

# **The biodiversity impact of health care: quantifying the extinction-risk footprint of health care in the Netherlands and other European countries**

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## Supplementary Material

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## S1: Detailed methods

### *Generating the satellite block from the Information on the IUCN Red List*

Species data was downloaded from the IUCN Red List version 2020-2 [1], with the species scope limited to comprehensively assessed species to ensure there was no geographic bias in the species assessment. The extinction risk category for each species was assigned a numeric value in equal steps ranging from 0 for Least Concern and Data Deficient, to 4 for Critically Endangered [2]. Next, each threat acting on that species was assigned a numeric Threat Impact score based on the scope and severity recorded for that threat, with a minimum value of 0 and a maximum value of 63 for a threat which is expected to cause very rapid declines in the whole population. Only threats with a timing value of Ongoing or Future were assigned a Threat Impact score, and where there was no information on the scope or severity of a threat the median possible value was used [3]. The extinction risk category value for each species was multiplied by the Threat Impact score for each threat acting on it to calculate the nSTAR value for each species-threat combination.

To allocate this nSTAR value to economic sectors, each of the threat classes used in the IUCN Red List [4] was assessed to determine which economic sectors are likely to be directly implicated in the activity generating that threat, with for example, the cultivation of rice allocated to Threat 2.1 - Annual & perennial non-timber crops. The binary concordance created by this allocation was then weighted according to the size of each economic sector and applied to the nSTAR values for each species-threat combination to calculate the nSTAR value associated with each species-sector combination. This sector to threat concordance is available at: <https://hdl.handle.net/2123/24233>.

Area of habitat (AOH) data was also derived from the species data in the IUCN Red List, which includes global species range data, elevation, and habitat preferences. When combined, these data created an AOH map for each species [5], which was used in conjunction with geographic boundary data to calculate the proportion of each species' AOH found in each country. This information was then applied to the nSTAR value for each species-sector combination to calculate a nSTAR value for each species-sector-country combination. Once these calculations were complete, 4,776 terrestrial bird, mammal, and amphibian species remained with a material nSTAR value. More detail on the methodology used to calculate the nSTAR metric, including associated limitations, is available in Irwin et al. [6].

### *Calculating the extinction-risk footprint*

The nSTAR value for each species-sector-country combination was then manipulated to match the country-sector structure of the Eora MRIO [7], creating a 4,776 x 14,839 satellite block  $\mathbf{Q}$ . The Eora MRIO provided an intermediate transaction matrix  $\mathbf{T}$ , a value-added matrix  $\mathbf{V}$ , and a final demand matrix  $\mathbf{Y}$ . The total output vector for this economic system,  $\mathbf{x}$ , was calculated from these matrices and then diagonalised and inverted to provide the matrix  $\hat{\mathbf{X}}^{-1}$ . The total requirements matrix  $\mathbf{A}$  was calculated by matrix multiplication of  $\mathbf{T}$  and  $\hat{\mathbf{X}}^{-1}$ , and the Leontief Inverse  $\mathbf{L}$  derived following equation (S1).

$$\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1} \quad (\text{S1})$$

where  $\mathbf{I}$  is an identity matrix equal in size to the intermediate transaction matrix  $\mathbf{T}$ .

The direct intensity matrix  $\mathbf{Z}$  was derived from the satellite block  $\mathbf{Q}$  through matrix multiplication of  $\mathbf{Q}$  and  $\hat{\mathbf{X}}^{-1}$ , and provided information on the extinction risk embodied in \$USD1 worth of total output from each sector. Given the three matrices  $\mathbf{Z}$ ,  $\mathbf{L}$ , and  $\mathbf{Y}$ , the extinction-risk footprint ( $\mathbf{f}_k$ ) for a given sector  $k$  was calculated using equation (S2).

$$\mathbf{f}_k = \mathbf{Z} * \mathbf{L} * \mathbf{Y}_k \quad (\text{S2})$$

More details on this methodology and its limitations are available in Irwin et al. [6].

