ 3.0 coordination group is to receive formally approved portfolio roadmaps representing 90% of inpatient care organisations with a workforce of over 250 FTE (EVZ, 2024). The target for 2025 is 95%. Among smaller healthcare organisations (50–250 FTE), the percentage of organisations that have a formally approved portfolio roadmap is relatively small. For this reason, EVZ proposes that these organisations should be asked to supply only a limited set of data rather than a full portfolio roadmap, and only for buildings with a gross floor area of more than 1000 m^2. Using data on the total floor area of healthcare real estate in the Netherlands from the Key Register of Addresses and Buildings (BAG), the figures obtained can then be extrapolated to generate indicators that are representative of the Dutch healthcare sector.

One objective of the theme 3 monitoring by EVZ is to use the portfolio roadmap approach to calculate various indicators at sub-sector level, including for natural gas consumption (in m^3/year) and direct CO_2 emissions from energy consumption (in $kgCO_2$/year) (EVZ, 2024). Because most of the stationary combustion occurs via the burning of natural gas for heat and the warming of water, these indicators are sufficient for the calculation of the emissions from stationary combustion on a sub-sector level. The data is available in the periodic publications by EVZ.

Mobile combustion
In the 2024 method, direct emissions from mobile combustion are separated into emissions from ambulance services and emissions from transport movements for outpatient care. These two sub-categories do not cover all direct mobility emissions; for practical reasons, sub-categories whose expected contribution to the total environmental footprint is small, such as emissions from trauma helicopters, are left out of the analysis.

- Ambulance services
  Ambulances were deployed approximately 1.5 million times in the Netherlands in 2023 (RIVM, 2023a). Since most of these vehicles run on diesel and drive mostly short distances within urban areas, the GHG emissions are expected to be considerable. Ambulances are therefore included in the environmental footprint calculation.
  In the Netherlands, ambulance services are organised within Regional Ambulance Services (RAVs), which are supported by the sector association, Ambulance Zorg Nederland (AZN). In 2019, AZN and several RAVs signed a letter of intent on ‘Zero Emission Ambulance Care’ (Ministry of Infrastructure and Water

Management, 2019). As part of the implementation of the zero emission roadmap, a simulation model is being developed that can be used to evaluate various sustainability measures (AZN, personal communication). This model is based on the total number of trips plus the associated distances covered. AZN has indicated that the initial figures will become available in 2025, and that the data can be used for the sectoral footprint. Specifically the total mileage of all ambulances will be used in the sectoral footprint.
A caveat is that this approach does not account for the relatively short distances routes of ambulances in urban areas. Urban driving is typically more fuel-intensive, whereas LCA datasets assume average driving environments.
Alternatively, spending on fuel can be used as a basis for calculating greenhouse gas emissions. The records of individual RAVs would serve as the primary source for this. However, since the Netherlands has 25 RAVs, this would require additional data collection, which will only be performed if the ambulance services appear to be a significant hotspot in an initial analysis.

- Outpatient care
  Part of the healthcare in the Netherlands is provided at the location of the healthcare receiver. This is known as outpatient care. Greenhouse gas statistics for vehicles used in outpatient care can be requested from the Netherlands Enterprise Agency (RVO). Since 1 July 2024, organisations with a workforce of more than 100 have been obliged to publish their official trips and commuting statistics (WPM Decision: RVO, 2023). Under the reporting obligation for work-related mobility of persons (WPM), organisations are required to report the total number of kilometres covered, separated by type of transport and fuel.
  In view of the administrative burden that the WPM Decision is expected to place on the healthcare sector, supplementary guidance has been made available for the nursing, healthcare and home care sector (Actiz, 2024). This makes it easier for healthcare providers to meet their reporting obligations based on their travel expenses claims or allowances.
  The lower limit of 100 employees means that part of the outpatient care sector is exempt from the reporting obligation. For a comprehensive view of the Dutch healthcare sector, the available data can be extrapolated based on the total number of FTE of healthcare organisations with a high share of outpatient care. As a result, the calculation of the mobility-related greenhouse gas emissions in outpatient care remains an estimate.

For both stationary combustion and mobility, the data collection results are first categorised by sub-sector and activity. Next, these interim results are converted into environmental impacts using key environmental indictors from LCA. For mobility, the collected data is aggregated to produce the total mileage per vehicle type, on sub-sector level.

4.1.1.2 Volatile gases

The healthcare sector uses various gases that are critical to the provision of care but also contribute to the climate problem. Like CO_2, these gasses absorb and re-emit infrared radiation, leading to gradual warming. The gases included in the method are known as fluorinated greenhouse gases, or F-gases. The principal F-gases, besides hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), are sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3) (RIVM, n.d.). Applications of F-gases include air conditioning, cooling and medical care. In the environmental footprint method, volatile gases are subdivided into medical gases, propellants and refrigerant gases.

Medical gases (anaesthetic gases)
Venema et al. (2022) conducted an inventory of the use of anaesthetic gases in Dutch hospitals. The authors arrived at an estimated emission of approximately 13.2 kilotonnes of CO_2 equivalents in 2019, of which 4,189 tonnes of CO_2 equivalents of sevoflurane and desflurane, and around 9,000 tonnes of CO_2 equivalents of nitrous oxide. The report of Van Steenmeijer et al. (2022) demonstrated that anaesthetic gases only account for 0.083% of total emissions. Even so, it is proposed to include these gases in the calculation given the strong commitment of the healthcare sector to reduce their use (e.g. NVA, 2021; Regulation (EU) 2024/573) and the potentially higher relative share of these gases in the revised method.

Up to and including 2023, the contribution of anaesthetic gases to the healthcare sector’s climate footprint can be determined using a study conducted in that year by the Netherlands Society of Anaesthesiologists (NVA). The NVA conducted a survey among all anaesthesiology practices affiliated with it, asking healthcare providers for data on the amounts of sevoflurane, isoflurane, desflurane and nitrous oxide purchased. The response rate was 57%. The composition of respondent practices is known and was taken into account in the extrapolation exercise to calculate the total consumption of anaesthetic gases in the healthcare sector. Since the NVA study was a one-off exercise, its results are used as a proxy in this environmental footprint calculation. In consultation with the NVA, possibilities to update the data are being examined.

Propellants (metered-dose inhalers)
The environmental footprint report from 2022 shows that greenhouse gas emissions from the use of metered-dose inhalers in 2016 amounted to 77 kilotonnes of CO2 equivalents, or 0.4% of the total climate footprint of the Dutch healthcare sector (Steenmeijer et al., 2022). The method for calculating greenhouse gas emissions from the use of metered-dose inhalers has remained unchanged in the 2024 method. The number of dispensed metered-dose inhalers is requested for the database of the Medicines and Medical Devices Information Project (GIP) (ZiN, 2024), after which the propellant content per package is determined based on data from the Medicines Evaluation Board (MEB). While approximately 30% of the gases remains in the inhaler after use, it is assumed that all gases are released into the atmosphere during the waste processing phase (ECHA, 2023).

Refrigerant gases
F-gases are used in cooling installations, air conditioning systems and heat pumps and are likely to end up in the atmosphere particularly during the eventual processing of these products (RIVM, n.d.).
The worldwide contribution of F-gases to climate change was estimated to be less than 1%, but this share is expected to rise, potentially to 10% in 2050 (Velders, Solomon & Daniel, 2014). Furthermore, 82% of total emissions of fluorinated greenhouse gases are released from refrigeration and mobile air conditioning devices (ECHA, 2023).
F-gas emissions from the use of air conditioning and particularly from specialised cooling plants, could therefore contribute considerably to the sectoral footprint.

The options for including F-gases in the environmental footprint method however, are limited. The only source that can provide physical (activity) data is the Environmental Barometer of Stichting Stimular (Stichting Stimular, n.d.). This instrument supports organisations in the healthcare sector in reporting their environmental performance and greenhouse gas emissions, it offers the possibility to estimate refrigerant gas emissions. Stichting Stimular uses this data to develop benchmarks for each type of healthcare provider. The utility of the Stimular data depends on its coverage and method, which is currently unknown. The implementation phase of the sectoral footprint method therefore start with an analysis of all available data sources.

To calculate the cumulative greenhouse gas effect of F-gas emissions from the healthcare sector, we use the current characterisation factors of the Intergovernmental Panel on Climate Change (IPCC) (GHG protocol, 2024). The results are reported by type of healthcare provider.

4.1.2 Direct freshwater consumption and direct land use
In the 2022 method, both indirect and direct freshwater consumption and land use were calculated via an input-output analysis. This analysis showed that the healthcare sector accounts for 7.5% of the total freshwater consumption footprint and 7.2% of land use in the Netherlands. This section briefly explores possibilities for disaggregating these results to sub-sector level.

4.1.2.1 Direct freshwater consumption
Various processes and procedures contribute to water consumption in the healthcare sector. Examples in healthcare include dialysis, laboratory use, cleaning and sterilisation of medical instruments, and refrigeration of medical equipment. Examples in long-term care are cooling and heating of buildings and the use of sanitary facilities.

In the 2022 method, freshwater consumption was calculated using input-output analysis, resulting in an aggregated sectoral footprint. To break this footprint down by sub-sector and activity category, we explored options for a bottom-up approach based on actual water consumption data. The aim was to make use of existing data from national knowledge institutes and sector associations, thereby minimising the administrative burden for healthcare organisations. However, an exploratory study showed that water utilities cannot provide data at the level of individual healthcare institutions, and sub-sector estimates are also not feasible. Moreover, the water consumption statistics from CBS lack the required granularity, making them unsuitable for inclusion in the 2024 method. As a result, the available options differ for the basic model and the specific model.

The basic model can use either input-output estimates or extrapolations based on key water consumption indicators for the healthcare sector. Input-output analysis provides an initial estimate of annual expenditure on water utilities, which can be broken down further using assumptions derived from the Annual Healthcare Report. By applying the standard water price for the reference year, this expenditure can be converted into an estimate of freshwater consumption in cubic metres. Alternatively, key indicators can be applied. For instance, data from the Environmental Barometer, published by Stichting Stimular, provide average water consumption figures per sub-sector. The most recent data for hospital care date from 2022 (based on 43 hospitals), while data for nursing homes, care for people with disabilities, mental healthcare and GP practices cover the period 2019–2022 and are based on 17, 6, 5 and 14 organisations respectively (MPZ, n.d.). Collaboration with MPZ could facilitate biennial updates of these figures, specifically tailored for use in environmental footprint calculations.

The specific model, by contrast, uses data provided directly by healthcare organisations. This makes it possible to request information on their actual spending on water utilities and other relevant data. As in the other work packages, these data can then be extrapolated to the level of sub-sectors.

4.1.2.2 Direct land use

In environmental footprint analyses, land use serves as an indicator to assess the impact of products or systems on biodiversity. After all, the way land is used and managed has direct consequences for ecosystems, habitat loss and the associated changes in biodiversity. In the ReCiPe 2016 framework, land use is expressed as the equivalent of square metres of arable land, which goes beyond merely including the physical area occupied by a product or system.

