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Supplementary appendix

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Supplementary appendix

The environmental footprint of the Dutch Healthcare sector: beyond climate impact

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The model and the data are provided publicly in the RIVM Github repository (https://github.com/rivm-syso/envr-footprint-healthcare). On this page, we also provide the unaggregated (intermediate) results that are not suitable to present in this document due to Exiobase's relatively high sectoral resolution.

Contents

1. Mathematical background 2
2. Construction of the expenditure vector 4
3. Impact calculation for private travel 8
4. Harmonisation among characterisation of environmental flows 12
5. Expenditure vector results 19
6 Environmental intensities results 20
7. Footprint results: total impacts in relation the national consumption footprint 21
8. Footprint results: contribution analysis by sector 22
9. Footprint results: hotspot analysis by sector 24
10. Footprint results: hotspot analysis by region 26
11. Consolidated review of variability of models and data underlying comparable studies 29
12. Role of pharmaceuticals in existing healthcare carbon footprint studies 32
13. Sector classification 33
References 38

1. Mathematical background

In this study we wanted to calculate the environmental footprints of the healthcare sector along several impact categories using EE-IOA. Input-output analysis (IOA) is a macroeconomic calculation method that can be used to analyse linkages between industries.[1,2] Underlying IOA is the input-output table, a matrix that consolidates the transactions between different industries and between these and final consumption categories. The Leontief inverse indicates how much economic activity is stimulated by one unit of demand for each sector, taking into account all activity in the entire value chain. By extending the input-output table with environmental accounts, which contain information on environmental extensions associated with all industries (and sometimes also households), the entire impact throughout the value chain can be calculated for a required output (environmentally extended IOA; EE-IOA).

The environmental footprint is the sum of all impacts associated with the operational phase (direct impact; e.g. from exhaust gases form ambulances) and impacts occurring in value chain of purchased good and services (indirect impact) given an expenditure vector (expenditure on the required goods and services), calculated with the following matrix equation:

$$p = \mathbf{c}(\mathbf{B}\,\mathbf{L}\,\mathbf{f} + \mathbf{d})$$

Reading from right to left, p (a scalar) is the total footprint along a particular impact dimension; **c** is the (1 x K) row vector of characterisation factors; **B** is the (K x N) direct extension intensity matrix; **L** is the (N x N) Leontief inverse; **f** is the (N x 1) expenditure column vector; and **d** is the (K x 1) vector of direct extension flows. In the above K is the number of extension categories (e.g., CO_2, CH_4, N_2O) and N is the number of sectors (which here are understood as either product or industry).

This equation is to be applied repeatedly to every of the five impact categories considered (each having a different **c** vector). A characterization factor (an entry of **c**) converts a particular extension (such as a CH_4 emission) into a common metric of impact (such as kg of CO_2-equivalent). If the impact category is climate change, a typical characterisation factor is Global Warming Potential (GWP). A direct extension intensity (an entry of **B**) indicates the amount of environmental extension flows that are generated by one unit of activity of a given sector. For example $B_{CO2,agriculture}$ = 5 kg CO_2/EUR means that 5 kg of CO_2 are emitted per every EUR of agricultural products sold. A total multiplier (an element of the Leontief inverse **L**) indicates the amount of activity in a sector stimulated by demand in another. For example, $L_{agriculture,industry}$ = 2 EUR/EUR means that for every EUR of demand in industry, 2 EUR are stimulated in agriculture. Expenditure vector **f** is the amount of money spent on every product category and direct extension flow **d** are the operational emissions that result from that demand. For example, an element of **f** might be fuel purchase and an element of **d** might be the emissions that result from the combustion of that fuel.

In this study, we decomposed the total indirect impacts of the footprint in two ways: contribution and hotspot analysis. A contribution analysis is a split of that grand total by the categories that compose the expenditure vector. For example, a contribution analysis might show that the purchase of electricity is the main contributor to a given footprint (more than the purchase of textiles or transport services, for example). Mathematically, we now calculate:

$$\mathbf{pc} = \mathbf{c}\,\mathbf{B}\,\mathbf{L}\,\hat{\mathbf{f}}$$

where **pc** is the (1 x N) row vector of impacts by expenditure category, and the hat (^) represents diagonalisation. The first elements of this equation (**c B L**) are also used to calculate the environmental intensities per expenditure category.

In a hotspot analysis the total indirect impact is split according to where (sectorally and/or geographically) the impact physically occurs. A hotspot analysis might show that most carbon emissions occur at a domestic coal fired power plant, rather than a foreign textile factory, for example. Mathematically, this is performed as:

$$\mathbf{ph} = \mathbf{c}\,\mathbf{B}\,\widehat{\mathbf{L}\,\mathbf{f}}$$

where **ph** is the (1 x N) row vector of impacts by sector.

There are other possible decompositions: we could combine hotspot and contribution analyses to obtain the impact by both sector where impact occurs and item in the expenditure vector. Another option to analyse the indirect impact of the footprint is to perform a structural path analysis (SPA)[3], whereby impacts are discriminated along each step of every value chain. We did not perform such analyses in the present study

2. Construction of the expenditure vector

To construct the expenditure vector, we use expenditure data provided by Statistics Netherlands[4]. Statistics Netherlands reports the healthcare expenditure data following two scopes: healthcare (gezondheidszorg) and a more expansive scope with healthcare and welfare services combined (zorg en welzijn). The expenditure for these scopes are again provided for two definitions; the internationally comparable definition, which only considers the healthcare expenditure for residents regardless of whether the service is provided domestically, and the broad definition, which only regards the expenditure on national health care, regardless whether it was received by residents or non-residents. In this study, we considered the expansive scope and the broad definition of healthcare. This choice was pragmatic, to align with the definitions in Exiobase and thus facilitate integration and interpretation. This is because in Exiobase, healthcare services are aggregated with social work services, and consumption by residents and non-residents is not reported separately.

The expenditure data is (mostly) classified according to the System of Health Accounts (SHA)[3]. The SHA categorises expenditure almost entirely by function (e.g. medical or preventive care) or by care providers (e.g. hospitals, nursing homes). The categories comprise of health and welfare services, with the exception of expenditure for medical goods (*HC51. Pharmaceuticals and other medical non-durables* and *HC52. Therapeutic appliances and other medical durables*). The financing of expenditure includes both direct expenditure by households and payments through financing schemes such as health insurance. We refer to the OECD document to explore how the classification covers the different goods and services.[5]

The healthcare expenditure needed to be mapped onto Exiobase industry categories. Furthermore, in preparation to apply the healthcare expenditure for the EE-IOA calculation, we also need convert the expenditure to basic prices, since Exiobase is reported in basic prices while the Dutch health expenditure is in purchaser prices. For this, we used the 2016 supply table in the national accounts[6]. To calculate the conversion factor, the categories in the supply table also needed to be mapped onto the expenditure data. Table S2.1 shows the correspondence we used between the healthcare expenditure and the industry categories for Exiobase and the national accounts. We calculated the conversion from purchaser price to basic price by subtracting taxes less subsidies, and trade and transport margins. Results for the converted healthcare expenditure are shown in Table S2.2.

Table S2.1 Concordance of the expenditure categories with categories used in Exiobase and the national accounts.

System of Health Accounts[5]	**Exiobase industry**	**Industry in national accounts**
HC51. Pharmaceuticals and other medical non-durables	62.Chemicals n.e.c.	28. Manufacture of pharmaceutical products and preparation
HC52. Therapeutic appliances and other medical durables	33. Medical precision and optical instruments, watches and clocks	33. Manufacture of computer, electronic and optical products
Rest: Healthcare services (HC1-HC9 excl. HC5)	85. Health and social work	83. Human health activities
Rest: Welfare services (day care, social work, youth care)		84. Residential care and social work

Table S2.2 The 2016 healthcare expenditure in purchaser price, the calculated conversion factor, calculated by dividing the sector's basic price by the purchaser price using the 2016 national supply use table, and the final healthcare expenditure in basic price (purchaser price expenditure multiplied with conversion factor).

Healthcare expenditure	**Healthcare expenditure in purchaser price (MEUR)**	**Sector supply in national accounts, purchaser price (MEUR)**	**Sector supply in national accounts, basic price (MEUR)**	**Conversion factor**	**Healthcare expenditure in basic price (MEUR)**
Health and welfare services	86096	(44635 + 36223 =) 70858	(44463 + 36223 =) 70686	1 (no conversion)	86096
Pharmaceuticals and other medical non-durables	5639	24452	16447	0·67	3778
Therapeutic appliances and other medical durables	3107	109444	92962	0·85	2641
Total	94842	-	-	-	92515

The total expenditure vector is the sum of the three categories of expenditure mapped onto the Exiobase, using the corresponding Exiobase industry categories (from Table S2.1). However, using only these three categories will produce an uninsightful result for the contribution analysis (the results will be decomposed for these three categories). To increase the detail in the contribution analysis for the impact from healthcare and welfare services, we used the (appropriately scaled) intermediate use vector for the Dutch *Health and social work* sector from Exiobase's inter-industry table.