The extinction-risk footprint derived using equation (S2) quantifies the impact that consumption at the point of final demand has on the extinction risk of all species in scope. In order to deconstruct this impact at a different point in the supply chain we generated a deconstructed footprint. First, the net multiplier matrix  $\mathbf{N}$  was calculated by multiplying the diagonalised total final demand matrix  $\hat{\mathbf{Y}}_{total}$  with  $\hat{\mathbf{X}}^{-1}$ . The multiplier generated here represents the relativity between the total output for each sector and the final demand for that sector [8]. Next, the transaction vector  $\mathbf{t}_i$  for the sector ( $i$ ) was obtained from the intermediate transaction matrix  $\mathbf{T}$  and multiplied element-wise with the value  $\mathbf{N}_{ii}$  to generate the intermediate demand vector  $\mathbf{d}_i$ . With  $\mathbf{d}_i$  substituted into equation (S2) in place of  $\mathbf{Y}$ , the footprint associated with the intermediate expenditure patterns of sector ( $i$ ) were calculated. Here, we used the intermediate expenditure vector for the Dutch health and social work industry sector, which is the 2<sup>nd</sup> order sector for 98% of the top 5,000 structural paths, as the substitute for final demand. This provided insight into the contribution that intermediate expenditure on each other sector makes to the total extinction-risk footprint of the Dutch health care sector.

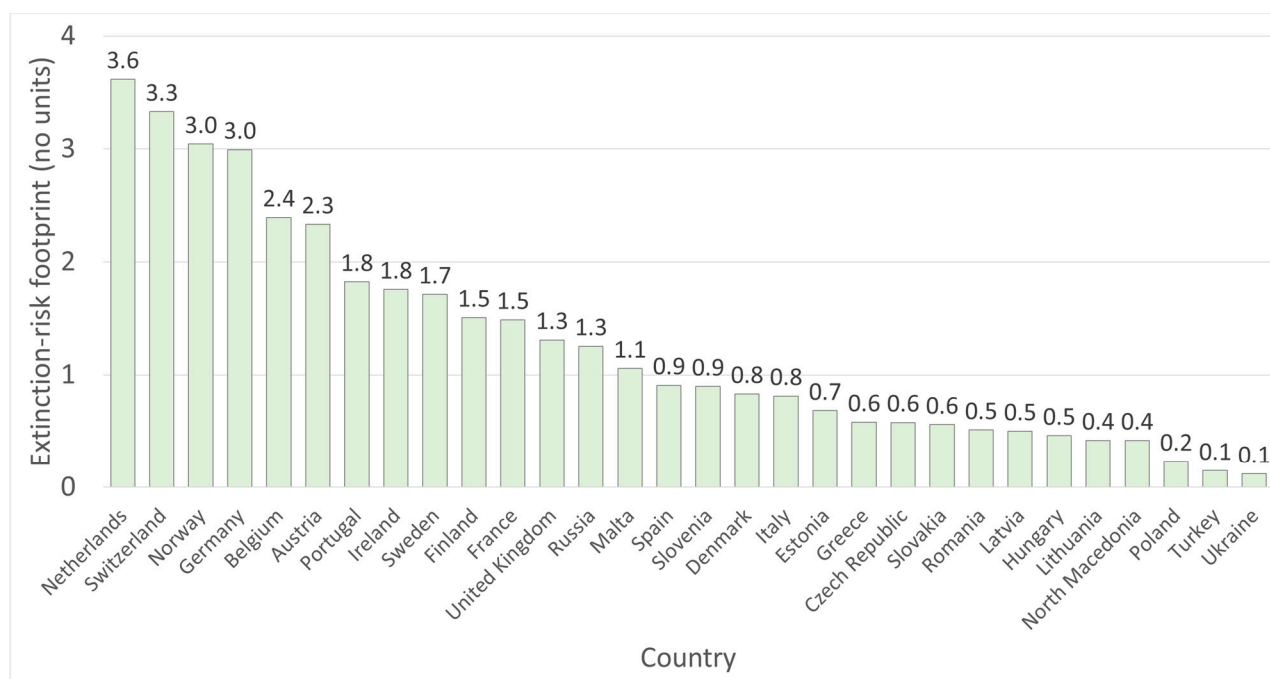
## S2: Sectoral structure of the Dutch economy

**Table S1: Sectors included within the Eora MRIO [7] for the Netherlands.** Sectors are ranked in order of the size of the extinction-risk footprint generated by consumption of products and services provided by that sector.