The contribution of healthcare real estate, also referred to as the ‘direct component’, to the overall land use of the sector is extremely small. As demonstrated by the 2022 method, it is in fact negligible compared with the land use arising from activities further downstream in the chain (Steenmeijer et al., 2022).

For this reason, direct land use in the revised method is limited to the number of square metres of healthcare real estate for which data can be obtained from the Key Register of Addresses and Buildings (BAG). This activity is already being carried out by EVZ within the context of Sustainability and Health Monitor Theme 3 of GDDZ 3.0, which allows the integration of this data in the sectoral footprint method.

4.1.3 Direct waste generation and processing

The Dutch healthcare sector uses a wide variety of pharmaceutical products, materials, substances, aids and protective equipment. The target set within GDDZ 3.0 is to achieve an average 25%

reduction of the generation of mixed waste by 2026 relative to 2018. The longer-term aim of the sector is that no more than 25% of all its waste is classified as 'mixed' by 2030. More generally, the Dutch healthcare sector intends to achieve maximum circular working practices by 2050 (national government, n.d.).

According to the 2022 study, the total waste generated in the Dutch healthcare sector amounted to 190 kilotonnes in 2018 (Steenmeijer et al., 2022). This figure includes direct and indirect waste generation within the various sub-sectors, including waste from healthcare consumers and waste generated upstream in the supply chain. Due to the database used in the 2022 method, these 190 kilotonnes were calculated without distinguishing between sorted and unsorted waste. Furthermore, GDDZ 3.0 gave no further substantiation of the effort to promote circular working practices, even though the healthcare sector has expressed a need for this (Waaijers-van der Loop et al., 2021). To achieve circular working practices, we first need insight into the extent to which the waste generated in the healthcare sector is sorted. Next, it is important to understand how the various waste flows are processed into secondary materials and, finally, to what extent those secondary materials are used in care-related products. The purpose of this part of the method is to periodically measure the performance of the various sub-sectors within the Dutch healthcare sector as regards sorting and processing their waste.

This section explores the scope of the 'direct waste generation and processing' work package in more detail, including the data collection techniques used. Next, we take a closer look at the analysis and presentation of the results of that analysis.

4.1.3.1 Waste flows and processing methods

The working method for mapping out the environmental impacts of waste in the healthcare sector consists of two components: waste generation at sub-sector level and processing methods for the various waste flows. The topic of secondary material use – i.e. the use of recycled materials – in care-related products is not taken into account in the method, due to the lack of reliable and consistent data.

Waste generation at sub-sector level

An initial scan of the environmental reports of several healthcare providers, such as hospitals and nursing homes, and the environmental report of the Environment Platform for the Care Sector (Cicero Zorggroep, 2022; Erasmus MC, 2023; OLVG, 2020;2022; Spaarne Gasthuis, 2023; MPZ, 2024ab) shows that, within the healthcare sector, waste is registered at three levels (see Table 6 in Appendix 9.2):

1. Unsorted hazardous and non-hazardous waste
2. coarsely sorted hazardous and non-hazardous waste (including mixed packaging and infectious waste); and
3. specifically sorted hazardous and non-hazardous waste (for example, swill and amalgam waste).

For periodically collecting physical data (in kg) on the various waste flows, RIVM uses the AMICE database. This database is managed by Rijkswaterstaat and updated on a monthly basis. The so-called 'waste

disposers', including healthcare providers, collectors and processors, are required to report and register waste with the National Waste Control Centre using EURAL codes and, in some cases, waste flow numbers as well (Rijkswaterstaat, 2022). The difference between EURAL codes and waste flow numbers is that the first have a fixed 6-digit structure while waste flow numbers have a variable 12-digit structure. Furthermore, EURAL codes are standardised and are used throughout Europe, whereas waste flow numbers are specific to the registration and reporting systems used in the Netherlands (Rijkswaterstaat, 2022).
The focus in waste flow monitoring will initially be on flows with a EURAL code, due to the fixed code structure and the use of those codes in the AMICE database. This means that, for some waste flows, data will be collected at level 1, while for others, level 2 or 3 data will be collected (see Table 6 in Appendix 9.2).

In order to collect physical data on the various waste flows at sub-sector level (i.e. according to the SBI classification), the database will be searched using Chamber of Commerce (KvK) numbers, postcode or name (for example, dentist or general practitioner).

Processing methods
To collect data on the processing of the various waste flows at sub-sector level, as well as on the mass (in kilograms) per processing method, the AMICE database will also be consulted. This database has various different processing methods, including storage, physical or mechanical processing and microbiological processing (see Table 7 in Appendix 9.2). In the collection of physical data, all processing methods will be taken into account.

4.1.3.2 Analysis and visualisation of the results

In order to gain insight into the extent to which waste in the healthcare sector is sorted and how it is processed, the following analytical steps are performed in succession:

Data preparation
Individual organisations register the waste flows by EURAL code on the basis of the Chamber of Commerce (KvK) number, postcode or name – not by SBI code (sub-sector level). To enable measurement and monitoring at sub-sector level, the following steps will be performed:

1. The SBI code linked to the KvK number or the name is registered in the KvK database. If only the postcode is known, the corresponding KvK number registered at that postcode will first be identified, followed by the associated SBI code.
2. If an organisation only has one SBI code, that code can be used immediately for aggregation. If an organisation has multiple SBI codes, a weighted approach will have to be pursued depending on the importance of the core activity of the organisation concerned. Alternatively, an SBI code at a higher level of aggregation can be assigned to the waste flow. In the latter case, an example would be to use SBI code 86.92 instead of 86.92.2 or 86.92.3 (see Table 2, chapter 2).

Analysis
In order to obtain sub-sector-level results on the degree of sorting in the various waste flows, the following steps are performed:

1. An initial exploration of the data shows that the origin of the waste (KvK number, postcode or name) is not always known – for example, in the case of route-based collection or a collectors' scheme – while the total collected mass is known. In such a case, various statistical techniques will be considered for the purpose of estimating the origin of the missing portion. For example, historical data can be analysed to identify patterns and trends in the origin of waste based on SBI codes, after which those patterns are projected on to the flows in order to estimate the origin of the missing data. If historical data offers insufficient insight, other techniques including extrapolation or regression analysis (regression imputation) will be applied.
2. The results from step 1 are aggregated into sorted and unsorted waste flows at sub-sector level.

For insight into the processing methods for the various waste flows at sub-sector level, in principle, we perform the same activities as described for step 1 above. If this approach fails to produce reliable results, the results will be presented at main sector level (the healthcare sector as a whole).

4.2 Working method for calculating indirect environmental impacts

The working method for calculating the healthcare sector's indirect environmental impacts is based on a combination of bottom-up and top-down data collection techniques and environmental impact calculation using IOA. One exception is the working method for energy and mobility, which are taken together due to the data source used. This chapter's focus is on identifying data sources, the steps required to process this data in the environmental footprint calculation and the associated opportunities and challenges. The working method has three components:

1. Energy and mobility
2. Purchased products and services, using input-output analysis
3. Indirect waste generation

4.2.1 Energy and mobility

Environmental impacts from energy consumption and mobility account for a considerable share of the total environmental footprint. According to the 2022 study, the healthcare sector's electricity and heat consumption in 2018 was responsible for 10.5% and 0.6%, respectively, of the overall environmental footprint. The estimated share of private mobility in 2018, including commuter traffic, was 2%, and even up to 5.7% when mobility in the rest of the upstream value chain is taken into account (Steenmeijer et al., 2022). In the GDDZ 3.0, parties commit to reducing greenhouse gas emissions from buildings, energy and transport. These aspects are therefore included in the method, in support of the GDDZ 3.0 targets.

4.2.1.1 Energy

Demand for energy in the healthcare sector is significant, due to the intensive use of technology, equipment and facilities that are essential for patient care, safety and comfort. For example, hospitals and healthcare institutions use electricity for medical equipment, lighting, ventilation and IT systems. In addition, heat is required for temperature control of buildings and water, while refrigeration is essential for the storage of pharmaceutical products, blood transfusion bags and medical equipment. In the supply chain of energy carriers used in the healthcare sector, all sorts of activities take place that contribute to the sector's overall footprint. These are the *indirect environmental impacts* from energy consumption. This does not include the environmental impacts arising from energy consumption in the supply chain of products and services, which are discussed in the input-output analysis in section 4.2.2.1.

This section only briefly discusses the quantification of indirect environmental impacts from energy consumption, because much of the required data is available through thematic monitoring by the Centre of Expertise for Sustainable Healthcare (EVZ). For an overview of the methodology applied by EVZ, please consult its monitoring plan (EVZ, 2024). This section presents a summary and explains how the data obtained with this method can be processed in the environmental footprint method.

Data collection from Sustainability and Health Monitor
Theme 3 GDDZ 3.0
The Centre of Expertise for Sustainable Healthcare (EVZ) is responsible for monitoring Theme 3 of the Green Deal for Sustainable Healthcare (GDDZ 3.0): "Reducing CO_2 emissions from buildings, energy, and transport at the sector level." To support the healthcare sector in achieving climate targets, EVZ applies a portfolio roadmap approach. This involves collecting data on energy use for the real estate portfolios of care and cure providers, primarily through self-reporting using EVZ-provided tools. The resulting dataset provides insight into both current and projected CO_2 emissions from healthcare real estate. EVZ maintains an online database and dashboard and publishes regular progress reports (EVZ, 2022).
The rate of participation of healthcare providers in this approach is relatively high. The initial progress report for the cure and care sector published by EVZ in 2022 represented 62% and 95%, respectively, of the total floor areas of these segments. EVZ expects a further increase in the rate of participation, which will improve the extrapolation of available data based on the total floor area of healthcare-sector buildings in the Netherlands.

To calculate the indirect environmental impacts from energy consumption, the following indicators from Theme 3 monitoring by EVZ will be adopted at the sub-sector level:

- Electricity consumption in kilowatt-hours per year (kWh/year)
- Natural gas consumption in cubic metres per year (m3/year)
- Consumption of heating and cooling in kWh or gigajoules (GJ) per year, referring to the share not yet covered under points 1 and 2
- Solar-powered electricity generation, in kWh/year

The indicators need to be linked to key environmental indicators, which entails choosing the correct energy mix.

The energy mix of the healthcare sector
To make their energy consumption more sustainable, healthcare providers regularly use 'guarantees of origin' (GOs) when entering into new energy contracts. GOs are certificates issued by independent certification agencies and allow producers to demonstrate they are genuinely generating renewable energy. Guarantees work on the premise that, by purchasing power from certain producers, buyers help create additional generation capacity for renewable power (also known as 'additionality'). Via this principle, healthcare providers that do not generate renewable power themselves, or not enough to meet their needs, can still contribute to the energy transition.
There are however, some uncertainties regarding the effectiveness of GOs in stimulating additionality. Since GOs can be traded freely on the international market, supply and demand are not always balanced, and there is a risk of double counting the benefits of renewable electricity (Hulshof, Jepma and Mulder, 2019; Hamburger, 2019; Langer et al., 2023). Moreover, the certificates are not always processed correctly in the country or organisation where the energy is generated. These issues are less relevant for the use of certificates from local or national energy projects.