For the expenditure on health and welfare services, we took the intermediate use column in the inter-industry table for *Health and Social work* for the Netherlands. We needed to scale this intermediate use vector as follows: by dividing the expenditure on health and welfare services (86096 MEUR, see table S2.3) by the Dutch *Health and social works*'s total input (total intermediate use + total production factors), scaling the total intermediate use to 26283 MEUR. Mathematically, this can be written as:

$$\mathbf{f}_{\mathrm{HCserv}} = \mathrm{Z}_{\mathrm{HSW}} * \frac{y_{HCserv}}{x_{HSW}}$$

where $\mathbf{f}_{\mathrm{HCserv}}$ is the expenditure vector column (N x 1; N being number of industries for all regions) for health and welfare services, $\mathbf{Z}_{\mathrm{HSW}}$ is the intermediate use vector column (N x 1) in the inter-industry table for the Dutch Health and social work sector, scalar x_{HSW} is the total input for the Dutch Health and Social work sector, and scalar y_{HCserv} is reported expenditure on health and welfare services.

For the expenditure on Pharmaceuticals and other medical non-durables and the expenditure on Therapeutic appliances and other medical durables, the basic price values are distributed over a vector for *Chemicals n.e.c.* and *Medical precision and optical instruments, watches and clocks*, respectively, according to a sourcing distribution. This distribution is the proportional allocation among providing regions for *Chemicals n.e.c.* and *Medical precision and optical instruments, watches and clocks* calculated from the total final demand for the Netherlands (see table S2.3).

Table S2.3 Sourcing distribution for Chemicals n.e.c. and Medical precision and optical instruments, watches and clocks. RoW = Rest of world.

Name	Chemicals n.e.c.	Medical precision and optical instruments, watches and clocks
Australia	0·57%	0·90%
Austria	0·01%	0·18%
Belgium	0·63%	0·61%
Brazil	1·19%	0·05%
Bulgaria	0·05%	0·06%
Canada	0·55%	0·23%
China	4·46%	2·39%
Croatia	0·00%	0·00%
Cyprus	0·00%	0·00%
Czech Republic	0·46%	0·17%
Denmark	0·02%	0·52%
Estonia	0·00%	0·00%
Finland	0·01%	0·10%
France	0·07%	5·52%
Germany	0·39%	10·62%
Greece	0·00%	0·02%
Hungary	0·03%	0·13%
India	1·69%	0·12%
Indonesia	1·37%	0·02%
Ireland	0·58%	0·93%
Italy	0·01%	1·16%
Japan	0·81%	0·00%
Latvia	0·00%	0·00%
Lithuania	0·00%	0·01%
Luxembourg	0·00%	0·00%
Malta	0·00%	0·01%
Mexico	0·36%	0·37%
Netherlands	2·36%	45·55%
Norway	0·03%	0·54%
Poland	0·25%	0·26%
Portugal	0·00%	0·06%
RoW Africa	12·02%	0·16%
RoW America	1·33%	1·85%
RoW Asia and Pacific	36·82%	2·16%
RoW Europe	0·81%	0·17%
RoW Middle East	8·97%	1·61%
Romania	0·08%	0·03%
Russia	2·79%	0·04%

Slovakia	0·00%	0·34%
Slovenia	0·12%	0·04%
South Africa	0·39%	0·04%
South Korea	0·49%	0·00%
Spain	0·06%	0·50%
Sweden	0·00%	0·82%
Switzerland	2·75%	2·60%
Taiwan	1·62%	0·76%
Turkey	0·21%	0·03%
United Kingdom	0·12%	3·22%
United States	15·54%	15·09%

3. Impact calculation for private travel

We follow the approach for calculating the total distance travelled by mode for employees, patients and visitors from Tennison et al.[7], which was also applied in the study by consultancy Gupta Strategists[8]. These distances travelled are linked to the corresponding activities in the Ecoinvent v3.7 database[9] to calculate the total impacts. The most suitable activities provide information in person.km and calculate the impact up to and including the use phase. The impact induced by private travel are calculated using life cycle assessment (LCA) data and thus include both direct impacts (use phase; impacts occurring during transport such as exhaust emissions) and indirect impacts (impact from production and waste disposal). We have split the impact results of private travel into direct impacts and indirect impacts. The indirect impacts are added to the hotspot analysis without further specification of the originating sector or region, as it would be too laborious to bridge the Exiobase and Ecoinvent classifications.

Travelled distance for commuting

Statistics Netherlands states that on average in 2016 1,220,750 employees work in healthcare and social work (including childcare).[10] As far as we are aware, there is no further information about the average number of commutes per week or year for healthcare professionals. For our estimation, we use the part-time factor ('The relative working hours for the job compared to a full-time job in the same company or business sector'); in 2016 this is 0·68 on average for the health and wellbeing sector (including childcare)[11]. We use the results for full-time work weeks (assumed 36 hours/week) combined with the part-time factor. From this we calculate that (0·68 * 36 hours/week =) 24·5 hours are worked per week. That means 159 working days on an annual average, and combined with an assumption of 21 days paid leave (including public holidays), we arrive at 138 working days per year. This means that there are (138 d/y * 1,220,750 employees =) 168 million commutes from and to work.

Statistics Netherlands also presents the distribution of the average number of journeys and the average corresponding distance travelled per transport mode per person per year for travel to and from work[12]. However, these figures are not specific to the care sector. We proportionally redistribute the total number of kilometres for Other transport modes, because no further information is available about this transport mode. We can then multiply the new distribution per trip by the average distance travelled per mode combined with the expected travel movements for commuting to work to calculate the total distance travelled per mode (see Table S3.1).

Table S3.1 The distribution of the number of trips by mode of transport for commuting and the average distance per trip provided by CBS to estimate the distance travelled by each mode of transport by care workers in 2016.

Mode of transport	**Number of movements per person per year**	**Share of total number of movements in %**	**Share of total number of movements, redistributed in %**	**Distance travelled per movement per person in km**	**Total distance for 168 mln commutes in mln km**
Car (driver)	86	53·4%	54·3%	25·30	2280
Car (passenger)	6	3·7%	3.8%	26·33	166
Train	7	4·3%	4·4%	39·49	280
Bus/tram/metro	7	4·3%	4·4%	13·70	100
Scooter/moped	4	2·5%	2·5%	7·74	32
Bicycle	41	25·5%	25·9%	4·68	201
Walking	7	4·3%	4·4%	2·83	21
Other modes of transport	3	1·9%	Proportionally redistributed	-	-

Travelled distance by patients and visitors

In table S10 by Tennison et al., we find that in England in 2016 the average traveled distance per resident for Personal medical business is 159 km (99 miles). A similar figure does not exist for the Netherlands; the Statistics Netherlands does not report such a figure specifically for the travel motive for care. Gupta Strategists also applied 150 km/person/year for distance travelled for private travel as a patient or visitor for all Dutch residents, which is a figure also adopted from the same NHS data provided by Tennison et al. Adopting the figure for England for the Netherlands, we get a total of 2·7e9 kms traveled by patients and visitors in 2016 (159 km/person/year * 16,980,000 inhabitants). It is uncertain whether the adopted figure for England is appropriate for the Netherlands. Finally, we assume the distribution of total passenger kilometres per transport mode for the Netherlands in 2016[13], see Table S3.2.

Table S3.2 The distribution of total travel kilometers by mode of transport provided by Statistic Netherlands to estimate the distance travelled by each mode of transport for private travel of patients and visitors.

Mode of transport	**bln km travelled in 2016**	**% of total travelled km**	**% of total travelled km redistributed**	**mln km travelled**
Car (driver)	97·7	50·2%	52·9%	1429
Car (passenger)	43·1	22·1%	23·3%	630
Train	16·9	8·7%	9·2%	247
Bus/tram/metro	5·9	3·0%	3·2%	86
Scooter/moped	1·1	0·6%	0·6%	16
Bicycle	14·6	7·5%	7·9%	213
Walking	5·3	2·7%	2·9%	76
Other modes of transport	10·2	5·2%	Proportionally redistributed	-

Ecoinvent processes per mode of transport

We consider that the modes of transportation *Car (passenger)* and *Walking* have no impact (the car impact is associated with the driver). We then linked the other five modes of transport to corresponding Ecoinvent v3.7 activities (see Table S3.3). For the impacts from travelling by train, there was no suitable activity for passenger trains in the Netherlands. Comparing the share of electrified railways over the years[14], Belgium comes closer to the Netherlands than any of the other existing available activities for passenger trains in Ecoinvent. The Dutch railway organisation NS states that in 2016 75% of all electric trains were powered by wind energy.[15] The Netherlands Environmental Assessment Agency estimates that the total installed wind energy capacity in the Netherlands is made up of around 10·5% off-shore and 89·5% on-shore for 2015.[16] We adapt the activity by replacing default inputs with inputs from Dutch providers, updating the values for the electricity from the grid, and adding the electricity from off-shore and on-shore wind energy (assuming both are 1-3 Mw turbines).