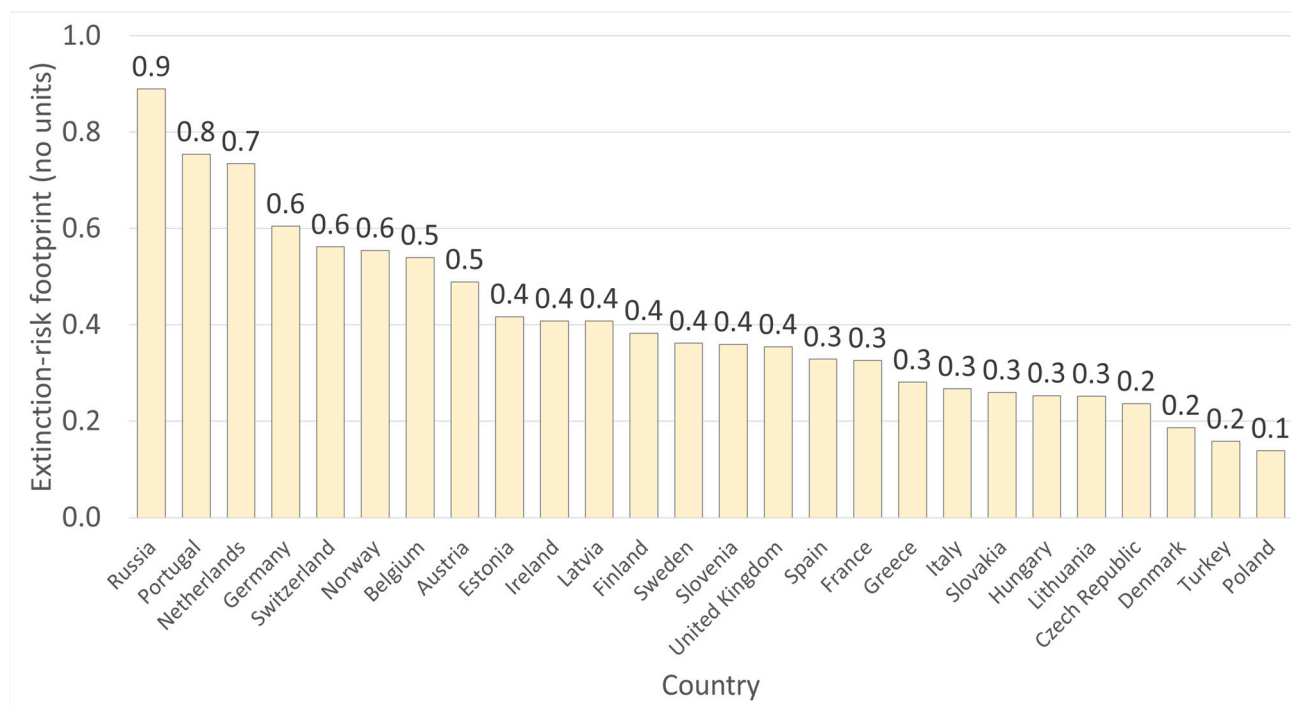
Extinction-risk footprint rank	Sector
1	Food products and beverages
2	Re-export
3	Tobacco products
4	Construction work
5	Hotel and restaurant services
6	Public administration and defence services; compulsory social security services
7	Health and social work services
8	Products of agriculture, hunting and related services
9	Education services
10	Wholesale trade and commission trade services, except of motor vehicles and motorcycles
11	Real estate services
12	Machinery and equipment n.e.c.
13	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods
14	Furniture; other manufactured goods n.e.c.
15	Chemicals, chemical products and man-made fibres
16	Motor vehicles, trailers and semi-trailers
17	Recreational, cultural and sporting services
18	Other business services
19	Other services
20	Other transport equipment
21	Trade, maintenance and repair services of motor vehicles and motorcycles; retail sale of automotive fuel
22	Medical, precision and optical instruments, watches and clocks
23	Post and telecommunication services
24	Office machinery and computers
25	Supporting and auxiliary transport services; travel agency services
26	Radio, television and communication equipment and apparatus
27	Insurance and pension funding services, except compulsory social security services
28	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials
29	Electrical energy, gas, steam and hot water
30	Printed matter and recorded media
31	Air transport services
32	Land transport; transport via pipeline services
33	Fabricated metal products, except machinery and equipment
34	Textiles
35	Coke, refined petroleum products and nuclear fuels
36	Research and development services
37	Renting services of machinery and equipment without operator and of personal and household goods
38	Wearing apparel; furs
39	Leather and leather products
40	Computer and related services
41	Electrical machinery and apparatus n.e.c.
42	Financial intermediation services, except insurance and pension funding services
43	Membership organisation services n.e.c.
44	Water transport services
45	Rubber and plastic products
46	Sewage and refuse disposal services, sanitation and similar services
47	Pulp, paper and paper products
48	Secondary raw materials
49	Basic metals
50	Other non-metallic mineral products
51	Products of forestry, logging and related services
52	Collected and purified water, distribution services of water
53	Services auxiliary to financial intermediation
54	Private households with employed persons
55	Fish and other fishing products; services incidental of fishing
56	Crude petroleum and natural gas; services incidental to oil and gas extraction excluding surveying
57	Other mining and quarrying products
58	Coal and lignite; peat
59	Uranium and thorium ores
60	FISIM
61	Metal ores