Due to the controversy surrounding GOs, it has not yet been decided whether they are to be included in the environmental footprint method, i.e. whether the energy mix is to be determined on the basis of purchased GOs or on the basis of the average Dutch (grey) energy mix. If the GDDZ 3.0 working group and other stakeholders consider GOs as valid driving forces for sustainability, alternative sources to the monitoring of Theme 3 by EVZ will be explored. This is because EVZ does not intend to register the use of GOs and will instead assume the average grey energy mix. Data from the Environmental Thermometer for Healthcare (Milieuthermometer Zorg) of the Environment Platform for the Care Sector (MPZ) may provide a solution. MPZ imposes requirements on the minimum percentage of purchased electricity from renewable sources corresponding with specific levels of the environmental thermometer. These reports can be used to produce a conservative estimate.

Environmental impact quantification
For a consistent environmental footprint calculation model, collected data on energy consumption should be uncharacterised (for example, consumption in kWh/m^3). Data can then be linked to key environmental indicators and environmental datasets that best represent the Dutch context. In this method, the environmental indicators published by Milieu Centraal will be used, which are updated annually by CE Delft (Milieu Centraal, 2024). Other environmental stressors are calculated using LCA, by adapting the Life Cycle Inventory (LCI) datasets from the Ecoinvent v3.11 database. The environmental impact assessment, which determines the contribution of environmental stressors to specific environmental impact categories, is carried out in the model using the ReCiPe 2016 midpoint (H) method.

4.2.1.2 Mobility

Greenhouse gas emissions and other environmental stressors related to the movement of persons to and from healthcare institutions or other transport movements in the supply chain of products and services, qualify as indirect environmental impacts. In the environmental footprint method, the indirect environmental impacts of mobility are subdivided into commuter-related mobility, patient and visitor-related mobility, official trips and work-related mobility, and transport and distribution.

Bottom-up vs top-down

For mobility the same principle applies of using bottom-up data wherever possible. However, data on mobility within the healthcare sector is not always available. This is why the 2022 method used estimates for commuter-related mobility, based on the number of transport movements and average commuting distances. As described in more detail below, it has since become possible to collect part of the required data using a bottom-up approach via a combination of voluntary (partnerships) and compulsory (regulation) reporting. However, as this reporting will not provide full coverage, we will use the top-down EE-IOA method (see section 3.1.2) for certain parts of the calculation of indirect mobility-related environmental impacts.

Commuter-related mobility, official trips and work-related mobility

As part of the monitoring of Theme 3, EVZ will report greenhouse gas emissions arising from mobility at sub-sector level. EVZ will request an aggregated dataset from the Ministry of Infrastructure and Water Management (IenW) and the Netherlands Enterprise Agency (RVO). RVO obtains this data via the reporting obligation for work-related mobility of persons (WPM), under which organisations with a workforce of more than 100 have been obliged, since 1 July 2024, to report on both work-related and commuter mobility (WPM Decision; RVO, 2023). Healthcare institutions fulfil their reporting obligation by entering the distances covered (in km) per type of vehicle and type of fuel in an online form. Since healthcare institutions with fewer than 100 employees are exempted from this obligation, the mobility data of larger healthcare institutions will be used to extrapolate this data based on the size of the workforce.

One limitation associated with the use of WPM data is that business-related air travel is not registered. Business air travel does, however, take place in the healthcare sector, including for conferences attended by medical specialists. Air-travel related emissions are difficult to identify, due to the general lack of specific data in the booking systems of the healthcare providers concerned. For the time being, therefore, air travel falls outside the scope of the environmental footprint method.

It is important that mobility data, like energy consumption data, is collected at a high level of detail. Consultation with RVO will take place to decide whether raw WPM data can be made available for monitoring purposes.

Patient and visitor mobility

Patient and visitor mobility falls outside the scope of the WPM, meaning data will have to be collected and estimated via a different route.

To ensure a bottom-up approach to data collection in this area as well, the implementation plans of the various healthcare sector associations regarding GDDZ 3.0 have been examined, with a specific focus on the theme of mobility.
This revealed that sector associations of hospitals and university medical centres intend to measure the number of transport movements of patients and visitors every two years, using surveys (NFU, 2023; NVZ, 2023). Sector associations in care for the elderly and the disabled and for mental healthcare have not made any such agreements, but they have expressed the ambition the map out the transport movements of patients and visitors where possible (Actiz, 2023; GGZ, 2023; VGN, 2023). The sector association for care insurers uses a similar formulation and undertakes to monitor passenger car mileage and CO2 emissions per person per year by healthcare institutions and umbrella organisations, both for staff and – where possible – for patients (ZN, 2023).

For the time being, therefore, it is only certain that periodic data on patient and visitor mobility will be collected for part of the medical care sector. The extent to which similar initiatives are undertaken in the other sub-sectors will emerge during implementation of the environmental footprint method. If this is not the case, estimates can be made for the other sub-sectors based on data made available by the Netherlands Federation of University Medical Centres (NFU) and the Netherlands Association of Hospitals (VZN).

Transport and distribution
Transport and distribution cover all mobility required for the contractual movement of persons and goods. Examples include postal and package services, relocation services and specialised transport. This activity category can be further subdivided into transport services purchased by healthcare providers and transport services taking place between various actors in the supply chain. For purchased transport services, the basic model makes an assumption based on data from the Annual Healthcare Report and an analysis of the used IOA database. In the specific model, the assumption is that spending data regarding purchased transport services can be obtained from the data supplied by partnerships or healthcare providers. In the IOA database used, all transport and distribution-related mobility in the supply chain will be covered by the industry categories ‘land-based transport (including transport via pipelines)’, ‘waterborne transport’ and ‘air transport’.

Environmental impact quantification
Most mobility-related data will be available at the level of kilometres driven per transport modality. This aligns with the units of the key environmental indicators used to convert the collected data into the final environmental impacts. Environmental indicators are obtained from the LCA database EcoInvent, and assume an average technology mix (v3.11).

4.2.2 *Purchased products and services, using input-output analysis*
The largest share of the environmental footprint of the Dutch healthcare sector is caused indirectly by the procurement of products and services. Besides energy and transport (see 4.1.2), this includes spending on

categories such as pharmaceutical products, medical aids and equipment, food and catering, waste management, real estate and capital goods. The 2022 study has shown that the goods and services purchased in 2018 accounted for 73.5% of the environmental footprint, 94.3% of total waste generation and nearly 100% of the other environmental impact categories (Steenmeijer et al., 2022). In this section, we explain how the environmental impacts in the supply chain for products and services are calculated in the 2024 method.

4.2.2.1 Introduction: input-output analysis

The healthcare sector uses a large number of highly diverse products and services. The calculation of the environmental impacts per product or service via a bottom-up approach (LCA, also see 3.2), would require physical (i.e. activity-) data for each of those products and services. An exploration of available data sources has shown that such data are not currently available at the level of detail required for bottom-up calculations. Interviews with stakeholders have furthermore revealed that physical data is only being collected for a limited number of specific products. There is also a lack of comprehensive and representative LCA data for the products and services used in the healthcare sector, as shown in a review and analysis of the database of available LCA datasets (Drew et al., 2022). Finally, a bottom-up approach would be prohibitively labour and time-intensive given the large numbers of products and services involved.

For these reasons, the environmental footprint method uses a top-down approach to quantify environmental impacts. This means that expenditure data (i.e. operating costs, spending on products and services) is linked to key environmental indicators from an EE-MRIO table using an input-output analysis (also see 3.2 for further explanations). For this purpose, every spending category is mapped to a corresponding EE-MRIO category. The link depends on the initial categorisation of the collected expenditure data and on the categorisation of the industry categories in the EE-MRIO table.
For an IOA, the market prices of purchased products and services must be converted into basic prices, i.e. the value of products net of taxes, margins and transport costs. This conversion is performed using conversion factors issued by CBS (CBS, 2023). This step ensures that the financial values are consistent with the structure of the EE-MRIO table and prevents disruptions due to additional costs.

The options for further specifying data by sub-sector and activity category depend on the granularity of the procurement data and industry categories in the EE-MRIO table. The choice of the table for the 2024 method is substantiated in section 3.1.2. Further information can also be found in Appendix 9.1. As explained in section 3.1.2, there are various options for the collection of procurement data. Section 4.2.2.2 describes the options for collecting data on inpatient procurement and section 4.2.2.3 for data on outpatient spending on pharmaceutical products and medical aids.

4.2.2.2 Operating costs of healthcare providers

This section describes the various options for collecting data on spending on products and services by healthcare organisations, both in healthcare and long-term care settings. These options illustrate the difference between the basic model and the two options of the specific model (also see 3.1.2), and vary in terms of the level of detail of the results and the required time investment. The options are described with due regard for the administrative burden on the healthcare sector, statistical integrity and feasibility. The basic model, and the described actions below can be carried out immediately. For the specific model, further exploratory studies and agreements with data owners are required (see 3.4 and 5.3).

For all options, the procurement of products and services by healthcare organisations – such as the outsourcing of specific care tasks – is not included, in order to avoid double counting. If the operating costs of the healthcare provider purchasing the service *and* those of the supplying healthcare provider were included, the same product or service would appear twice in the calculation of environmental impacts.

Basic model
The basic model uses open-source information about the operating costs of healthcare organisations. This data is then mapped to more specific products and services (industry categories) using assumptions based on the underlying relationships between industry categories from the MRIO table.

Data on the operating costs of healthcare providers is obtained from open annual accountability reporting (Annual Healthcare Report, DigiMV), in which Dutch healthcare providers give insight into their financial management and spending of public resources. The open annual accountability reports of the healthcare sector are facilitated and monitored by the Dutch Healthcare Authority (NZa). With some exceptions, all healthcare providers and combined organisations are required to publish these reports (CiBG, n.d.). A large majority of healthcare providers in the Netherlands thereby provide insight into the balance sheets and income statements of their organisations.

The publicly available information from the open annual accountability reports consists of healthcare providers' spending on a number of aggregated financial items relating to assets and liabilities (CiBG, n.d.). CBS also collects supplementary data on the following additional cost categories: food, raw materials and auxiliary materials, maintenance, depreciation, rents and leases, and other operating costs (Public Annual Reporting Regulations (WMG) Act, 2024). The additional data collected by CBS is not publicly available, but it is made accessible in aggregated form through healthcare institutions statistics (CBS, 2015). Those statistics offer a level of detail that is sufficient for the basic model.