The total travelled distance with Bus/tram/metro is not further specified. Based on available suitable activities, we assume there is a 50% share of kilometers travelled with *50% Transport, tram (GLO)* and 50% *Transport, regular bus (GLO).*

To our knowledge there are no reliable sources for the share of electrified scooters/mopeds in 2016. A news article discussing the emergence of electric scooters suggests that the share is roughly 2-3%.[17] For the impacts from transport with scooters/mopeds, we assume a 3% share of electric scooters. The impact per kilometer travelled is calculated with a composition of 97% *Transport, passenger, motor scooter (GLO)* and 3% *Transport, passenger, electric scooter (GLO)*. For the share of electric bicycles in 2016 we could not find any data. Therefore, we only consider impact from *Transport, passenger, bicycle (GLO)*.

Table S3.3 The selected Ecoinvent activities to represent the mode of transport (Corresponding Ecoinvent activities)

Mode of transport	**Corresponding Ecoinvent activities**
Car (driver)	*Transport, passenger car, medium size, petrol, EURO 5 (RER)| Cut-off, U*
Car (passenger)	No impact
Train	*Transport, passenger train (BE)| processing | Cut-off, U*, aangepast voor NL
Bus/tram/metro	*50% Transport, tram (GLO)| market for | Cut-off, U* and 50% *Transport, regular bus (GLO)| market for | Cut-off, U*
Scooter/moped	97% *Transport, passenger, motor scooter (GLO)| market for | Cut-off, U* and 3% *Transport, passenger, electric scooter (GLO)| market for | Cut-off, U*
Bicycle	*Transport, passenger, bicycle (GLO)| market for | Cut-off, U*
Walking	No impact
Other modes of transport	-

4. Harmonisation among characterisation of environmental flows

Since we are combining the EE-IOA footprint with LCA results, we needed to ensure harmonisation for the characterisation to integrate the results. As a starting point, we used ReCiPe 2016 (H) midpoints for the LCA results, and we used the characterisation table by DESIRE FP7 for the EE-IOA. The list below shows if and how the results for the different methods needed to be adapted to be harmonized. Converting ReCiPe's copper equivalent midpoint was challenging, since there is no consensus on how to assess resource use.[18,19] DESIRE FP7 uses mass-based accounting, and ReCiPe uses surplus ore potential. We chose mass-based accounting for the footprint calculation in this study, since it requires much less effort to convert the LCA midpoint results to mass than to create a characterisation table between ReCiPe's and Exiobase's extensions. To convert copper to copper ore equivalents (Cu-eq.), we used a conversion provided by Impact World+ (8,674 kg copper deprived/kt copper ores)[20]. The provided conversion (0·87 % copper ore grade) is in line with the average copper ore grade in recent years, which is around 0·9%[21]. Land use can be expressed in both km^2 and m^2a by converting the LCA results or adapting the characterisation table for the EE-IOA. Again, we chose to convert the LCA results to km^2 since it requires less effort. For waste production, which does not have a corresponding LCA midpoint, we summed up all waste fractions from the extension of Exiobase's hybrid SUT.

Climate change in kg CO2-eq.

- LCA results: GWP100 in Kg CO_2-eq. from ReCiPe 2016 (H) midpoint.
- EEIOA results: using ReCiPe 2016 (H) characterisation factors on greenhouse gas emissions in Exiobase extensions.

Table S4.1 Used characterisation for climate change.

Extension	Unit	kg CO2 eq.
CO2 - combustion - air	kg	1
CH4 - combustion - air	kg	25
N2O - combustion - air	kg	298
CH4 - non combustion - Extraction/production of (natural) gas - air	kg	25
CH4 - non combustion - Extraction/production of crude oil - air	kg	25
CH4 - non combustion - Mining of antracite - air	kg	25
CH4 - non combustion - Mining of bituminous coal - air	kg	25
CH4 - non combustion - Mining of coking coal - air	kg	25
CH4 - non combustion - Mining of lignite (brown coal) - air	kg	25
CH4 - non combustion - Mining of sub-bituminous coal - air	kg	25
CH4 - non combustion - Oil refinery - air	kg	25
CO2 - non combustion - Cement production - air	kg	1
CO2 - non combustion - Lime production - air	kg	1
SF6 - air	kg	26087
HFC - air	kg CO2-eq	1
PFC - air	kg CO2-eq	1
CH4 - agriculture - air	kg	25
CO2 - agriculture - peat decay - air	kg	1
N2O - agriculture - air	kg	298
CH4 - waste - air	kg	25
CO2 - waste - biogenic - air	kg	1
CO2 - waste - fossil - air	kg	1

Abiotic material extraction in kt

- LCA results: Mineral resource scarcity in kg Cu-eq. from ReCiPe 2016 (H) midpoint, then using the characterisation factor from Impact World+ to convert kg Cu-eq. to total copper ores (kt).
- EEIOA results: Adapting the DESIRE characterisation for Domestic Extraction in kt by removing factors for biotic domestic extraction

Table S4.2 Used characterisation for abiotic material extraction.

Extension	Unit	kt
Domestic Extraction Used - Metal Ores - Bauxite and aluminium ores	kt	1
Domestic Extraction Used - Metal Ores - Copper ores	kt	1
Domestic Extraction Used - Metal Ores - Gold ores	kt	1
Domestic Extraction Used - Metal Ores - Iron ores	kt	1
Domestic Extraction Used - Metal Ores - Lead ores	kt	1
Domestic Extraction Used - Metal Ores - Nickel ores	kt	1
Domestic Extraction Used - Metal Ores - Other non-ferrous metal ores	kt	1
Domestic Extraction Used - Metal Ores - PGM ores	kt	1
Domestic Extraction Used - Metal Ores - Silver ores	kt	1
Domestic Extraction Used - Metal Ores - Tin ores	kt	1
Domestic Extraction Used - Metal Ores - Uranium and thorium ores	kt	1
Domestic Extraction Used - Metal Ores - Zinc ores	kt	1
Domestic Extraction Used - Non-Metallic Minerals - Building stones	kt	1
Domestic Extraction Used - Non-Metallic Minerals - Chemical and fertilizer minerals	kt	1
Domestic Extraction Used - Non-Metallic Minerals - Clays and kaolin	kt	1
Domestic Extraction Used - Non-Metallic Minerals - Gravel and sand	kt	1
Domestic Extraction Used - Non-Metallic Minerals - Limestone, gypsum, chalk, dolomite	kt	1
Domestic Extraction Used - Non-Metallic Minerals - Other minerals	kt	1
Domestic Extraction Used - Non-Metallic Minerals - Salt	kt	1
Domestic Extraction Used - Non-Metallic Minerals - Slate	kt	1

- LCA results: Water consumption in m^3 from ReCiPe 2016 (H) midpoint. Divide by 1e6.
- EEIOA results: Water Consumption Blue – Total in Mm^3 from the DESIRE characterisation table.

Table S4.3 Used characterisation for blue water consumption.

Extension	Unit	Mm3
Water Consumption Blue - Agriculture - rice	Mm3	1
Water Consumption Blue - Agriculture - wheat	Mm3	1
Water Consumption Blue - Agriculture - other cereals	Mm3	1
Water Consumption Blue - Agriculture - roots and tubers	Mm3	1
Water Consumption Blue - Agriculture - sugar crops	Mm3	1
Water Consumption Blue - Agriculture - pulses	Mm3	1
Water Consumption Blue - Agriculture - nuts	Mm3	1
Water Consumption Blue - Agriculture - oil crops	Mm3	1
Water Consumption Blue - Agriculture - vegetables	Mm3	1
Water Consumption Blue - Agriculture - fruits	Mm3	1
Water Consumption Blue - Agriculture - fibres	Mm3	1
Water Consumption Blue - Agriculture - other crops	Mm3	1
Water Consumption Blue - Agriculture - fodder crops	Mm3	1
Water Consumption Blue - Livestock - dairy cattle	Mm3	1
Water Consumption Blue - Livestock - nondairy cattle	Mm3	1
Water Consumption Blue - Livestock - pigs	Mm3	1
Water Consumption Blue - Livestock - sheep	Mm3	1
Water Consumption Blue - Livestock - goats	Mm3	1
Water Consumption Blue - Livestock - buffaloes	Mm3	1
Water Consumption Blue - Livestock - camels	Mm3	1
Water Consumption Blue - Livestock - horses	Mm3	1
Water Consumption Blue - Livestock - chicken	Mm3	1
Water Consumption Blue - Livestock - turkeys	Mm3	1
Water Consumption Blue - Livestock - ducks	Mm3	1
Water Consumption Blue - Livestock - geese	Mm3	1
Water Consumption Blue - Manufacturing - Products of meat cattle	Mm3	1
Water Consumption Blue - Manufacturing - Products of meat pigs	Mm3	1
Water Consumption Blue - Manufacturing - Products of meat poultry	Mm3	1
Water Consumption Blue - Manufacturing - Meat products nec	Mm3	1
Water Consumption Blue - Manufacturing - products of Vegetable oils and fats	Mm3	1
Water Consumption Blue - Manufacturing - Dairy products	Mm3	1
Water Consumption Blue - Manufacturing - Processed rice	Mm3	1
Water Consumption Blue - Manufacturing - Sugar	Mm3	1
Water Consumption Blue - Manufacturing - Food products nec	Mm3	1
Water Consumption Blue - Manufacturing - Beverages	Mm3	1
Water Consumption Blue - Manufacturing - Fish products	Mm3	1
Water Consumption Blue - Manufacturing - Tobacco products (16)	Mm3	1