### S3: Extinction-risk footprint data for additional countries

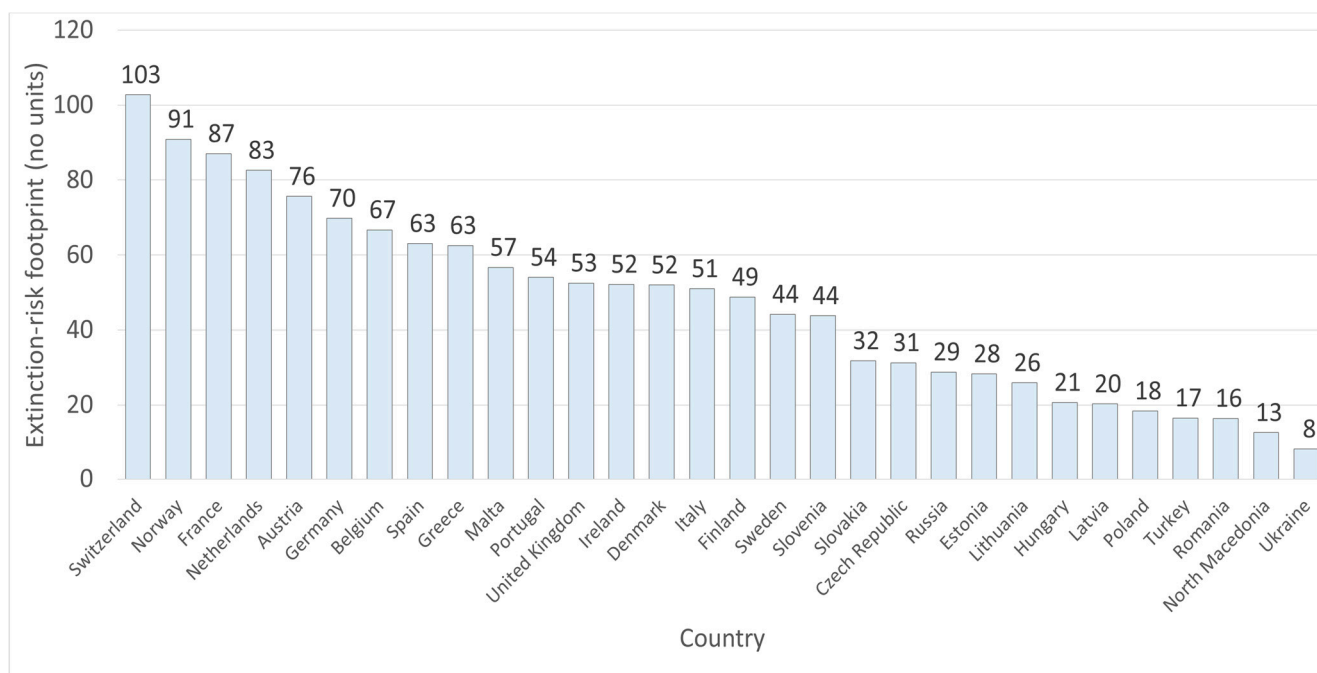
Further information on the extinction-risk footprint and related measures of those European countries that report expenditure on Health care separately from Education and other services are provided in figures S1 – S5.