To be able to use operating cost data from the annual accountability reports, the data needs to be categorised by SBI code (as explained in further detail in section in 2.1). This enables the environmental footprint results to be provided by the desired sub-sector level. In their open annual accountability reports, healthcare providers identify their core activities using one or more SBI codes. CBS carries out additional steps to link healthcare providers to a single SBI code. The use of CBS data ensures that the right categorisation is used.

The specific model
In the specific model, the aim is to obtain more detailed spend-data for the sub-sectors. This is done by enriching and disaggregating the general operating costs with detailed operating cost data obtained directly from the healthcare providers' records. For obtaining these datasets, two routes have been identified:

1. *Requesting bundled data through collaborative partnerships*
   In this option financial data is collected from existing projects at procurement organisations and collaborative partnerships, such as Intrakoop, NFU, NVZ and MPZ. Many healthcare providers are members of such organisations, and share operating costs to receive tailored advice or assist in research projects. In interviews with stakeholders various opportunities for sharing data were identified, though the procedure for data sharing needs to be designed and formalised (see 3.4 and 5.3).
   To make the collected data usable for tailored advice and research, procurement organisations and partnerships categorise and harmonise the data they receive from their members. Categorisation involves classifying the data according to a consistent scheme, while harmonisation means resolving inconsistencies within the dataset. Currently, each procurement organisation uses its own scheme and working methods, leading to significant variation. However, the environmental footprint method requires a single, standardised approach. As a result, data must be re-categorised and re-harmonised before it can be used. This is a process that is both time-consuming and, at present, entirely manual.
   Before scaling up the data to national totals, it first has to be assigned to the correct cost category of the schedule used in the Annual Healthcare Report and CBS (for example, 'costs of raw materials and auxiliary materials'). In this step, which is known as 'normalisation' in the environmental footprint method, the average composition of each cost category is determined per sub-sector. After that, each cost category is scaled up to the sector level per sub-sector, based on the data from the Annual Healthcare Report.
2. *Direct request for data from healthcare providers*
   In this option, more detailed spend-data is obtained by collecting financial data directly from healthcare providers. Using stratified random sample approach, the average time investment required from providers is reduced, while still generating enough data per sub-sector to allow extrapolation to the national level.
   The sample is taken from the total population of healthcare providers listed in the Annual Healthcare Report. It is then stratified based on core activities (sub-sector) and other relevant characteristics, such as revenue or size of the workforce. This creates subgroups of comparable healthcare providers within the population, with the aim to reduce variability in the collected data. During the implementation of the footprint method, the specific characteristics for stratification of the population will be determined in an iterative approach.
   Data collected through the sample approach will be sourced from the administrative records of healthcare providers. Most healthcare providers use Enterprise Resource Planning (ERP)

systems for their operations, which track procurement, logistics, and finances. ERP systems typically include modules for procurement processes, assortment management, and contract management. Cost overviews are often generated from the 'accounts payable' administration, which records purchased products and services at the invoice level. Procurement organisations such as Intrakoop use these data to provide tailored advice. In other words, healthcare providers already have data that can offer insight into the products and services they purchase, this is information that can make a significant contribution to calculating their environmental footprint and prioritising sustainability measures.

However, collecting data for this second option of the specific model faces three major challenges. First, there is no standardised system for recording costs in healthcare organisations. Organisations often have an individual approach to keeping track of their accounts. Similarly, there is no agreed-upon, uniform classification system for medical products, even though these products play a key role in tracking environmental impacts and making healthcare more sustainable (Ecorys, 2011; Intrakoop, 2020). Second, there are considerable differences in the way healthcare organisations operate, even when they provide similar types of care. For example, food services may be outsourced or prepared in-house. If such differences are not taken into account, large variations in operating costs can arise, leading to variations in the final environmental footprint calculation Third, directly requesting data from healthcare providers is challenging to implement. Collecting data in this way is time-consuming and can result in a high level of non-response, as shown in the Monitor on Socially Responsible Commissioning and Procurement (MVOI), conducted by RIVM since 2016 (Hollander et al., 2023).

To address the first two challenges, proper categorisation and harmonisation are essential. This means that the same cost and product categories must be applied consistently. Categorisation can take place either before data collection (at the source, by the data suppliers) or afterwards (by the data receiver). Several initiatives are currently underway among healthcare providers, such as the introduction of a standardised classification system for medical devices. Additionally, procurement organisations and partnerships have considerable experience in manually categorising large datasets.

Considerations

The choice between the available options for collecting detailed operating cost data has a direct impact on the quality and representativeness of the environmental footprint method. The highest level of representativeness can only be achieved by drawing a random sample from the entire population of healthcare providers and analysing the operating costs of those selected providers as the basis for extrapolation to the national level.

By contrast, collecting data through existing procurement partnerships inevitably introduces selection bias. Not all healthcare providers are members of such partnerships, and even among members, not all share their spending data. In addition, the membership of purchasing cooperatives tends to be concentrated in particular sub-sectors and among organisations of a certain size. For instance, Intrakoop has around 500 member organisations, but only 80 currently share their spending data. Most of these 80 are organisations from the nursing, care, and homecare sector (VVT), with smaller shares from mental healthcare (GGZ) and disability care (GZC), and only a few hospitals. As a result, data collected solely through procurement partnerships will be less representative of Dutch healthcare as a whole and therefore less suitable as the basis for reliable environmental footprint calculations and sector-wide decision-making.

Follow-up
The choice between the three options is included as an important step of the method, as it is necessary to assess whether the current information flows and systems of healthcare providers and partnerships are able to meet the data requirements of the environmental footprint method. This calls for collaboration with organisations in the field, which is beyond the scope of this method document. To nevertheless ensure a practicable environmental footprint calculation method, we have opted for the distinction between the basic model and the specific models. This is because the basic model is not subject to the points mentioned above and can be implemented as the conditions for specific models are being assessed in collaboration with healthcare providers.

4.2.2.3 Pharmaceutical products and medical aids in outpatient settings

In addition to considering the indirect environmental impacts of the annual expenditure on products and services within Dutch healthcare and long-term care, the method will also account for the indirect environmental impacts of the production of pharmaceutical products and medical aids prescribed in outpatient settings. For these products the same lack of detailed environmental data applies, making it impossible to calculate the environmental impacts using a bottom-up approach. IOA is therefore also used for this category of products. As the IOA method and the required steps have already been explained, this section is limited to a description of the data source.

In the Netherlands, data on pharmaceutical products and medical aids prescribed in outpatient settings are gathered and processed by the National Healthcare Institute (ZiN), as part of the Pharmaceutical Products and Medical Aids Information Project (GIP) (ZiN, n.d.). The GIP database, which is accessible to the public, contains data on the number of provisions, standard daily doses, costs and number of users. This data is based on claims for pharmaceutical care and medical device care provided by 19 care insurers. This concerns pharmaceutical products and medical aids prescribed by GPs or medical specialists outside a hospital and subsequently provided by dispensing GPs or medical aid suppliers. The data only includes items that are covered by basic insurance under the Health Insurance Act.

To categorise pharmaceutical products and medical aids, the GIP database uses existing information systems such as the G-Standard of Z-Index, the Bever medical aids file of Nigella and the indexes of the WHO's Anatomic Therapeutic Chemical Classification with defined daily doses (ATC/DDD) (ZiN, n.d.). As a result, the level of detail of data in the GIP database is relatively high, and the use of the data in the environmental footprint method requires no further preparatory steps.

Once the data has been obtained from the GIP database, the expenditure is linked to the corresponding industry categories in the EE-MRIO table, as was the case with purchased products and services in section 4.2.2.2. However, since the MRIO table only has two industry categories which correspond with medical aids and pharmaceutical products, a distinction is made only between spending on medical aids and spending on pharmaceutical products.

4.2.3 *Indirect waste generation*

The 2022 method takes indirect waste generation into account for the assessment of the sectoral impacts. This refers to waste arising from the supply chains of products and services purchased by the Dutch healthcare sector. Indirect waste generation is an important environmental impact to consider, particularly because service-oriented sectors such as healthcare generally exhibit higher levels of indirect waste generation compared to sectors with more primary economic activities, such as construction (Salemdeeb et al., 2016).
This difference can be explained by the healthcare sector's reliance on broad and complex supply chains, which cover a wide range of products and services, from medical equipment and pharmaceuticals to cleaning services and food. Each step in this chain contributes to the overall environmental impact, including indirect waste generation.
By contrast, the construction sector also has significant environmental impacts, but these are often concentrated in direct waste generation from construction and demolition activities. Although construction can also produce indirect waste, the diversity and complexity of its supply chain are generally lower than those of the healthcare sector.

In the 2022 method, waste generation was included by adding waste generation from the extension of the hybrid Exiobase supply-use table. In Exiobase v3, waste flows are represented through a dedicated waste module that links production activities to waste generation and treatment. Potential waste is calculated using a mass-balance approach, meaning that all inputs that are not embodied in final products or recorded as emissions, are treated as waste. These calculated flows are then linked with country-specific data on waste management, which determines how much is recycled, incinerated, landfilled, or composted (Merciai & Smith, 2018).
However, this data was only available for 2011, while the rest of the model was based on 2016 data (Steenmeijer et al., 2022). This temporal mismatch introduces inaccuracies because waste generation patterns, treatment technologies, and recycling rates may have changed considerably. As a result, the calculated footprint may either overestimate or underestimate current waste generation, depending on whether overall waste production or recycling efficiency has increased or decreased over time.

At present, it is not possible to include waste generation in the sectoral footprint method due to a lack of suitable and up-to-date waste data. This is because waste flows are not included as environmental extension or other flow in the EE-IOA database used in the method. Nevertheless, as shown in the 2022 method, the inclusion of waste flows in IO tables is technically possible. This is also demonstrated in other IO databases, where waste flows are included by applying a waste input–output (WIO) model or by using physical or hybrid IO or supply–use tables with waste fractions (Towa et al., 2020). Still, the other benefits of PBL-FIGARO, such as its temporal relevance and healthcare specificity, are reason to select this database for the model despite its lack of a waste extension.

The exclusion of indirect waste generation is recognised as a limitation of the updated 2024 method. However, its inclusion is not considered a priority at this stage, given the relatively greater importance of direct waste generation by the healthcare sector. In parallel with the implementation of the method, further investigation will be carried out into the possibility of extending the IO database or making use of other data sources.

5 Discussion

5.1 Reflection on the objectives

The 2024 method was designed with specific objectives in mind, which serve as guidelines for both its development and evaluation. In this chapter, we explore whether those objectives can actually be achieved with the proposed approach.

The main objectives of the method are as follows: 1) identifying hotspots within the healthcare sector where sustainability measures potentially have the greatest impact, 2) helping set priorities for sustainability measures, 3) producing key environmental indicators for the healthcare sector and 4) contributing to progress monitoring on the path towards a sustainable healthcare sector.