Water Consumption Blue - Manufacturing - Textiles (17)	Mm3	1
Water Consumption Blue - Manufacturing - Wearing apparel; furs (18)	Mm3	1
Water Consumption Blue - Manufacturing - Leather and leather products (19)	Mm3	1
Water Consumption Blue - Manufacturing - Pulp	Mm3	1
Water Consumption Blue - Manufacturing - Secondary paper for treatment, Re-processing of secondary paper into new pulp	Mm3	1
Water Consumption Blue - Manufacturing - Paper and paper products	Mm3	1
Water Consumption Blue - Manufacturing - Printed matter and recorded media (22)	Mm3	1
Water Consumption Blue - Manufacturing - Plastics, basic	Mm3	1
Water Consumption Blue - Manufacturing - Secondary plastic for treatment, Re-processing of secondary plastic into new plastic	Mm3	1
Water Consumption Blue - Manufacturing - N-fertiliser	Mm3	1
Water Consumption Blue - Manufacturing - P- and other fertiliser	Mm3	1
Water Consumption Blue - Manufacturing - Chemicals nec	Mm3	1
Water Consumption Blue - Manufacturing - Rubber and plastic products (25)	Mm3	1
Water Consumption Blue - Manufacturing - Glass and glass products	Mm3	1
Water Consumption Blue - Manufacturing - Secondary glass for treatment, Re-processing of secondary glass into new glass	Mm3	1
Water Consumption Blue - Manufacturing - Ceramic goods	Mm3	1
Water Consumption Blue - Manufacturing - Bricks, tiles and construction products, in baked clay	Mm3	1
Water Consumption Blue - Manufacturing - Cement, lime and plaster	Mm3	1
Water Consumption Blue - Manufacturing - Ash for treatment, Re-processing of ash into clinker	Mm3	1
Water Consumption Blue - Manufacturing - Other non-metallic mineral products	Mm3	1
Water Consumption Blue - Manufacturing - Basic iron and steel and of ferro-alloys and first products thereof	Mm3	1
Water Consumption Blue - Manufacturing - Secondary steel for treatment, Re-processing of secondary steel into new steel	Mm3	1
Water Consumption Blue - Manufacturing - Precious metals	Mm3	1
Water Consumption Blue - Manufacturing - Secondary preciuos metals for treatment, Re-processing of secondary preciuos metals into new preciuos metals	Mm3	1
Water Consumption Blue - Manufacturing - Aluminium and aluminium products	Mm3	1
Water Consumption Blue - Manufacturing - Secondary aluminium for treatment, Re-processing of secondary aluminium into new aluminium	Mm3	1
Water Consumption Blue - Manufacturing - Lead, zinc and tin and products thereof	Mm3	1
Water Consumption Blue - Manufacturing - Secondary lead for treatment, Re-processing of secondary lead into new lead	Mm3	1
Water Consumption Blue - Manufacturing - Copper products	Mm3	1
Water Consumption Blue - Manufacturing - Secondary copper for treatment, Re-processing of secondary copper into new copper	Mm3	1
Water Consumption Blue - Manufacturing - Other non-ferrous metal products	Mm3	1
Water Consumption Blue - Manufacturing - Secondary other non-ferrous metals for treatment, Re-processing of secondary other non-ferrous metals into new other non-ferrous metals	Mm3	1
Water Consumption Blue - Manufacturing - Fabricated metal products, except machinery and equipment (28)	Mm3	1
Water Consumption Blue - Manufacturing - Machinery and equipment n.e.c. (29)	Mm3	1
Water Consumption Blue - Manufacturing - Office machinery and computers (30)	Mm3	1
Water Consumption Blue - Manufacturing - Electrical machinery and apparatus n.e.c. (31)	Mm3	1
Water Consumption Blue - Manufacturing - Radio, television and communication equipment and apparatus (32)	Mm3	1
Water Consumption Blue - Manufacturing - Medical, precision and optical instruments, watches and clocks (33)	Mm3	1

Water Consumption Blue - Manufacturing - Motor vehicles, trailers and semi-trailers (34)	Mm3	1
Water Consumption Blue - Manufacturing - Other transport equipment (35)	Mm3	1
Water Consumption Blue - Manufacturing - Furniture; other manufactured goods n.e.c. (36)	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by coal	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by gas	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by nuclear	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by hydro	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by wind	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by petroleum and other oil derivatives	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by biomass and waste	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by solar photovoltaic	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by solar thermal	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by tide, wave, ocean	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity by Geothermal	Mm3	1
Water Consumption Blue - Electricity - tower - Electricity nec	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by coal	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by gas	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by nuclear	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by hydro	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by wind	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by petroleum and other oil derivatives	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by biomass and waste	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by solar photovoltaic	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by solar thermal	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by tide, wave, ocean	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity by Geothermal	Mm3	1
Water Consumption Blue - Electricity - once-through - Electricity nec	Mm3	1
Water Consumption Blue - Domestic - domestic Water Consumption Blue	Mm3	1

Land use in km^2

- LCA results: Land use in m^{2}a crop eq. from ReCiPe 2016 (H) midpoint, then converting the ReCiPe midpoint result with factors from table 11.1 in the ReCiPe 2016 documentation: m^{2}a crop eq. (annual crop equivalent) equates to land use in m^2 by 1:1. Divide by 1e6.
- EEIOA results: Land use in km^2 from the DESIRE characterisation table.

Table S4.4 Used characterisation for land use.

Extension	Unit	km2
Cropland - Cereal grains nec	km2	1
Cropland - Crops nec	km2	1
Cropland - Fodder crops-Cattle	km2	1
Cropland - Fodder crops-Meat animals nec	km2	1
Cropland - Fodder crops-Pigs	km2	1
Cropland - Fodder crops-Poultry	km2	1
Cropland - Fodder crops-Raw milk	km2	1
Cropland - Oil seeds	km2	1
Cropland - Paddy rice	km2	1
Cropland - Plant-based fibers	km2	1
Cropland - Sugar cane, sugar beet	km2	1
Cropland - Vegetables, fruit, nuts	km2	1
Cropland - Wheat	km2	1
Forest area - Forestry	km2	1
Other land Use: Total	km2	1
Permanent pastures - Grazing-Cattle	km2	1
Permanent pastures - Grazing-Meat animals nec	km2	1
Permanent pastures - Grazing-Raw milk	km2	1
Infrastructure land	km2	1
Forest area - Marginal use	km2	1

Total waste production in kt

- LCA results: no LCA results on waste production.
- EEIOA results: no characterization; sum of all waste fractions in tonnes from Exiobase's hybrid SUT

5. Expenditure vector results

Table S5 The aggregated expenditure vector, according to the classification of the 163 Exiobase sectors is provided in appendix 13 . The expenditure vector for all product groups (163 rows) and the expenditure vector for all product groups including sourcing (163 x 49 rows) are published on the Github repository. The aggregation classification of the 163 Exiobase sectors is provided in appendix 13.

Aggregated sector description	Total health care expenditure (MEUR)	Expenditure on healthcare services (MEUR)	Expenditure on pharmaceuticals and chemical products (MEUR)	Expenditure on medical appliances (MEUR)
Chemical	5861	2068	3793	0
Coal and Petroleum	147	147	0	0
Construction	555	555	0	0
Electrical, electronic and measuring equipment	4194	1554	0	2639
Electricity	828	828	0	0
Food and catering	1948	1948	0	0
Furniture and timber	49	49	0	0
General and special Machinery	353	353	0	0
Metal Products	78	78	0	0
Minerals and Metals	178	178	0	0
Natural gas and gaseous fuels	70	70	0	0
Non-metallic mineral products	47	47	0	0
Paper Products	676	676	0	0
Services	9757	9757	0	0
Steam, hot water supply and water distribution	50	50	0	0
Textile	79	79	0	0
Transport	1103	1103	0	0
Transport Equipment	66	66	0	0
Waste management and disposal	258	258	0	0

6 Environmental intensities results

Table S6 The weighted averages for the environmental intensities in total impact per MEUR. There are (163 sectors x 49 sourcing regions =) 7987 intensity values for the product groups and respective sourcing region, which can be found in full on the Github repository. The aggregation classification of the 163 Exiobase sectors is provided in appendix 13. This means that the weighted averages for the product group is based on the sourcing regions by the healthcare industry. The weighted average is also affected by the sourcing region, which means that the intensities of a product group can be different for other sectoral footprints, since not all sectors source their products from the same region.