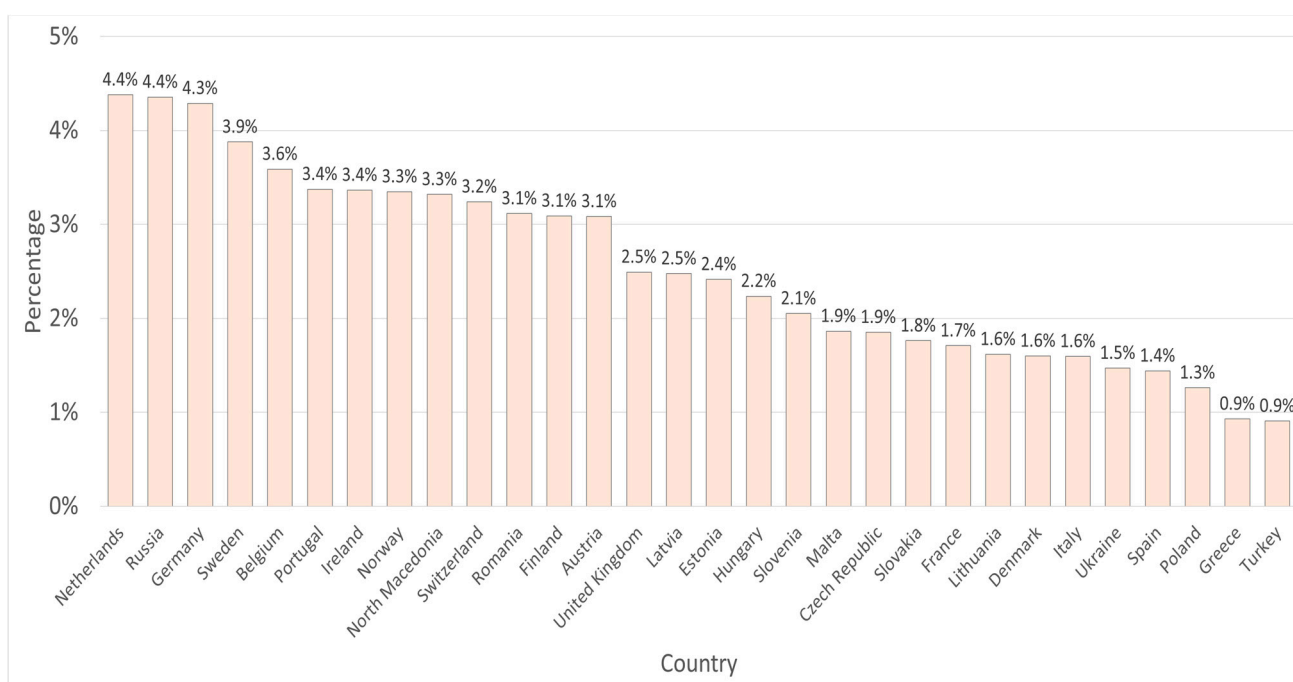
**Figure S1: Health care extinction-risk footprint per million people.** Note that Germany, United Kingdom, and Denmark each use unique sector definitions, so their footprint values may not be directly comparable with the other countries.