In support of these key objectives, we have formulated sub-objectives that establish the preconditions for the method. For example, the data must reflect specific time periods so as to make it possible to monitor developments between the various reporting periods. Additionally, the continuity of the method must be guaranteed to enable consistent evaluations over time. Also, the results should reflect sector trends, which calls for a sufficient level of detail in both the data and results.

Both the basic model and the specific model can be said to achieve the primary objectives. The breakdown by sub-sector and activity category helps us estimate more effectively which parts of the healthcare sector contribute most to the sectoral footprint. In addition, the implementation and use of data sources that are updated more frequently ensures continuity, making a better fit for the Sustainability and Health Monitor (Ministry of Health, Welfare and Sport, MEVA).

Nevertheless, not all sub-objectives are achieved. For example, the method offers little opportunity to study trends or to identify causal links between measures and their effect on the environmental footprint.
The next section first discusses the procedural limitations. This includes the challenges and risks that arise from implementation of the method. The second section explains the disadvantages of the environmental impact calculation methods used (IOA and LCA). The chapter concludes with two sections on follow-up steps in the implementation and further development of the method.

5.2 Procedural limitations

The method has two procedural limitations: its dependence on third parties and the need for time-consuming steps in the processing of the data received. These limitations arise from the way in which information in the Dutch healthcare sector is organised.

Reflection on data availability
The data landscape in the Dutch healthcare sector is characterised by a decentralised public-private system. This is reflected in all aspects of the sector, including the supply chain of products and services.

This decentralisation creates a complex network of information flows, involving healthcare providers, procurement organisations, care insurers, policymakers and other actors. The need for insights from all those actors has generated a significant demand for data in a landscape where data is fragmented or tends to be hard or impossible to access. This lack of information has fuelled the rise of various types of information owners and traders, ranging from joint initiatives and consortiums to commercial players that aim to inventory and map out data flows. Despite their efforts, none of those parties appears to have a comprehensive overview of any specific category in the healthcare sector, such as medical aids, pharmaceutical products or food services.

This fragmentation is exacerbated by the lack of uniform methods to collect, process and access data. Variations in the systems used, such as classification and accounting systems, contribute to an inconsistent body of data – as do the diverse approaches to modelling and extrapolating the data. This makes it hard to present a consistent picture of the healthcare sector's environmental footprint. The multiplicity of actors in this 'information market', which all have their own interests and operating methods, underscores the need for intensive collaboration and coordination.

Various data sources and dependencies
The methodology uses many different types of data, most of which are owned by a range of organisations. Some databases and datasets are public, but not all. This means that access to data and authorisation of its use for the purpose of calculating the environmental footprint depend on agreements with every individual data owner. In all cases, there are risks regarding the continuity and consistency of data, given the absence of firm guarantees as to its future availability. The preliminary study involved consultation with several institutions and data owners (such as PBL, CBS, EVZ and Rijkswaterstaat), which may help to reduce those risks. The dependence on third parties has also contributed to the division of the model into a basic model and a specific model. Although the basic model also relies on third parties, the types of projects and programmes from which the data originates make it more likely that continuity can be ensured. The small share of dependencies in the basic model that carry a higher risk can largely be mitigated by expanding the EE-IOA in the basic model, although this partly comes at the expense of its representativeness. In the specific model, the dependencies and risks are significant. For this reason, additional exploration and coordination with the data owners and stakeholders is desirable (see section 5.3).

Heterogeneity of data and categorisation
As explained above, the use of various types of data presents unique challenges, due to the differences in units, quality and level of detail (as discussed in section 3.1.3.).
One crucial step in processing the data, therefore, is the categorisation of the physical and monetary data according to SBI business sectors. This task is currently divided between three parties (CBS, EVZ and the party that makes the environmental footprint calculation), which increases the risk of inconsistencies. Agreements on the division of tasks and harmonisation of the categorisation method could reduce this risk.

Risks in relation to categorisation also exist in the processing of data retrieved from healthcare providers, such as operating costs in the specific model. This is due to the absence of a standard accounting system, and to the use of various calculation methods and classification systems to track the product range and operating costs. To open up the data for internal or external research, the classification and categorisation are in some cases carried out by the healthcare providers themselves, but more commonly by partnerships and external parties. This has created huge variations in the classification of costs in the product categories and accounting systems.

We have identified two possible solution strategies to mitigate such inconsistencies. Both these strategies are beyond the scope of this assignment and, for that reason, are recommended as subjects for further research.

1. One strategy is to develop and apply a uniform accounting system, the possibilities for which are currently being studied within several projects in the healthcare sector (such as GS1 Nederland, n.d.). If healthcare providers and suppliers of pharmaceutical products and medical services in the Netherlands use a standardised system for product data, it will become easier to collect up-to-date information on the use of products and services in the healthcare sector. This also creates possibilities to feed further product data into information systems which can be valuable for detailed analyses from a bottom-up perspective.
2. Another strategy is to automate data collection and processing. At present, these processes are largely manual, increasing the risk of human error. Automation, possibly supported by techniques such as machine learning, will help to structure heterogeneous data more effectively according to a scheme that is aligned with the environmental footprint method. In addition to improving the quality and consistency of data, this would also increase process efficiency.

5.3 Methodological limitations

Some limitations of the individual methods included in the methodology have substantial consequences for the quality and reliability of the results. This section first discusses the limitations that have direct consequences for the objective of the methodology. The next section will introduce several general limitations.

Not all costs are recorded

In input-output analysis, it is important that all activities that are harmful to the environment can be expressed in terms of costs, and that the relevant data can be collected. However, there will always be products and services that are used by healthcare professionals but that are not reflected in the costs accounted by healthcare organisations. Examples include the use of personal digital storage, personal mailboxes and the personal purchasing of office items or other work-related products. Within the healthcare sector as a whole, the current share of these components is unlikely to be high, but this may well change in future, for example with the increasing use of AI-tools as a personal assistant.

Limited representation of sustainability efforts in cost-based analyses
One fundamental assumption in IOA is that all production processes within a particular sector or industry category are comparable (the homogeneity assumption). This means that IOA assumes that all manufacturers in the pharmaceutical sector, for example, produce pharmaceutical products in the same way – which is not actually the case. The simplifying effect of this assumption can result in major distortions and mistaken interpretation of the results (Kitzes, 2013). The disadvantage within the environmental footprint method is that the procurement of more sustainable products will not reduce the footprint unless their production is significant on the scale of the entire industry category of manufacturers. Indeed, the opposite effect may occur. As sustainable products tend to be more expensive than conventional ones, in a cost-based method, this may result in a higher assigned environmental burden. For technological transitions, therefore, such innovations and sustainability measures should be incorporated externally into the analysis (de Bortoli & Agez, 2023).

The specific model partly accounts for this: for example, for reusable instruments, there will be a shift from costs of purchasing products to costs of sterilisation. However, the same level of specification cannot be achieved on the key environmental indicator side within the MRIO database. This is because these indicators are highly aggregated, resulting in the combination of a wide variety of producers at different sustainability levels in the inddustry categories (the aggregation issue, Kitzes, 2013; Eurostat, 2021). A strong increase in the number of products and industries included in these databases in the near future is unlikely. So there is a reasonable chance that, while trends can be identified on the cost side (input), they will not be reflected directly or in similar detail in the actual environmental footprint calculation results (output).
Nor do input-output tables always reflect large-scale innovations. For example, PBL-Figaro does not yet include a suitable industry category for the use of AI and digital storage, despite the strong increase in the use of these services and the associated demand for energy. If the servers for digital storage and AI are not located on the premises of the organisation, there is currently no way to quantify the environmental footprint of these services within the healthcare sector.

Causal links cannot be demonstrated
EE-IOA is a macro-economic method that uses relationships between sectors and statistical tables. This makes it difficult to distinguish the direct effects of specific actions or policy measures from other influences, such as technological progress or market dynamics within the chain (Aguilar-Hernandez et al., 2018). When the environmental footprint of the healthcare sector decreases, there may be various causes, such as the use of more renewable energy in the chain or the procurement of products from healthcare providers in different regions. This makes it difficult to determine the extent to which specific sector agreements have contributed to the decrease.

Also note that EE-IOA and LCA are environmental modelling techniques that inherently include simplifications. Although they are suitable for producing general estimates of the effect of policy measures, they do not account for other, less predictable consequences of those measures (Walzberg et al., 2021). To improve our understanding of the underlying mechanisms and of the complexity of policy measures, we need methods that allow a system-wide analysis of all interactions and time dynamics. Dynamic analytical techniques can provide a solution in this regard.

Examples include system dynamics modelling (SDM), involving the study of relationships between the elements of a system by means of causal diagrams and feedback loops, and agent-based modelling (ABM), involving observation of the interactions between individual agents (organisations, individuals, etc.) in relation to macro-outcomes (Asif, Lieder & Rashid, 2016; Lieder, Asif & Rashid, 2017). Controlled experiments and data analysis can help to identify emerging patterns and potential causal mechanisms. In order to determine whether the relationships suggested by these dynamic models are truly causal, the models must be carefully validated using historical and empirical data, combined with literature and additional analyses.

By simulating the time dimension and interactions, dynamic models can be used in follow-up research to provide insight into a system’s sensitivities and leverage points, and into possible causal mechanisms. Even so, integrating these methods remains a complex exercise (Walzberg et al., 2021). This is why the use of these methods for enhancing the insights from environmental analyses is being studied as part of the RIVM Sustainability and Health programme.

Other challenges of IOA and LCA
Both methods come with limitations, which are only partly compensated if the methods are combined. Linking the two methods and applying them in combination (hybridisation) produces additional limitations to be taken into account.
One important limitation of IOA is that the MRIO (multiregional input-output) tables contain inconsistencies and aggregation errors. These tables combine data from various national and international sources, potentially resulting in discrepancies compared with the original data. One solution is to apply the Single And Multi-regional Consolidated Approach (SAMCA method) develop by CBS. In that approach, data is split geographically and aligned more closely with national accounts (Walker et al., 2023). However, this CBS method is still under development and is mainly intended for use in CBS’s own research projects. For this reason, it cannot be used in the environmental footprint method any time soon.

LCAs often struggle with gaps in the analyses, due to the fact that it is hard or even impossible to fully map out supply chains. This leads to errors as certain environmental impacts are not taken into account, causing the final calculation to be lower. This type of error is known as the ‘truncation error’ in LCA. The combination of LCA and IOA can present additional problems, such as double counting or further truncation errors. In hybridisation, some IOA data is replaced by specific bottom-up data, increasing the risk of environmental impacts being double-counted or, conversely, being ignored.

Scope limitations
The system boundaries of the environmental footprint calculation impose a limit on the completeness of the footprint. As explained in chapter 2, the environmental impacts for healthcare and long-term care are calculated excluding informal and community-based care. However, the environmental impacts caused by home-based consumption of healthcare products and services are not fully included either, due to the limited availability or quality of the data. Only the direct impacts from aerosols in the use of metered-dose inhalers are calculated. The indirect impacts of home-based consumption are limited to products and services covered by the Health Insurance Act (4.2.2.2). Other items, such as products sold over the counter, are excluded. This means that part of the care that qualifies as healthcare and long-term care is excluded from the calculation.