Aggregated sector description	Global warming kt CO_2-eq/MEUR	Material extraction kt/MEUR	Blue water consumption Mm^3/MEUR	Land use km^2/MEUR	Waste generation kt/MEUR
Chemical	1·24	4·61	0·0426	2·45	0·446
Coal and Petroleum	1·28	0·48	0·0052	0·25	0·065
Construction	0·49	1·36	0·0032	0·31	0·239
Electrical, electronic and measuring equipment	0·32	0·34	0·0028	0·15	0·090
Electricity	2·23	0·16	0·0067	0·13	0·087
Food and catering	0·52	0·27	0·0483	2·90	0·329
Furniture and timber	0·53	0·41	0·0110	4·62	0·092
General and special Machinery	0·51	0·76	0·0067	0·34	0·213
Metal Products	0·62	1·07	0·0057	0·21	0·514
Minerals and Metals	0·61	7·76	0·0063	0·18	0·909
Natural gas and gaseous fuels	1·55	0·18	0·0012	0·05	0·015
Non-metallic mineral products	1·14	5·20	0·0067	0·36	0·139
Paper Products	0·30	0·29	0·0041	1·26	0·109
Services	0·12	0·14	0·0019	0·13	0·029
Steam, hot water supply and water distribution	3·02	0·24	0·0026	0·15	0·079
Textile	0·95	0·81	0·0210	1·38	0·140
Transport	0·59	0·16	0·0022	0·17	0·041
Transport Equipment	0·38	0·51	0·0036	0·25	0·141
Waste management and disposal	1·07	0·22	0·0029	0·19	0·225

7. Footprint results: total impacts in relation the national consumption footprint

Table S7 Total footprint of the Dutch healthcare sector in relation to the national final consumption.

Impact category	**Healthcare footprint**	**National consumption footprint**	**Healthcare share of national consumption footprint**
Climate change (kt CO_2-eq.)	17575	241358	7·3%
Material extraction (kt)	33801	259060	13·0%
Blue water consumption (Mm^3)	394	5226	7·5%
Land use (km^2)	23845	329537	7·2%
Waste generation (kt)	4803	113826	4·2%

8. Footprint results: contribution analysis by sector

Table S8 The contribution analysis for the impact categories, following the GHG protocol terminology. Scope 1 are direct impacts, scope 2 are impacts from electricity production and steam/hot water supply, while scope 3 are all other indirect emissions. Classification of the 163 Exiobase sectors is provided in appendix 13. May not sum to total due to rounding.

Scope	Source (grouped)	Global warming (kt CO_2-eq.)	Material extraction (kt)	Blue water consumption (Mm^3)	Land use (km^2)	Waste generation (kt)
Scope 1	Operational impacts (including anaesthetic gases)	1588 (9·0%)	0 (0·0%)	0 (0·0%)	0 (0·0%)	190 (4·0%)
Scope 2	Electricity	1848 (10·5%)	135 (0·4%)	6 (1·5%)	108 (0·5%)	72 (1·5%)
	Steam and hot water supply	109 (0·6%)	0 (0·0%)	0 (0·0%)	0 (0·0%)	1 (0·0%)
Scope 3	Coal & petroleum	189 (1·1%)	71 (0·2%)	1 (0·3%)	37 (0·2%)	10 (0·2%)
	Construction	269 (1·5%)	755 (2·2%)	2 (0·5%)	172 (0·7%)	133 (2·8%)
	Electrical, electronic & measuring equipment	1336 (7·6%)	1408 (4·2%)	12 (3·0%)	620 (2·6%)	378 (7·9%)
	Food, tobacco & agricultural products	1018 (5·8%)	517 (1·5%)	94 (23·9%)	5645 (23·7%)	641 (13·3%)
	Furniture & timber	26 (0·1%)	20 (0·1%)	1 (0·3%)	225 (0·9%)	4 (0·1%)
	General and special machinery	182 (1·0%)	267 (0·8%)	2 (0·5%)	120 (0·5%)	75 (1·6%)
	Metal products	48 (0·3%)	83 (0·2%)	0 (0·0%)	16 (0·1%)	40 (0·8%)
	Minerals & metals	108 (0·6%)	1380 (4·1%)	1 (0·3%)	32 (0·1%)	162 (3·4%)
	Natural gas & gaseous fuels	108 (0·6%)	13 (0·0%)	0 (0·0%)	4 (0·0%)	1 (0·0%)
	Non-metallic mineral products	53 (0·3%)	242 (0·7%)	0 (0·0%)	17 (0·1%)	6 (0·1%)
	Paper products	202 (1·1%)	195 (0·6%)	3 (0·8%)	849 (3·6%)	73 (1·5%)
	Pharmaceuticals & chemical products	7239 (41·2%)	26936 (79·7%)	249 (63·2%)	14326 (60·1%)	2609 (54·3%)
	pMDI propellant releases	77 (0·4%)	0 (0·0%)	0 (0·0%)	0 (0·0%)	0 (0·0%)
	Private travel by patients & visitors	573 (3·3%)	24 (0·1%)	0 (0·0%)	2 (0·0%)	0 (0·0%)
	Services	1176 (6·7%)	1397 (4·1%)	18 (4·6%)	1301 (5·5%)	279 (5·8%)
	Textile	76 (0·4%)	64 (0·2%)	2 (0·5%)	109 (0·5%)	11 (0·2%)
	Transport	647 (3·7%)	175 (0·5%)	2 (0·5%)	188 (0·8%)	46 (1·0%)
	Transport equipment	25 (0·1%)	34 (0·1%)	0 (0·0%)	17 (0·1%)	9 (0·2%)
	Waste management & disposal	276 (1·6%)	56 (0·2%)	1 (0·3%)	49 (0·2%)	58 (1·2%)
	Water distribution	42 (0·2%)	12 (0·0%)	0 (0·0%)	7 (0·0%)	3 (0·1%)
Non-protocol	Private travel by patients & visitors	359 (2·0%)	19 (0·1%)	0 (0·0%)	1 (0·0%)	0 (0·0%)

Total		17575 (100%)	33801 (100%)	394 (100%)	23845 (100%)	4803 (100%)

9. Footprint results: hotspot analysis by sector

Table S9 The sectoral hotspot analysis for the impact categories. Classification of the 163 Exiobase sectors is provided in appendix 13. May not sum to total due to rounding.

Scope	Sector/source	Global warming (kt CO_2-eq.)	Material extraction (kt)	Blue water consump-tion (Mm^3)	Land use (km^2)	Waste generation (kt)
Direct	Operational impacts (including anaesthetic gases)	1588 (9·0%)	0 (0·0%)	0 (0·0%)	0 (0·0%)	190 (4·0%)
Indirect	Chemical	2174 (12·4%)	211 (0·6%)	15 (3·8%)	3 (0,0%)	229 (4·8%)
	Coal & petroleum	1636 (9·3%)	15 (0·0%)	0 (0·0%)	1 (0·0%)	39 (0·8%)
	Construction	108 (0·6%)	13 (0·0%)	0 (0·0%)	1 (0·0%)	119 (2·5%)
	Electrical, electronic & measuring equipment	555 (3·2%)	3 (0·0%)	4 (1·0%)	0 (0·0%)	11 (0·2%)
	Electricity	3969 (22·6%)	1 (0·0%)	7 (1·8%)	4 (0·0%)	95 (2·0%)
	Food, tobacco & agricultural products	2074 (11·8%)	92 (0·3%)	350 (88·8%)	23418 (98·2%)	1434 (29·9%)
	Furniture & timber	63 (0·4%)	0 (0·0%)	1 (0·3%)	78 (0·3%)	7 (0·1%)
	General & special machinery	21 (0·1%)	1 (0·0%)	1 (0·3%)	1 (0·0%)	6 (0·1%)
	Metal products	504 (2·9%)	9 (0·0%)	5 (1·3%)	2 (0·0%)	46 (1·0%)
	Minerals & metals	451 (2·6%)	33107 (97·9%)	2 (0·5%)	18 (0·1%)	2444 (50·9%)
	Natural gas & gaseous fuels	522 (3·0%)	18 (0·1%)	0 (0·0%)	0 (0·0%)	0 (0·0%)
	Non-metallic mineral products	468 (2·7%)	23 (0·1%)	0 (0·0%)	1 (0·0%)	8 (0·2%)
	Paper products	114 (0·6%)	1 (0·0%)	2 (0·5%)	32 (0·1%)	72 (1·5%)
	pMDI propellant releases	77 (0·4%)	0 (0·0%)	0 (0·0%)	0 (0·0%)	0 (0,0%)
	Private travel	553 (3·1%)	0 (0·0%)	0 (0·0%)	0 (0·0%)	0 (0·0%)
	Private travel, occuring in other	379 (2·2%)	42 (0·1%)	0 (0·0%)	3 (0·0%)	0 (0·0%)

	sectors (not distributed)					
	Services	412 (2·3%)	248 (0·7%)	2 (0·5%)	93 (0·4%)	21 (0·4%)
	Steam, hot water supply & water distribution	545 (3·1%)	0 (0·0%)	0 (0·0%)	1 (0·0%)	5 (0·1%)
	Textile	115 (0·7%)	0 (0·0%)	4 (1·0%)	150 (0·6%)	6 (0·1%)
	Transport	844 (4·8%)	7 (0·0%)	0 (0·0%)	26 (0·1%)	3 (0·1%)
	Transport equipment	11 (0·1%)	0 (0·0%)	0 (0·0%)	0 (0·0%)	1 (0·0%)
	Waste management & disposal	391 (2·2%)	10 (0·0%)	0 (0·0%)	12 (0·1%)	67 (1·4%)
Total		17575 (100%)	33801 (100%)	394 (100%)	23845 (100%)	4803 (100%)