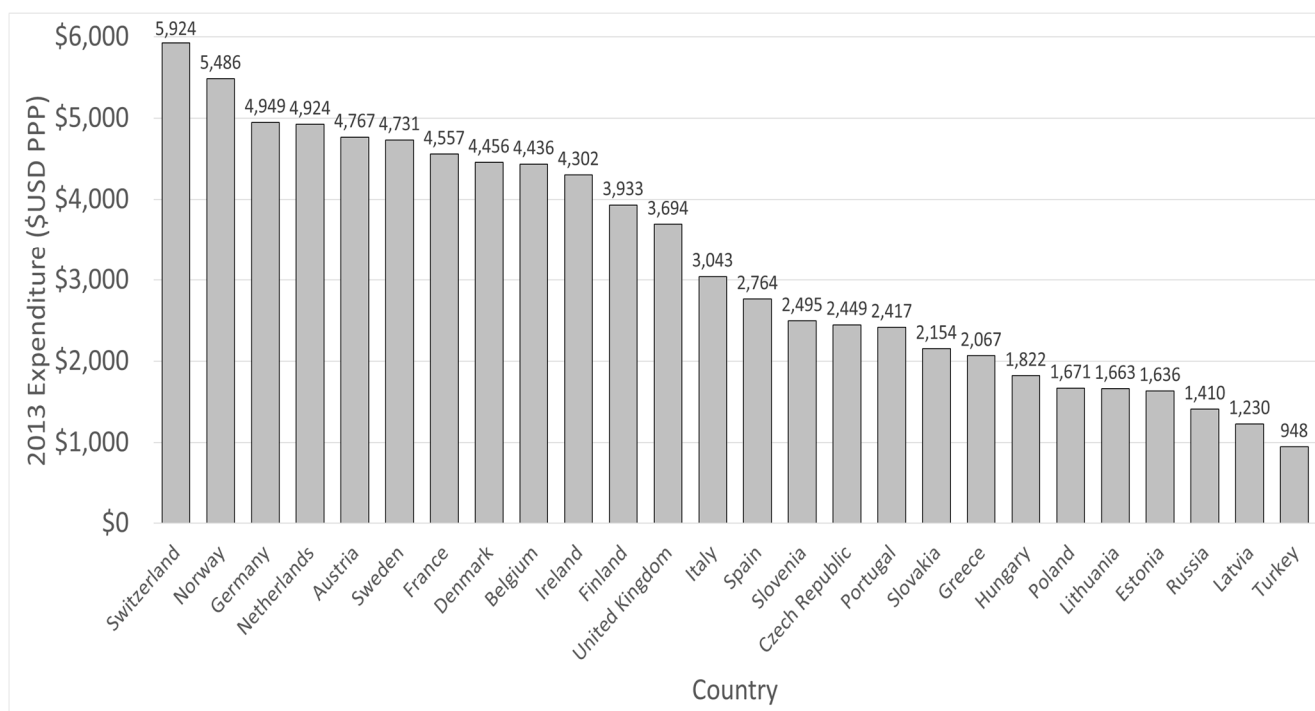
**Figure S2: Health care extinction-risk footprint per \$USD billion expenditure.** Note that Germany, United Kingdom, and Denmark each use unique sector definitions, so their footprint and expenditure values may not be directly comparable with the other countries. Expenditure data are for 2013 per-capita, at current prices and current purchasing power parities (PPPs) [9].



**Figure S3: Total extinction-risk footprint per million people across all sectors.**



**Figure S4: Health care's extinction-risk footprint as a share of the country total.** Note that Germany, United Kingdom, and Denmark each use unique sector definitions, so their footprint values may not be directly comparable with the other countries.



**Figure S5: Health care expenditure per-capita for 2013 at current prices and current purchasing power parities (PPPs) [9].** Note that Germany, United Kingdom, and Denmark each use unique sector definitions, so their expenditure values may not be directly comparable with the other countries. Expenditure data are not available for North Macedonia, Romania, Malta, and Ukraine.