The method does not provide for a uniform reporting system for environmental impact indicators. The data that can be collected for the indirect components (in the chain) of freshwater consumption and waste generation is insufficient. Hence, the objective to calculate both the direct and indirect components for all environmental impact indicators, thereby clarifying the role of the healthcare sector compared with other sectors, has not been achieved.
PBL Netherlands Environmental Assessment Agency is currently examining the possibilities for implementing freshwater consumption in PBL-FIGARO, which would ultimately enable the calculation of the indirect impacts of freshwater consumption. It is unlikely that this will also be realised for indirect waste generation.

5.4 Use to the healthcare sector, implementation and collaboration

Collaboration with healthcare organisations yields the best insights. To achieve the best possible method, therefore, we will have to collect data both from individual healthcare organisations and sector associations.

Many healthcare providers are keen to work on sustainability issues, as is reflected in the commitment of healthcare providers to GDDZ 3.0 and the variety of long-term partnerships. In addition, laws and regulations on climate and the environment are being developed, which come with implications for the healthcare sector. This is fuelling a growing need for knowledge about the environmental performance of healthcare providers. This, in turn, is reflected in a growing demand for information from the healthcare sector as well as a growing diversity in sustainability projects. There are opportunities for collaboration in this area, not only to collect data for the environmental footprint method but also to provide this back to healthcare organisations as valuable insights.

An example is the upcoming Corporate Sustainability Reporting Directive (CSRD), which is expected to implications for the sectoral footprint methodology. Several European Sustainability Reporting Standards (ESRS) indicators align closely with the quantitative indicators used in the method. This creates a two-way relationship, data reported under the CSRD could be used to improve the footprint methodology, reducing the need for direct data requests from healthcare providers and thereby lowering administrative burdens. Conversely, the sectoral footprint results can help organisations in the sector, such as healthcare insurers, in meeting their own CSRD reporting requirements by providing sub-sector level insights into environmental performance. This applies to other organisations within the healthcare sector as well, and has benefits to organisations that fall outside of the CSRD requirements (Stobernack et al. 2025).

This section briefly discusses the scope of collaboration and ways to ensure its proper management.

Scope of the collaboration
So far, 20 major parties have been identified for the basic model. These parties manage crucial data, play a key role in the implementation of the method or have a significant interest in the results and the way they are presented. These 20 parties include 9 healthcare sector associations, the other 11 include knowledge parties and governmental organisations.
For the specific model, the number of parties on which the method depends is many times greater. This is due to the wish to obtain data from healthcare providers and the random sample approach required for that purpose. However, all that is required is a check with the sector associations to which the healthcare providers are affiliated.

For each of the 20 parties, it must be determined, among other things, whether the data can be provided at the required frequency. This also includes identification of what is needed for the data to be shared. For example, is the required infrastructure in place, are there any confidentiality issues and does the data on the supply side match that on the demand side? What is important in the environmental footprint method is to identify both the role of parties such as the data owners and to gain a clearer picture of their interests in the results. For example, some parties will have a need for benchmarking as well as for insight into their own performance. To clarify the influence of the parties on the method and vice versa, an exploratory study must be conducted.

Exploratory study
For that reason, Q1 2025 will see a series of exploratory talks to identify the parties willing to enter into a partnership. Next, in Q2, these parties will be invited to consider the options for providing the requested data and the possibilities for subsequently processing this data. This will serve as a basis for mapping out the digital infrastructure for data collection.
A partnership plan will then be drafted with the parties willing to join. This plan is expected to be completed in Q2, which marks the start of a test phase (pilot) for implementation (Q3 2025).

Test phase
The test phase will consist of retrieving, harmonising, categorising and processing the data and discussing the provisional results with the participants, in the form of iterative processes. This will include attention for new opportunities and for possibilities to use the environmental footprint in action perspectives for the participating organisations

and the healthcare sector at large. It also includes the more effective organisation of procurement data or (compulsory) annual reporting. Next, the method will be implemented and the final results will be published in an RIVM report (2026).

5.5 Further methodological development

Immediately following delivery of the method document
The methodology includes several steps and choices which are essential but can only be made once the first data comes in. In other words, this is where the next steps in the implementation of the method are shaped. This concerns the following elements:

- Sample determination: the size of the sample is determined in part by the variation in the data between the healthcare organisations that supply it. To understand the extent of variation, an example dataset must first be requested and analysed. Next, the sampling method must be developed in consultation with statisticians within the organisation.
- Classification by SBI business category and activity category: Bottom-up physical and monetary data will be categorised by multiple parties. The possibilities for a harmonised categorisation system or model have to be explored and assessed.
- Linking monetary data to EE-IOA industry categories: because the industry categories have been aggregated in MRIO tables, multiple products and services will have to be grouped together and linked to the appropriate industry category. Decisions on the aggregation of monetary data require better insight into this data.

Further development in the long term
While the proposed 2024 method is an improvement compared with the 2022 method, some issues remain that even this method is unable to resolve. The further development required to address these issues is beyond the scope of this assignment. Even so, in parallel with the implementation of the method, an exploratory assessment will be conducted to determine which improvement steps are feasible in the following areas:

- Scenarios – Despite method improvements, it is still impossible to calculate the effects of sustainability measures in the healthcare sector or to assess the impact of changes in the sector on those measures. It is necessary, therefore, to further develop the method for application in scenario analyses. This is why we recommend that a follow-up study be carried out in collaboration with experts and knowledge institutions specialising in environmental methodologies. That study could focus on combining dynamic models with EE-IOA and developing datasets that distinguish more effectively between sustainable and non-sustainable processes. Those improvements might help policymakers make more effective choices and accelerate the transition towards sustainability. For more information about this recommendation, also see the SIA knowledge memorandum, previously conducted by RIVM (Coenen, Garcia Valicente & Pieters, 2024).

- Adding further environmental impact categories – The current selection of environmental impact categories does not fully reflect the healthcare sector's environmental footprint. Due to a lack of data, impact categories such as ecotoxicity, terrestrial acidification and eutrophication are not taken into consideration. For this reason, the conditions for extending the environmental impact categories will be included in the environmental footprint reports.
- Development of tools – Following implementation of the first environmental footprint calculation according to the 2024 method, we will examine whether it is desirable and possible to make the methodology available to healthcare providers as a tool to help them gain insight into the environmental footprint of their own organisations. In that context, we will also examine whether the detailed data from healthcare providers can lead to more detailed analyses and extra perspectives for action.

6 Conclusion

This method report describes the method for calculating the environmental footprint of the Dutch healthcare sector. The report builds on the 2022 method, with several improvements.
Sector-wide environmental footprint calculations have the potential to support efforts to make the healthcare sector more sustainable, by helping identify environmental hotspots and by setting priorities for sustainability measures, policy and research. These calculations make it possible to evaluate initiatives and measure progress, and their key figures emphasise the urgency of mitigation efforts and the sector's responsibility. Sectoral environmental footprint calculations support more detailed sustainability studies on specific subjects and themes, and complement the current monitoring of GDDZ themes.

Compared with the 2022 method, the revised methodology introduces several significant changes:

- More detailed insights: by disaggregating the environmental footprint results by sub-sector (such as hospital care, home care and care for the disabled) and activity category (such as energy, mobility and procurement of pharmaceutical products), sustainability measures can be identified and prioritised more effectively.
- More bottom-up data: thanks to existing sustainability initiatives within and surrounding the healthcare sector, a larger share of the calculation involves measured data, compared with the aggregated statistics of the 2022 method. One example is the use of data from Sustainability and Health Monitor Theme 3 of GDDZ 3.0, by EVZ.
- More specific data: healthcare providers, whose role in the methodology remains important, are asked for more specific data regarding their spending. This makes it possible to map out more categories and identify hotspots.
- Better IOA database: this monetary data is linked to a more suitable and updated database with key environmental indicators, to ensure that the methodology remains useful over the years ahead.
- Periodic calculation: Thanks to these improvements, the methodology can be implemented periodically, contributing to the monitoring of trends in the sector.

Challenges and limitations

Although the improved methodology represents a step forward, it still has clear limitations. The absence of harmonised data streams and a standardised accounting system within the healthcare sector remains a barrier to consistent data collection. In addition, there are currently insufficient environmental intensity factors available to perform a complete environmental footprint calculation using a bottom-up approach. As a result, the method cannot yet provide recommendations at the level of individual products or clinical procedures.

Furthermore, an important component of the methodology — the specific model — depends on close collaboration with healthcare providers to obtain additional and detailed data. Without such collaboration, certain analyses can only provide high-level insights, which limits the practical applicability of the results at the organisational level.

The role of collaboration

One conclusion we can draw from the development of the method, therefore, is that collaboration within the sector is essential to address these limitations. Healthcare providers play a dual role in this process. On the one hand, by sharing detailed data they can contribute to a more complete and accurate picture of the sector's environmental footprint. On the other hand, the methodology and its reporting provide a way to feed insights back to providers, helping them to identify and implement concrete sustainability measures. This interplay between data provision and feedback is essential for the overall effectiveness of the methodology.

Follow-up

It is necessary, therefore, to strengthen and further develop collaboration with healthcare providers, sector associations and knowledge organisations. This should include efforts to explore data sharing processes and reduce the administrative burden, for example through existing initiatives such as sector-wide sustainability programmes. At the same time, it is important to examine how the methodology could support healthcare organisations with practical tools and insights helping them to manage their sustainability processes independently.

These efforts will start at the beginning of Q1 2025 with a combination of interviews with stakeholders and presentations. During the subsequent test phase, we will examine in consultation with a group of stakeholders whether the required data can be delivered.
In parallel with this process, we will start calculating the environmental footprint of the healthcare sector in accordance with the basic model, which can then be enriched with the outcomes of the exploratory study.

Conclusion

The revised methodology provides a solid basis for monitoring the environmental footprint of the Dutch healthcare sector. In the execution phase, the practice of not only retrieving data but also exploring ways of returning the findings to healthcare organisations will help to further improve the methodology. Collaboration, improvement of data quality and data sharing are key ingredients of this approach. In this way, the methodology will promote the transition to a climate-neutral and circular healthcare sector in the Netherlands.