10. Footprint results: hotspot analysis by region

Table S10 The geographical hotspot analysis for the different countries and regions in Exiobase. May not sum to total due to rounding. The country classification is adopted from a concordance table created for the DESIRE project.[30]

		Global warming (kt CO2-eq.)	Material extraction (kt)	Blue water consump-tion (Mm3)	Land use (km2)	Waste generation (kt)
Africa	**Rest of World Africa**	389 (2·2%)	298 (0·9%)	25·9 (6·6%)	3098 (13·0%)	191 (4·0%)
	South Africa	399 (2·3%)	159 (0·5%)	2·6 (0·7%)	812 (3·4%)	94 (2·0%)
America	**Brazil**	281 (1·6%)	299 (0·9%)	8·5 (2·2%)	1478 (6·2%)	432 (9·0%)
	Canada	106 (0·6%)	104 (0·3%)	0·4 (0·1%)	575 (2·4%)	45 (0·9%)
	Mexico	74 (0·4%)	104 (0·3%)	2·5 (0·6%)	145 (0·6%)	52 (1·1%)
	USA	839 (4·8%)	639 (1·9%)	33·5 (8·5%)	1780 (7·5%)	313 (6·5%)
	Rest of World Americas	362 (2·1%)	603 (1·8%)	10·8 (2·7%)	2905 (12·2%)	943 (19·6%)
Asia and Pacific	**Australia**	197 (1·1%)	416 (1·2%)	6·1 (1·5%)	2743 (11·5%)	291 (6·1%)
	China	2150 (12·2%)	7300 (21·6%)	37·4 (9·5%)	1198 (5·0%)	412 (8·6%)
	Indonesia	407 (2·3%)	912 (2·7%)	1·1 (0·3%)	630 (2·6%)	152 (3·2%)
	India	484 (2·8%)	16031 (47·4%)	52·6 (13·3%)	423 (1·8%)	130 (2·7%)
	Japan	156 (0·9%)	54 (0·2%)	0·2 (0·1%)	11 (0·0%)	6 (0·1%)
	Korea	104 (0·6%)	25 (0·1%)	0·3 (0·1%)	9 (0·0%)	7 (0·1%)
	Taiwan	186 (1·1%)	41 (0·1%)	0·1 (0·0%)	47 (0·2%)	0 (0·0%)
	Rest of World Asia and Pacific	766 (4·4%)	463 (1·4%)	61·5 (15·6%)	1673 (7·0%)	228 (4·7%)
Europe	**Austria**	15 (0·1%)	33 (0·1%)	0·1 (0·0%)	28 (0·1%)	6 (0·1%)
	Belgium	119 (0·7%)	113 (0·3%)	1·1 (0·3%)	36 (0·2%)	33 (0·7%)
	Bulgaria	11 (0·1%)	41 (0·1%)	0·2 (0·0%)	59 (0·2%)	13 (0·3%)

	Switzerland	25 (0·1%)	97 (0·3%)	0·1 (0·0%)	22 (0·1%)	4 (0·1%)
	Czech Republic	37 (0·2%)	29 (0·1%)	0·1 (0·0%)	30 (0·1%)	4 (0·1%)
	Germany	317 (1·8%)	329 (1·0%)	1·6 (0·4%)	201 (0·8%)	70 (1·4%)
	Denmark	27 (0·2%)	21 (0·1%)	0·1 (0·0%)	18 (0·1%)	6 (0·1%)
	Spain	80 (0·5%)	70 (0·2%)	4·1 (1·1%)	273 (1·1%)	32 (0·7%)
	Estonia	7 (0·0%)	4 (0·0%)	0·0 (0·0%)	38 (0·2%)	1 (0·0%)
	Finland	13 (0·1%)	61 (0·2%)	0·1 (0·0%)	75 (0·3%)	12 (0·2%)
	France	123 (0·7%)	174 (0·5%)	1·4 (0·4%)	190 (0·8%)	29 (0·6%)
	UK	134 (0·8%)	91 (0·3%)	0·5 (0·1%)	96 (0·4%)	14 (0·3%)
	Greece	28 (0·2%)	50 (0·1%)	0·6 (0·2%)	75 (0·3%)	8 (0·2%)
	Croatia	6 (0·0%)	7 (0·0%)	0·0 (0·0%)	7 (0·0%)	0 (0·0%)
	Hungary	19 (0·1%)	14 (0·0%)	0·2 (0·1%)	55 (0·2%)	5 (0·1%)
	Ireland	73 (0·4%)	20 (0·1%)	0·4 (0·1%)	86 (0·4%)	22 (0·5%)
	Italy	61 (0·3%)	70 (0·2%)	0·8 (0·2%)	60 (0·3%)	8 (0·2%)
	Lithuania	9 (0·1%)	5 (0·0%)	0·0 (0·0%)	59 (0·2%)	2 (0·0%)
	Luxembourg	9 (0·1%)	1 (0·0%)	0·0 (0·0%)	2 (0·0%)	1 (0·0%)
	Latvia	6 (0·0%)	1 (0·0%)	0·0 (0·0%)	71 (0·3%)	1 (0·0%)
	Malta	1 (0·0%)	1 (0·0%)	0·0 (0·0%)	0 (0·0%)	0 (0·0%)
	Norway	58 (0·3%)	46 (0·1%)	0·1 (0·0%)	102 (0·4%)	6 (0·1%)
	Poland	55 (0·3%)	150 (0·4%)	0·8 (0·2%)	86 (0·4%)	38 (0·8%)
	Portugal	18 (0·1%)	47 (0·1%)	0·3 (0·1%)	21 (0·1%)	5 (0·1%)
	Romania	33 (0·2%)	18 (0·1%)	2·1 (0·5%)	219 (0·9%)	15 (0·3%)
	Russia	766 (4·4%)	361 (1·1%)	5·7 (1·4%)	2353 (9·9%)	151 (3·2%)
	Slovakia	9 (0·1%)	7 (0·0%)	0·1 (0·0%)	20 (0·1%)	2 (0·0%)
	Slovenia	5 (0·0%)	4 (0·0%)	0·0 (0·0%)	3 (0·0%)	1 (0·0%)
	Sweden	22 (0·1%)	107 (0·3%)	0·2 (0·0%)	260 (1·1%)	40 (0·8%)
	Rest of World Europe	284 (1·6%)	101 (0·3%)	5·4 (1·4%)	861 (3·6%)	56 (1·2%)
Middle East	**Cyprus**	3 (0·0%)	3 (0·0%)	0·1 (0·0%)	6 (0·0%)	1 (0·0%)
	Turkey	49 (0·3%)	172 (0·5%)	4·6 (1·2%)	56 (0·2%)	14 (0·3%)

	Rest of World Middle East	1861 (10·6%)	3227 (9·5%)	109·3 (27·7%)	599 (2·5%)	237 (4·9%)
The Nether-lands	**The Netherlands, operational**	1588 (9·0%)	0 (0·0%)	0·0 (0·0%)	0 (0·0%)	190 (4·0%)
	The Netherlands, not operational	4420 (25·2%)	832 (2·5%)	9·9 (2·5%)	247 (1·0%)	482 (10·0%)
All	**Global**	379 (2·2%)	42 (0·1%)	0·3 (0·1%)	3 (0·0%)	0 (0·0%)
Grand Total		17575 (100%)	33801 (100%)	394·2 (100%)	23845 (100%)	4803 (100%)

11. Consolidated review of variability of models and data underlying comparable studies

Table S11 below shows the overview of the variability for models and data underlying the previous healthcare footprint studies that cover the carbon footprint of Dutch healthcare. The table showcases the differences for eight different aspects. The main difference between the present study and the work by Gupta Strategists is that the latter uses environmental intensities calculated for England rather than for the Netherlands, which can affect the results due to different sourcing of the countries' healthcare sectors. The studies by HCWH & Arup, Pichler et al. and Lenzen et al. are global studies that do not add bottom-up data to the EE-IOA footprint results. Furthermore, for Gupta Strategists, HCWH & Arup, Pichler et al. the definition of healthcare is narrower, as it does not include social work services. Also, Pichler et al. only considers CO_2 in their study, unlike the other studies that consider most or all greenhouse gases. The aforementioned three reasons can explain why the absolute values for the carbon footprint are lower compared to our results.