#### S4: Additional data for top 10 countries

**Table S2: Detailed data for 10 European countries**

Source of data:	World Bank (A)	OECD (B)	World Bank (C)	Output of research (D)	calculated <sup>1</sup> (E)	calculated <sup>2</sup> (F)	Output of research (G)	calculated <sup>3</sup> (H)	calculated <sup>4</sup> (I)	calculated <sup>5</sup> (J)	calculated <sup>6</sup> (K)	Footprint decomposition at third order				
Country	2013 GDP (\$USD billions)	OECD health expenditure 2013 USD ppp per capita	2013 Population (million)	Country consumption extinction-risk footprint	Country consumption extinction-risk footprint per capita (millions)	Country consumption extinction-risk footprint per \$billion GDP	Health care sector extinction-risk footprint	Health care sector extinction-risk footprint per capita (millions)	Health care sector extinction-risk footprint per \$billion GDP	Health care extinction-risk footprint per \$billion Health expenditure OECD	Health care sector extinction-risk footprint as share of total country extinction-risk footprint	Rank 1 intermediate footprint sector	Rank 2 intermediate footprint sector	Rank 3 intermediate footprint sector	Rank 4 intermediate footprint sector	Rank 5 intermediate footprint sector
Netherlands	877	4924	16.8	1388	83	1.6	60.8	3.6	0.07	0.73	4.38%	F&B	Agriculture	All other	Other services	Chemicals & Pharmaceuticals
Germany	3733	4949	80.6	5629	70	1.5	241.4	3.0	0.06	0.60	4.29%	F&B	Agriculture	All other	Other services	Other products & Manufacturing
Sweden	587	4731	9.6	424	44	0.7	16.4	1.7	0.03	0.36	3.88%	All other	Other services	F&B	Other products & manufacturing	Agriculture
Belgium	522	4436	11.2	744	67	1.4	26.7	2.4	0.05	0.54	3.59%	F&B	Other	Chemicals	Health Care services	Agriculture
Portugal	226	2417	10.5	565	54	2.5	19.1	1.8	0.08	0.75	3.38%	F&B	Agriculture	Chemicals	Business services	Health Care services
Ireland	239	4302	4.6	241	52	1.0	8.1	1.8	0.03	0.41	3.37%	Other products & manufacturing	Chemicals	All other	Health Care services	Other services
Norway	523	5486	5.1	462	91	0.9	15.5	3.0	0.03	0.55	3.35%	All other	Agriculture	Other products & manufacturing	F&B	Other services
Switzerland	689	5924	8.1	831	103	1.2	26.9	3.3	0.04	0.56	3.24%	F&B	All other	Agriculture	Other services	Chemicals
Finland	271	3933	5.4	265	49	1.0	8.2	1.5	0.03	0.38	3.09%	F&B	Chemicals	Agriculture	Other services	All other
Austria	430	4767	8.5	641	76	1.5	19.8	2.3	0.05	0.49	3.09%	F&B	Chemicals	Agriculture	Other services	All other
TOTAL	8096	4587	160.4	11191	70	1.38	443	2.8	0.055	0.60	3.96%					

<sup>1</sup> Calculated by dividing column (D) by column (C)

<sup>2</sup> Calculated by dividing column (D) by column (A)

<sup>3</sup> Calculated by dividing column (G) by column (C)

<sup>4</sup> Calculated by dividing column (G) by column (A)

<sup>5</sup> Calculated by dividing column (G) by [(column (B) × column (C)) ÷ 1000]

<sup>6</sup> Calculated by dividing column (G) by column (D)

Sources: World bank [GDP \(current US\\$\) - Belgium, Germany, Netherlands, Sweden, Switzerland, United Kingdom, Ireland, Norway, Finland, Austria | Data \(worldbank.org\)](#)  
World bank [Population, total - Belgium, Germany, Netherlands, Sweden, Switzerland, Portugal, Ireland, Norway, Finland, Austria | Data \(worldbank.org\)](#)  
OECD [Health expenditure and financing \(oecd.org\)](#)

Note that there is a difference in the way the total footprint and health care footprints are calculated. The consumption footprint includes the demand for all sectors coming from consumption based in that country. The health care footprint uses all demand for the health care sector in that country, regardless of which country that demand comes from. This could be an issue if the cross-country demand is strong (for NLD it is not, it represents 1% of the total).