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8 Glossary

Description of an environmental footprint

- **Environmental stressor**: The environmental impact of an element, such as CO_2 emissions, land use, metal extraction or water consumption.
- **Environmental impact**: The actual environmental damage caused by an environmental stressor, such as the impact of CO_2 emissions on climate change.
- **Environmental impact category**: The categories into which environmental stressors are classified, such as acidification of terrestrial or marine ecosystems, climate change, ozone layer depletion, fine particulate matter formation, etc.
- **Environmental footprint**: The total impact of a sector, organisation or product on the environment, specified for multiple environmental impact categories.
- **Environmental intensity factor**: A factor that indicates the volume of an environmental impact per unit of a particular activity (e.g. CO_2 emissions per euro spent).
- **Midpoint indicator**: A figure that indicates the environmental pressure at the level of an individual environmental problem, e.g. climate change, acidification or ecotoxicity. An environmental intervention, such as the release of a particular substance into the air, can contribute to one or multiple midpoints.
- **Endpoint**: A measurement level that indicates the eventual damage to human health and ecosystems.
- **Characterisation**: The assessment of environmental impacts, divided across multiple impact categories using midpoint or endpoint indicators.
- **Characterisation factor**: A factor that determines the extent to which an intervention contributes to an environmental impact.
- **Global Warming Potential (GWP)**: A relative measure that indicates the greenhouse effect of 1 kg of a substance in the atmosphere over a specific period of time. GWP is expressed relative to the effect of 1 kg of CO_2 in the atmosphere. The GWPs most frequently used today have been calculated over a period of 100 years.
- **Greenhouse gas**: A gas that contributes to global warming and climate change by trapping heat within the atmosphere.
- **CO_2 equivalents** (CO_2-eq): **A unit of measurement** that is used to compare emissions of several greenhouse gases based on their GWP by converting the quantities of other gases to the equivalent amount of carbon dioxide with the same GWP.
- **Ecotoxicity**: The harmful effects of substances on ecosystems, in particular on water and soil systems.
- **Climate resilience**: The extent to which a system can resist climate change and extreme weather conditions.
- **Climate change** (kt CO_2-eq): The long-term shift in average weather patterns on Earth that is caused by natural processes

but primarily by human activity, in particular the emission of greenhouse gases measured in kilotonnes of CO_2 equivalents.
- **Abiotic use of raw materials** (kt): The amount of non-biological raw materials, such as metals and minerals, used in the healthcare sector.
- **Biotic use of raw materials** (kt): The amount of biological raw materials, such as crops and wood, used in the healthcare sector.

Description of the environmental footprint method

- **Bottom-up**: An analytical method whereby data from individual processes is collected and scaled up to present a comprehensive overview.
- **Top-down**: An analytical method whereby an overall picture is broken down into detailed components.
- **MRIO tables**: Multi-regional input-output tables that represent the economic and environmental interrelations between regions and sectors.
- **IOA** (input-output analysis): An economic analytical method that describes relationships between sectors and is used for environmental impact studies.
- **Cradle-to-gate**: A partial life cycle assessment of a particular product, from the extraction of the raw material (cradle) to the factory gate. The phases in which the product is used or turns into waste are not included in the impact assessment.
- **Cradle-to-grave**: A total life cycle assessment of a particular product, from the extraction of the raw material (cradle) to production, transport, product use and waste processing.
- **(EE) MRIO – (environmentally extended) multiregional input-output table**: An input-output table composed of the economies of several countries or groups of countries, as distinct from a single-region table, which covers a single national economy.
- **EE-IOA – environmentally extended input-output analysis**: An IOA with environmental extensions, used to calculate the environmental impacts of global value chains.
- **LCA – life cycle assessment**: A method used to examine the environmental impacts over the total life cycle of a process, product or material.
- **LCI – life cycle inventory**: The second step in an LCA. An LCI is a collection of all environmental interventions (emissions into and extractions from the environment) that occur within a defined system.
- **LCIA – life cycle impact assessment**: The third step in an LCA, in which environmental interventions are quantified into environmental impact scores (midpoints and endpoints), based on characterisation factors.
- **Contribution analysis**: A contribution analysis calculates the indirect impacts of purchased goods and services (the embedded impact of the total value chain per product).
- **Hotspot analysis**: A hotspot analysis is used to calculate the indirect impact for the location (a sector or geographical area) where the physical impact occurs.

- **Structural path analysis**: A technique used to analyse the contributions of individual production chains to the total environmental footprint.
- **Truncation error**: An error that occurs in LCA and IOA models due to the omission of some environmental impact factors.
- **Double counting**: The unintended double inclusion of emissions or environmental impacts in calculations, usually due to the use of multiple methods or datasets.
- **Industry category**: A classification of economic activities, used in MRIO tables and CBS statistics.
- **Supply chain**: The chain of companies and processes that contribute to the manufacture and delivery of healthcare products.
- **Activity category**: A categorisation of activities within the healthcare sector based on their environmental impacts.

Description of data and sources

- **Exiobase**: A commonly used MRIO database that provides economic and environmental data per sector and region.
- **PBL-FIGARO**: An EE-MRIO database managed by PBL that provides better alignment with European statistics (Eurostat FIGARO).
- **Ecoinvent**: An LCA database with data on the environmental impacts of products and processes.
- **ReCiPe**: A frequently used environmental impact assessment method within LCAs.
- **Environmental accounts** (CBS): National statistic compiled by Statistics Netherlands (CBS) monitoring the environmental impact of various sectors of the economy.
- **SAMCA**: A specific method for CBS environmental accounts, aimed at sectoral analyses in conjunction with national statistics.
- **Statline**: An open CBS database with statistics on the economy, environment and healthcare.
- **Eurostat**: The statistical office of the European Union, which gathers economic and environmental data at the European level.
- **SBI** (Standard Business Classification): A classification of companies and sectors used by CBS.
- **SHA** (System of Health Accounts): An international standard for care expenditure and economic analyses in the healthcare sector.

Description of the healthcare sector

- **Healthcare sector**: All providers of curative care or long-term care and nursing.
- **Sub-sector**: A specific segment of the healthcare sector, such as hospitals or home care.
- **Primary care**: Healthcare that is directly accessible to patients without a referral, such as GP care, physiotherapy and dental care.
- **Informal and community-based care**: Preventive care and public healthcare without any direct involvement of a healthcare provider, such as information services and vaccination programmes.

- **Care sector**: The sector of long-term care, such as nursing homes and home care.
- **Cure sector**: Curative care, such as the care provided by hospitals and specialist care.

Abbreviations

- **GDDZ 3.0** (Green Deal Sustainable Care 3.0): A sustainability programme and set of agreements between the national government and parties in the healthcare sector, the aim of which is to reduce the environmental impact of that sector.
- **EVZ** (Centre of Expertise for Sustainable Healthcare): A knowledge and support platform that helps healthcare organisations make their buildings and processes more sustainable by offering practical tools, advice and expertise.
- **VWS** (Ministry of Health, Welfare and Sport): The government ministry responsible for healthcare policy in the Netherlands.
- **RAV** (Regional Ambulance Service): A partnership of ambulance service providers.
- **NVA** (Netherlands Society of Anaesthesiologists): Professional association of anaesthesiologists.
- **RWS** (Rijkswaterstaat, Directorate-General for Public Works and Water Management): A government organisation that is responsible for infrastructure and the environment and is involved in environmental policy.
- **LMA** (National Waste Control Centre): A centre for registering waste materials in the Netherlands.
- **EURAL codes**: European codes for waste classification.
- **AMICE** (Electronic Information and Communication on Waste Reporting): A database in which the receipt and transfer of waste materials are recorded through notifications. The government body responsible for AMICE is Rijkswaterstaat.
- **GO** (Guarantee of Origin): A certificate for sustainable sources of energy.
- **RVO** (Netherlands Enterprise Agency): Government organisation that offers subsidies, schemes, knowledge and networks to entrepreneurs, businesses and public authorities to support them in carrying out sustainable, innovative and international activities.
- **WPM** (Work-related Mobility of Persons Act): A monitoring programme of the Ministry of Infrastructure and Water Management to monitor greenhouse gas emissions from business travel and commuter transport.
- **NFU** (Netherlands Federation of University Medical Centres): A partnership of university medical centres.
- **NVZ** (Dutch Hospital Association): An association that looks after the collective interests of hospitals in the Netherlands.
- **MPZ** (Environment Platform for the Care Sector): Umbrella organisation for sustainability in the healthcare sector.
- **DigiMV**: A digital platform for the financial annual reporting of healthcare institutions.
- **NZa** (Dutch Healthcare Authority): Healthcare market regulator.
- **ZiN** (National Healthcare Institute): An organisation that monitors the quality and funding of healthcare.

- **GIP** (Pharmaceutical products and medical aids information project): A system for the registration of pharmaceutical products and information about their use.
- **ERP** (Enterprise Resource Planning): Software for business management and logistics.
- **CSRD** (Corporate Sustainability Reporting Directive): An EU directive under which major organisations are obliged to report their environmental impacts.

9 Appendices

9.1 MRIO databases

Multi-Regional Input-Output (MRIO) tables have been compiled based on data from national statistical offices and on international trade flows. The sources used and the composition of the data vary from database to database. As a result, databases have characteristics that influence the quality of the environmental footprint that is calculated using them (Tukker en Dietzenbacher, 2013). Criteria that are important for environmental footprint calculation are the consistency, timeliness and level of detail of the databases used. it is also important for databases to cover a broad spectrum of environmental impacts (Wilting, 2022). For this monitor, that means that the selected MRIO table should preferably:

- use data that is consistent with national statistics, also of other countries, to ensure international comparability of data;
- be updated regularly;
- cover a large number of industry categories, especially the individual categories that are essential for the healthcare sector;
- contain environmental pressure data on the climate and the circular economy.

MRIO standard databases

There are various global MRIO databases. The most frequently used databases are GTAP (Aguiar, 2023), WIOD (Dietzenbacher et al., 2013), EORA26 (Lenzen et al., 2013), GLORIA (GLORIA, 2021), EXIOBASE (Stadler et al., 2018), ICIO (OECD, 2024) and FIGARO (Remond-Tiedrez and Rueda-Cantuche, 2019).

Table 5 Overview of MRIO databases.

Database	Countries/ regions	Indus-tries	Separate industry for pharma-ceutical products	Environmental extensions					Update Frequency	Years
				Greenho	Land use	Water	Raw	Waste		
EORA26	190	26	No	x	x	x	x		2 years	1990–2022
EXIOBASE	49	163	No	x	x	x	x	x	Unclear	1995–2022
FIGARO	46	64	Yes						1 year	2010–2022
GLORIA	164	97	Yes	x	x	x	x		Regular	1990–2027
GTAP	160	65	Yes	x	x				3–4 years	2004, 2007, 2011, 2014, 2017
ICIO	77	45	Yes						Regular	1995–2020
WIOD	44	56	Yes						Unclear	1995–2014

None of the global MRIO tables is fully consistent with the Dutch national data. This is because the data from all countries has to be linked, which is only possible if the national data is first adapted and harmonised with the other countries in the database. In order to minimise the consequences of this, Tukker et al. recommend using databases that primarily contain official data from authoritative organisations, such as Eurostat and OECD – in other words, the FIGARO or ICIO (2018) databases. The other databases also use direct national supply-use tables (SUTs) or input-output tables (IOTs).