When comparing the decomposed footprint, if available, we also observe significant differences. The contribution analysis in the study by Gupta Strategists shows energy as the highest contributor to the carbon footprint (38%), which accounts for 11% in the present study. The hotspot analysis in the study by HCWH & Arup shows that Food, catering, and accommodation contributes the most to the carbon footprint (23%), which contributes 6% to the carbon footprint in the present study.

Finally, the differences in the share of the healthcare footprint as part of the national consumption footprint is partially explained by the variance in the national carbon footprint values (163 – 333 Mt CO_2-eq). In our research we have chosen the different environmental impacts as the main research objective as relatively few studies contribute to a wider environmental scope, therefore we have chosen not to do a full comparison, like a full comparison performed in chapter 6 in the appendix of Wu[25], between the different carbon footprint models.

Table S11 Overview of the variability for models and data underlying previous healthcare footprint studies that cover the carbon footprint of Dutch healthcare. FP = Footprint; GHG = greenhouse gases; SHA = System of Health Accounts, an internationally comparable definition of healthcare proposed by the OECD, that considers healthcare provision to residents (excluding social work and care provision to non-residents); SPA = structural path analysis.

	Present study	**Gupta Strategists, 2019[8]**	**HCWH & Arup, 2019[22]**	**Pichler et al., 2019[23]**	**Lenzen et al., 2020[24]**
MRIO	Exiobase v3 (2018)	MRIO[a] for England (2004)	WIOD (2016)	Eora full version (2018)	Eora full version (2018)
Year	2016	2017	2014	2014	2015
Selected environmental extension	All GHG according to ReCiPe 2016	All GHG according to IPCC (2007)	CO_2, CH_4, N_2O according to IPCC (2007)	CO_2	All GHG according to IPCC (2007)

Source environmental extension	Exiobase extensions	GHG intensities (impact/euro) for England	CO_2: WIOD extension; N_2O and CH_4: PRIMAP	IPCC (2007)	Eora extensions
Characterisation	Recipe 2016 (H)	IPCC (2007)	IPCC (2007)	-	IPCC (2007)
Definition of healthcare	Broad definition[b], health care and social work services	Broad definition[b], health care	Internationally comparable [c], health care (SHA)	Internationally comparable [c], health care (SHA)	Internationally comparable definition[c], Health care and social work services
Added element to EEIOA footprint calculation	Private travel, pMDI propellants, anaesthetic gases	Private travel	-	-	-
Short description footprint calculation (please refer to the cited studyfor the full description)	Operational (direct) CO_2-eq as reported by Statistics Netherlands; indirect emissions calculated for intermediate purchases by healthcare services, and the consumptive expenditure for medical goods. The expenditure data is based on healthcare expenditure data as reported by Statistics Netherlands	Impact from energy purchase through bottom-up estimations, impact from other purchases with intermediate purchasing expenditure taken from England, scaled with NL/England ratio of health care expenditures - except largest purchasing categories (>5% of	The study linked all SHA expenditure categories to the related WIOD sector categories. These were then linked to the OECD healthcare statistics. The scope 1 emissions are calculated by multiplying the direct emission intensity for the related healthcare sectors by the consumptive	The study linked all SHA expenditure categories to the related EORA sector categories. These are linked to the OECD healthcare statistics.	Footprint calculation for consumption of Health and social work services from final demand in EORA.

		total), replaced with Dutch expenditure data	healthcare expenditure.		
Applied breakdown perspective	Contribution and hotspot analysis	Contribution analysis	SPA, simplified to hotspotanalysis per GHGP scope	Contribtution analysis, only for the global level	SPA, only for the global level
Healthcare FP (Mt CO_2-eq.)	17·6	11	13·3	15·8	13·4
Share of national consumption FP	7·3%	7%	5·9%	8·1%	4·02%
National consumption FP (Mt CO_2-eq.)	241	163	225[d]	195[d]	333 [d]

a) National accounts (single region) by the UK's Office for National Statistics (ONS), expanded to a MRIO for 2004 with data from Eurostat, GTAP, OECD and IDE-JETRO
b) excluding import (healthcare provision to residents abroad), including export (healthcare provision to non-residents)
c) including import (healthcare provision to residents abroad), excluding export (healthcare provision to non-residents)
d) Inferred from the carbon footprint and share of the national consumption footprint as reported in the study

12. Role of pharmaceuticals in existing healthcare carbon footprint studies

We see that Pharmaceuticals and other chemical products also play a major role in the contribution analysis of the healthcare carbon footprint for other countries. In this contribution analysis of the Japanese study[25] , the purchase of Medication contributes most to the footprint (18%), closely followed by Electricity (17%). The contribution analysis in the study for Austria[26] indicates that Pharmaceuticals as a product group also contribute most to the total footprint (21%), followed by medical consumables (17%). In the study for England[7] , the Pharmaceuticals and chemicals product group is also the largest contributor to the footprint (20%). The study for China[27] even shows that Pharmaceuticals contribute 55% of the total climate footprint for the Chinese healthcare sector. In the study for Australia[28] and Canada[29] only the consumption of pharmaceuticals is reported separately, the purchase of pharmaceuticals is aggregated in the impacts of healthcare services. However, the study for Australia indicates that the impact intensities for Pharmaceuticals and Medication is significantly higher than impact intensities for other goods and services. Even then, the direct consumption of medicines is still the largest contributor to the climate footprint of the Canadian care sector, at 25%. Finally, Pichler et al.[23] shows that even globally Pharmaceuticals/chemicals is responsible for 20% of the climate footprint of the combined healthcare footprint of the OECD countries.

So we see that for a high income country the contribution of Pharmaceuticals and other chemical products is relatively high with a contribution of 38% to the total climate footprint of the health sector. Nevertheless, for all these studies, this product group still contributes the most to the healthcare footprint compared to other goods or services.

13. Sector classification

Table S13 Classification of the 163 sectors in Exiobase

Sector name	Aggregate description for table S5, S6, S8 and S9	Aggregate description for figure 1	Aggregate description for figure 2
Cultivation of paddy rice	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Cultivation of wheat	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Cultivation of cereal grains nec	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Cultivation of vegetables, fruit, nuts	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Cultivation of oil seeds	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Cultivation of sugar cane, sugar beet	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Cultivation of plant-based fibers	Textile	Other	Other
Cultivation of crops nec	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Cattle farming	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Pigs farming	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Poultry farming	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Meat animals nec	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Animal products nec	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Raw milk	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Wool, silk-worm cocoons	Textile	Other	Other
Manure treatment (conventional), storage and land application	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Manure treatment (biogas), storage and land application	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Forestry, logging and related service activities (02)	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Fishing, operating of fish hatcheries and fish farms; service activities incidental to fishing (05)	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Mining of coal and lignite; extraction of peat (10)	Coal and Petroleum	Other	Fossil fuel industry
Extraction of crude petroleum and services related to crude oil extraction, excluding surveying	Coal and Petroleum	Other	Fossil fuel industry
Extraction of natural gas and services related to natural gas extraction, excluding surveying	Natural gas and gaseous fuels	Heat and electricity	Fossil fuel industry
Extraction, liquefaction, and regasification of other petroleum and gaseous materials	Natural gas and gaseous fuels	Heat and electricity	Fossil fuel industry
Mining of uranium and thorium ores (12)	Minerals and Metals	Other	Mining of minerals and metals
Mining of iron ores	Minerals and Metals	Other	Mining of minerals and metals
Mining of copper ores and concentrates	Minerals and Metals	Other	Mining of minerals and metals
Mining of nickel ores and concentrates	Minerals and Metals	Other	Mining of minerals and metals
Mining of aluminium ores and concentrates	Minerals and Metals	Other	Mining of minerals and metals