## S5: Top 40 countries impacted by consumption of Dutch health care products and services

The extinction risk impact of consumption of Dutch health care is overwhelmingly experienced outside of the Netherlands, with 99.96% of the footprint imported. Table S3 includes the top 40 countries impacted by Dutch health care consumption, which together represent 91% of the total Dutch health care extinction-risk footprint.

**Table S3: Top 40 countries impacted by consumption of Dutch health care**

Impacted Country			% total Dutch health care extinction-risk footprint
1	MDG	Madagascar	12.2%
2	ROW	Rest of World <sup>^</sup>	10.2%
3	BRA	Brazil	4.9%
4	TZA	Tanzania	4.8%
5	IDN	Indonesia	4.3%
6	CMR	Cameroon	4.0%
7	HND	Honduras	3.9%
8	GTM	Guatemala	3.1%
9	ETH	Ethiopia	3.0%
10	GHA	Ghana	2.7%
11	LKA	Sri Lanka	2.7%
12	CRI	Costa Rica	2.6%
13	ZAF	South Africa	2.3%
14	PER	Peru	2.1%
15	IND	India	1.9%
16	PHL	Philippines	1.9%
17	CIV	Côte d'Ivoire	1.7%
18	KEN	Kenya	1.5%
19	ECU	Ecuador	1.5%
20	ARG	Argentina	1.4%
21	AUS	Australia	1.4%
22	COD	Democratic Republic of the Congo	1.3%
23	DOM	Dominica	1.3%
24	MEX	Mexico	1.2%
25	USA	United States of America	1.2%
26	MYS	Malaysia	1.2%
27	CHN	China	1.1%
28	PNG	Papua New Guinea	1.0%
29	PAN	Panama	1.0%
30	VNM	Vietnam	0.9%
31	FRA	France	0.8%
32	COL	Colombia	0.8%
33	BOL	Bolivia	0.8%
34	RUS	Russia	0.8%
35	CUB	Cuba	0.7%
36	CHL	Chile	0.6%
37	GIN	Guinea	0.5%
38	SUR	Suriname	0.5%
39	MAR	Morocco	0.5%
40	STP	São Tomé and Príncipe	0.5%

<sup>^</sup> 'Rest of World' includes 61 countries which are not explicitly included in the Eora MRIO<sup>7</sup> but for which nSTAR data are available.

## S6: Top 10 species impacted by consumption of Dutch health care products and services

The top 10 species impacted by consumption of the products and services provided by the Dutch health care sector are included in Table S4.

**Table S4: Top 10 species impacted by consumption of Dutch health care**

	Species / Common name		Class	Extinction risk category	Dutch health care extinction-risk footprint (no units)	Percent of species' total extinction-risk footprint
1	Leptotila wellsi	Grenada Dove	Aves	CR	0.46	0.13%
2	Leptodactylus fallax	Mountain Chicken	Amphibia	CR	0.45	0.13%
3	Piliocolobus waldroni	Miss Waldron's Red Colobus	Mammalia	CR	0.42	0.12%
4	Colobus vellerosus	White-thighed Colobus	Mammalia	CR	0.42	0.10%
5	Cercopithecus roloway	Roloway monkey	Mammalia	CR	0.23	0.13%
6	Pteropus livingstonii	Livingstone's Flying Fox	Mammalia	CR	0.21	0.13%
7	Pteropus nitendensis	Temotu Flying Fox	Mammalia	EN	0.20	0.13%
8	Cercocebus lunulatus	White-naped Mangabey	Mammalia	EN	0.19	0.14%
9	Setophaga angelae	Elfin Woods Warbler	Aves	EN	0.19	0.13%
10	Eleutherodactylus locustus	Locust Coqui	Amphibia	EN	0.18	0.13%

Extinction risk category abbreviations

CR Critically Endangered

EN Endangered

Further information is available at: [https://nc.iucnredlist.org/redlist/content/attachment\\_files/RedListGuidelines.pdf](https://nc.iucnredlist.org/redlist/content/attachment_files/RedListGuidelines.pdf)

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