The majority of MRIO databases were developed by academic institutes, so it is uncertain to what extent they have been maintained (Wilting, 2022). On the other hand, the continuity of tables is better guaranteed if they are embedded institutionally, as is the case with FIGARO and ICIO. Both databases – as well as GLORIA – are regularly updated. The other databases are less frequently updated and not as well maintained, use obsolete data and apply nowcasting to update tables.

Databases with data broken down into important industry categories, such as healthcare services, pharmaceutical products and medical aids, make it possible to specify the environmental footprint of the healthcare sector per product category. Every examined IO database contains a industry category for healthcare services, as well as various sectors for medical aids (e.g. 'manufacture of textiles', 'manufacture of rubber and plastic products', 'manufacture of fabricated metal products', etc.). Most databases also have a separate industry category for pharmaceutical products, with the exception of EXIOBASE and EORA. However, EXIOBASE does contain significantly more industry categories than the other tables.

ICIO and FIGARO have no environmental pressure data, so they do not qualify as EE-MRIOs. All of the other MRIO tables contain data on greenhouse gas emissions, but only EORA26, EXIOBASE and GLORIA also contain data on other environmental pressures such as the use of raw materials, water and land.

The strengths and weaknesses of each database must be carefully weighed against each other. EXIOBASE, the database that was used for the 2022 method, provides the requisite environmental extensions but lacks consistency, up-to-date content and detailed breakdowns by industry category. Institutionally embedded databases like FIGARO and ICIO achieve higher scores on these points, but they do not contain any environmental data. None of the standard databases are ideal, therefore, as a basis for calculating the environmental footprint of the Dutch healthcare sector.

The lack of suitable global databases will have to be addressed again in the years ahead, given that the International Monetary Fund (IMF) is currently developing its own MRIO table, called MARIO (Guilhoto et al., 2023). This database will be updated regularly, provide a broad coverage of geographical locations and industry categories, contain environmental data and aim to enhance the consistency of data.

Adapted MRIO database
In the Netherlands, PBL Netherlands Environmental Assessment Agency is developing adapted MRIO tables that will combine the strengths of multiple standard global databases. One example is PBL-FIGARO, based on FIGARO. While FIGARO offers the advantages of an institutionally embedded database, the industry categories are highly aggregated (65 sectors) and do not contain any environmental data. In PBL-FIGARO, several industry categories have been broken down based on GLORIA data. Next, data from Eurostat, FAOstat and GLORIA are used to add environmental extensions. So PBL-FIGARO also includes environmental data on greenhouse gas emissions (CO_2, CH_4 and N_2O), land use (arable land, grazing land, land for forestry, land for mining and built-up land) and resource use (biomass, fossil energy carriers, metals and other mineral resources).

As a result, PBL-FIGARO, with its Eurostat-based data, environmental data and extensive coverage of industry categories, is the most suitable database for use in the environmental footprint calculation of the Dutch healthcare sector.

9.2 Direct waste flows in the healthcare sector and processing methods

Table 6 Waste flows in the Dutch healthcare sector subject to monitoring.

Level 1 – unsorted waste*	**EURAL (Los et al., 2019)**
Non-hazardous	
Industrial waste	20 03 01
Construction and demolition waste	17 09 04
Bulky waste (such as mattresses and furniture)	20 03 07
Hazardous	
Hazardous construction and demolition waste	17 01 06
Level 2 – coarsely sorted waste*	
Non-hazardous	
Mixed packaging (incl. plastic packaging, metal packaging and drink cartons (PMD))	15 01 06
Mixed metals	17 04 07 and 20 01 40
Waste from the healthcare sector whose collection and disposal are not subject to special requirements in order to prevent infection (such as dressings, plaster casts, linen, disposable clothing, diapers and other incontinence materials)	18 01 04
Non-hazardous pharmaceutical products	18 01 09 and 20 01 32
Electrical and electronic equipment	20 01 36
Plastics (such as PP, HDPE, PS and PET)	20 01 39
Hazardous	
Chemicals consisting of or containing hazardous substances	18 01 06
Infectious waste materials (including specific hospital waste (SZA) packaging, laryngoscope blades, staplers and GMOs)	18 01 03

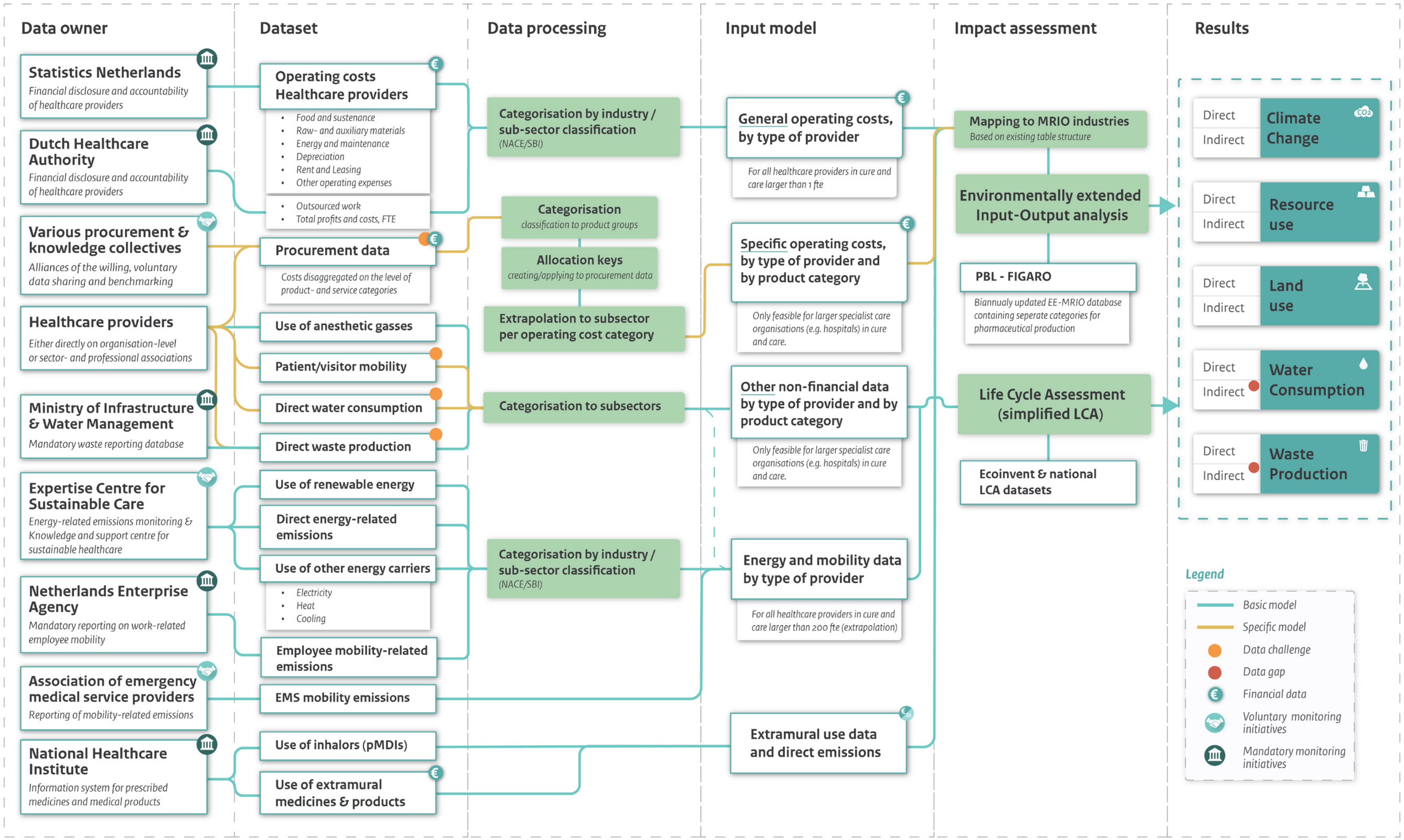
Level 1 – unsorted waste*	**EURAL (Los et al., 2019)**
Equipment containing chlorofluorocarbons (such as refrigerators, dishwashers and washing machines)	20 01 23
Waste from the healthcare sector whose collection and disposal are subject to special requirements in order to prevent infection	18 01 03
Level 3 – specifically sorted waste*	
Non-hazardous	
Wooden packaging (pallets)	15 01 03
Plastic packaging	15 01 02
Metallic packaging	15 01 04
Composite packaging (incl. drink cartons and coffee cups)	15 01 05
Glass packaging	15 01 07
Grade A/B wood waste	17 02 01 and 20 01 38
Iron and steel	17 04 05 and 19 10 01
Cables	17 04 11
Grade C wood waste; hazardous	19 12 06 and 20 01 37
(Confidential) paper and cardboard	20 01 01
Glass	20 01 02
Swill (food waste, boiled and unboiled kitchen waste)	20 01 08
Used frying fat	20 01 25
Textiles	20 01 11
Clothing	20 01 10
Concrete	17 01 01
Toner cartridges	08 03 18
Wastes containing oil	
Alkaline batteries	16 06 04
Hazardous	
Amalgam waste	18 01 10
Cytotoxic and cytostatic pharmaceutical products	18 01 08 and 20 01 31
Laboratory chemicals	16 05 06
Inorganic chemicals	16 05 07
Organic chemicals	16 05 08
Fluorescent tubes, neon lamps, energy-saving lamps	20 01 21
Antifreeze fluids	16 01 14
Fixed solutions	09 01 04
Ink waste	15 01 10
Packaging containing hazardous substances	15 01 10
Aqueous suspensions containing polluted pigment	08 01 19
Lead batteries	16 06 01
Ni-Cd batteries	16 06 02
Mercury-containing batteries	16 06 03

* Categorisation based on scan of environmental and sustainability reports of several healthcare providers as well as on EURAL codes

Table 7 Waste processing methods included in the AMICE database (LMA, n.d.).

Main category processing method	**Processing techniques (LMA, n.d.)**
Storage and handling	Storage
	Transfer and bulk storage
Direct application	Use as fodder
	Use as fertiliser
	Use as building material
	Use as fuel
	Other use as a raw material
Physical or mechanical processing	Breaking
	Shredding/cutting
	Sorting/separating
	Immobilise for reuse
	Chemical/physical separation
	Detoxification, neutralisation and dewatering
	Distillation
	Metal recovery (chemical)
	Extractive cleaning (soil)
	Oxidation under high pressure
Microbiological processing	Anaerobic degradation
	Anaerobic composting
	Aerobic composting
	Biological cleaning (water)
	Biological cleaning (soil)
Thermal processing	Incineration in grate furnaces
	Incineration in rotary kilns
	Pyrolysis
	Gasification
	Annealing (soil)
	Incineration with material recovery (including chlorine, sulphur)
	Incineration with energy recovery (co-combustion)
Landfill	Direct disposal
	Immobilisation

9.3 Methodological diagram of the 2024-method



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