Mining of precious metal ores and concentrates	Minerals and Metals	Other	Mining of minerals and metals
Mining of lead, zinc and tin ores and concentrates	Minerals and Metals	Other	Mining of minerals and metals
Mining of other non-ferrous metal ores and concentrates	Minerals and Metals	Other	Mining of minerals and metals
Quarrying of stone	Minerals and Metals	Other	Mining of minerals and metals
Quarrying of sand and clay	Minerals and Metals	Other	Mining of minerals and metals
Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	Minerals and Metals	Other	Mining of minerals and metals
Processing of meat cattle	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Processing of meat pigs	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Processing of meat poultry	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Production of meat products nec	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Processing vegetable oils and fats	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Processing of dairy products	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Processed rice	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Sugar refining	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Processing of Food products nec	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Manufacture of beverages	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Manufacture of fish products	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Manufacture of tobacco products (16)	Food, tobacco and agricultural products	Food and food services	Agricultural sector
Manufacture of textiles (17)	Textile	Other	Other
Manufacture of wearing apparel; dressing and dyeing of fur (18)	Textile	Other	Other
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear (19)	Textile	Other	Other
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (20)	Furniture and timber	Other	Other
Re-processing of secondary wood material into new wood material	Furniture and timber	Other	Other
Pulp	Paper Products	Other	Other
Re-processing of secondary paper into new pulp	Paper Products	Other	Other
Paper	Paper Products	Other	Other
Publishing, printing and reproduction of recorded media (22)	Paper Products	Other	Other
Manufacture of coke oven products	Coal and Petroleum	Other	Fossil fuel industry
Petroleum Refinery	Coal and Petroleum	Other	Fossil fuel industry
Processing of nuclear fuel	Chemical	Pharmaceuticals and chemical products	Pharmaceutical and chemical industry
Plastics, basic	Chemical	Pharmaceuticals and chemical products	Pharmaceutical and chemical industry
Re-processing of secondary plastic into new plastic	Chemical	Pharmaceuticals and chemical products	Pharmaceutical and chemical industry
N-fertiliser	Chemical	Pharmaceuticals and chemical products	Pharmaceutical and chemical industry

P- and other fertiliser	Chemical	Pharmaceuticals and chemical products	Pharmaceutical and chemical industry
Chemicals nec	Chemical	Pharmaceuticals and chemical products	Pharmaceutical and chemical industry
Manufacture of rubber and plastic products	Chemical	Pharmaceuticals and chemical products	Pharmaceuticals and chemical products
Manufacture of glass and glass products	Non-metallic mineral products	Other	Other
Re-processing of secondary glass into new glass	Non-metallic mineral products	Other	Other
Manufacture of ceramic goods	Non-metallic mineral products	Other	Other
Manufacture of bricks, tiles and construction products, in baked clay	Non-metallic mineral products	Other	Other
Manufacture of cement, lime and plaster	Non-metallic mineral products	Other	Other
Re-processing of ash into clinker	Non-metallic mineral products	Other	Other
Manufacture of other non-metallic mineral products n.e.c.	Non-metallic mineral products	Other	Other
Manufacture of basic iron and steel and of ferro-alloys and first products thereof	Metal Products	Other	Other
Re-processing of secondary steel into new steel	Metal Products	Other	Other
Precious metals production	Metal Products	Other	Other
Re-processing of secondary preciuos metals into new preciuos metals	Metal Products	Other	Other
Aluminium production	Metal Products	Other	Other
Re-processing of secondary aluminium into new aluminium	Metal Products	Other	Other
Lead, zinc and tin production	Metal Products	Other	Other
Re-processing of secondary lead into new lead, zinc and tin	Metal Products	Other	Other
Copper production	Metal Products	Other	Other
Re-processing of secondary copper into new copper	Metal Products	Other	Other
Other non-ferrous metal production	Metal Products	Other	Other
Re-processing of secondary other non-ferrous metals into new other non-ferrous metals	Metal Products	Other	Other
Casting of metals	Metal Products	Other	Other
Manufacture of fabricated metal products, except machinery and equipment (28)	Metal Products	Other	Other
Manufacture of machinery and equipment n.e.c. (29)	General and special Machinery	Other	Other
Manufacture of office machinery and computers (30)	General and special Machinery	Other	Other
Manufacture of electrical machinery and apparatus n.e.c. (31)	Electrical, electronic and measuring equipment	Medical, electrical equipment and machinery	Other
Manufacture of radio, television and communication equipment and apparatus (32)	Electrical, electronic and measuring equipment	Medical, electrical equipment and machinery	Other
Manufacture of medical, precision and optical instruments, watches and clocks (33)	Electrical, electronic and measuring equipment	Medical, electrical equipment and machinery	Other
Manufacture of motor vehicles, trailers and semi-trailers (34)	Transport Equipment	Other	Other
Manufacture of other transport equipment (35)	Transport Equipment	Other	Other
Manufacture of furniture; manufacturing n.e.c. (36)	Furniture and timber	Other	Other
Recycling of waste and scrap	Waste management and disposal	Other	Other

Recycling of bottles by direct reuse	Waste management and disposal	Other	Other
Production of electricity by coal	Electricity	Heat and electricity	Electricity sector
Production of electricity by gas	Electricity	Heat and electricity	Electricity sector
Production of electricity by nuclear	Electricity	Heat and electricity	Electricity sector
Production of electricity by hydro	Electricity	Heat and electricity	Electricity sector
Production of electricity by wind	Electricity	Heat and electricity	Electricity sector
Production of electricity by petroleum and other oil derivatives	Electricity	Heat and electricity	Electricity sector
Production of electricity by biomass and waste	Electricity	Heat and electricity	Electricity sector
Production of electricity by solar photovoltaic	Electricity	Heat and electricity	Electricity sector
Production of electricity by solar thermal	Electricity	Heat and electricity	Electricity sector
Production of electricity by tide, wave, ocean	Electricity	Heat and electricity	Electricity sector
Production of electricity by Geothermal	Electricity	Heat and electricity	Electricity sector
Production of electricity nec	Electricity	Heat and electricity	Electricity sector
Transmission of electricity	Electricity	Heat and electricity	Electricity sector
Distribution and trade of electricity	Electricity	Heat and electricity	Electricity sector
Manufacture of gas; distribution of gaseous fuels through mains	Natural gas and gaseous fuels	Heat and electricity	Fossil fuel industry
Steam and hot water supply	Steam, hot water supply and water distribution	Heat and electricity	Other
Collection, purification and distribution of water (41)	Steam, hot water supply and water distribution	Other	Other
Construction (45)	Construction	Other	Other
Re-processing of secondary construction material into aggregates	Construction	Other	Other
Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessoiries	Services	Services	Other
Retail sale of automotive fuel	Services	Services	Other
Wholesale trade and commission trade, except of motor vehicles and motorcycles (51)	Services	Services	Other
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52)	Services	Services	Other
Hotels and restaurants (55)	Food, tobacco and agricultural products	Food and food services	Other
Transport via railways	Transport	Other	Other
Other land transport	Transport	Other	Other
Transport via pipelines	Transport	Other	Other
Sea and coastal water transport	Transport	Other	Other
Inland water transport	Transport	Other	Other
Air transport (62)	Transport	Other	Other
Supporting and auxiliary transport activities; activities of travel agencies (63)	Services	Services	Other
Post and telecommunications (64)	Services	Services	Other
Financial intermediation, except insurance and pension funding (65)	Services	Services	Other
Insurance and pension funding, except compulsory social security (66)	Services	Services	Other

Activities auxiliary to financial intermediation (67)	Services	Services	Other
Real estate activities (70)	Services	Services	Other
Renting of machinery and equipment without operator and of personal and household goods (71)	Services	Services	Other
Computer and related activities (72)	Services	Services	Other
Research and development (73)	Services	Services	Other
Other business activities (74)	Services	Services	Other
Public administration and defence; compulsory social security (75)	Services	Services	Other
Education (80)	Services	Services	Other
Health and social work (85)	Services	Services	Other
Incineration of waste: Food	Waste management and disposal	Other	Other
Incineration of waste: Paper	Waste management and disposal	Other	Other
Incineration of waste: Plastic	Waste management and disposal	Other	Other
Incineration of waste: Metals and Inert materials	Waste management and disposal	Other	Other
Incineration of waste: Textiles	Waste management and disposal	Other	Other
Incineration of waste: Wood	Waste management and disposal	Other	Other
Incineration of waste: Oil/Hazardous waste	Waste management and disposal	Other	Other
Biogasification of food waste, incl. land application	Waste management and disposal	Other	Other
Biogasification of paper, incl. land application	Waste management and disposal	Other	Other
Biogasification of sewage slugde, incl. land application	Waste management and disposal	Other	Other
Composting of food waste, incl. land application	Waste management and disposal	Other	Other
Composting of paper and wood, incl. land application	Waste management and disposal	Other	Other
Waste water treatment, food	Waste management and disposal	Other	Other
Waste water treatment, other	Waste management and disposal	Other	Other
Landfill of waste: Food	Waste management and disposal	Other	Other
Landfill of waste: Paper	Waste management and disposal	Other	Other
Landfill of waste: Plastic	Waste management and disposal	Other	Other
Landfill of waste: Inert/metal/hazardous	Waste management and disposal	Other	Other
Landfill of waste: Textiles	Waste management and disposal	Other	Other
Landfill of waste: Wood	Waste management and disposal	Other	Other
Activities of membership organisation n.e.c. (91)	Services	Services	Other
Recreational, cultural and sporting activities (92)	Services	Services	Other
Other service activities (93)	Services	Services	Other
Private households with employed persons (95)	Services	Services	Other
Extra-territorial organizations and bodies	Services	Services	Other

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