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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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Abstract: The health care sector exists to support and promote human wellbeing; however, its operations contribute to environmental degradation undermining nature's capacity to support the same wellbeing. Biodiversity loss, in particular, creates threats to wellbeing through a reduction in ecosystem service provisioning and increases in disease. This study aims to estimate the extinction-risk footprint associated with the health care sector, focusing on Europe. We created an environmentally-extended multi-region input–output model using data on the extinction risk of species available from the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species. Using input–output analysis, we then quantified the extinction-risk footprint of the Dutch health care sector and, for comparison, that of the 30 European nations which use similar sector classifications in their National Accounts reporting. We found that the Netherlands has the highest health care extinction-risk footprint on a per-capita basis and that health care contributes 4.4% of the Dutch consumption extinction-risk footprint compared with an average of 2.6% across the comparator set. Food and beverage supply chains make a disproportionate contribution to health care's extinction-risk footprint, while supply chains implicated in the sector's carbon footprint make a limited contribution. These results suggest that reducing the environmental impact of the health care sector may require a differentiated approach when multiple environmental indicators are considered.

Keywords: biodiversity loss; extinction risk; footprint; multi-region input–output (MRIO); input–output analysis; Red List of Threatened Species

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1. Introduction

Earth's biodiversity is declining, with rates of species extinction at a higher level than the historical average and accelerating [1]. Of value intrinsically [2], biodiversity is also critical for human health and wellbeing through the provision of products such as food, medicines, and fuel; the provision of ecosystem services which provide clean air and water; and through connection to cultural practices and nature [3]. The loss of biodiversity not only reduces the provision of these benefits but also threatens human health, with strong linkages found between the increased prevalence of zoonotic diseases and biodiversity loss [3,4]. The Convention on Biological Diversity (CBD), which came into force in 1993, is the international instrument that informs global efforts to conserve biodiversity and promote the sustainable use of biological resources [5]; however, the achievement of many of the targets set under its auspices is off-track [6]. As the international community begins to implement the most recent global agreement related to the CBD, the Global Biodiversity Framework [7], understanding how each economic sector contributes to biodiversity loss provides a starting point for identifying targeted opportunities to reduce this loss.

The health care sector, with its pivotal role in promoting population health, is also implicated in the environmental impacts which threaten it, such as greenhouse gas emissions, water use, and pollution [8,9]. The Netherlands, along with 61 other countries, has committed to "deliver climate resilient and low carbon, sustainable health systems" as part of the World Health Organization's Alliance for Transformative Action on Climate and Health [10]. In addition, the Netherlands has made broader commitments under its 'Green Deal on Sustainable Healthcare' [11], including socially and environmentally responsible procurement, reduced pharmaceutical residue in drinking water, and a healthy environment [12]. Given this commitment to a broader range of environmental impacts, the Netherlands presents a meaningful starting point to examine the impact of the health care sector on biodiversity loss.

The link between the provision of health care and biodiversity loss has rarely been studied, and only within the context of the total environmental impacts of the sector [8,13], or as part of an analysis of the total biodiversity footprint of a country [14]. Here, we specifically study the impact of the health care sector on biodiversity by quantifying its extinction-risk footprint, focusing on the Netherlands and other selected European nations for contrast. Direct drivers of biodiversity loss include over-exploitation, land use change, climate change, and invasive species [15]. Many of these drivers are precipitated by localized activity such as agricultural expansion, which is in turn undertaken to provide inputs into complex, global supply chains. These supply chains ultimately satisfy consumer demand which may be geographically displaced from the location of those activities and the resultant environmental impact [16–18]. Unravelling these supply chain connections requires a methodology that can connect each transaction within these supply chains to every other transaction, and to the environmental impact itself. We utilized input–output methodology and adapted the recently developed Species Threat Abatement and Restoration metric [19] to calculate an extinction-risk footprint for the Dutch health care sector and explore the supply chain connections which contribute to this footprint.

The aims of this study are to (1) estimate the extinction-risk footprint associated with the consumption of health care products and services in the Netherlands and other European countries; (2) identify the characteristics of this footprint in the Netherlands; and (3) explore opportunities to reduce the effect of this Netherlands-based consumption on global extinction risk. The key findings are that the Netherlands has the highest health care extinction-risk footprint on a per-capita basis across the comparator set, and that food and beverage supply chains make a disproportionate contribution to health care's extinction-risk footprint in the Netherlands. This suggests that further research into these supply chains will be valuable in reducing the health care sector's impact on species extinction risk.

2. Methods

2.1. Methodology

Input–output analysis, first proposed by Leontief [20], has been used to quantify the environmental impact of consumption across various environmental stressors [21,22]. This methodology connects the flow of money between sectors and countries throughout the global economy to the direct activity which generates an environmental impact at the source. Through this connection, the impact attributable to the final consumption of a product or service can be calculated and assigned to the sector and location which has induced that environmental impact.

Two key inputs are required for this type of analysis—a quantifiable measure of the environmental indicator to be studied, and economic data at an appropriate resolution. To obtain a quantifiable measure of biodiversity loss, we reapply the methodology introduced in Irwin et al. [17], which utilizes data from the IUCN Red List of Threatened Species [23] to generate a measure of extinction risk for each in-scope species, country, and economic sector. The IUCN Red List provides detailed information on each species, including its extinction risk category, its distribution and habitat preferences, and detailed information on the type, scope, and severity of threats acting on that species [24]. Economic data available in the Eora multi-region input–output (MRIO) database provides the second input to this analysis [25].

Species information was used to generate the non-normalized Species Threat Abatement and Restoration (nSTAR) metric, which provides a quantifiable value of the extinction risk of each species. This unit-less metric differs from other biodiversity loss metrics in its use of species extinction risk as the quantifiable representation of biodiversity loss rather than land use or species threats [16,26–28], converting the extinction risk classification of the species and the scope and severity of the threats acting on it into a numeric value that provides an indicator of how likely a species is to move closer to extinction. The sum of all nSTAR values provides a measure of the current global extinction risk across all in-scope species, such that a global nSTAR value of zero would indicate that no species are threatened with extinction, and the inclusion of threat information enables the connection of this metric to economic activity, where relevant. The nSTAR value for each species–sector–country combination, reapplied from Irwin et al. [17], constituted the satellite block **Q** which, together with the economic data available in the Eora MRIO [25], provided an environmentally-extended MRIO from which the extinction-risk footprint for each country and sector was generated. Further details on the methods and associated limitations are available in Irwin et al. [17] and in the Supplementary Materials. Once the extinction-risk footprint was calculated, three analytical approaches available within input–output methodology were used to explore the characteristics of the footprint.

Structural path analysis pinpoints the detailed supply chains through which the extinction-risk footprint accumulates by following the expenditure through sector-to-sector transactions within an individual supply chain until it reaches the sector of direct environmental impact [29]. Figure 1 provides a simplified example of a fifth order supply chain where expenditure on Dutch health care generates a direct extinction risk impact at a mining site in the Democratic Republic of the Congo via expenditure on products manufactured in Belgium. The top 5000 supply chains, ranked by footprint value, were calculated to understand the location of the sectors which ultimately bear the impact of the final consumption of Dutch health care.

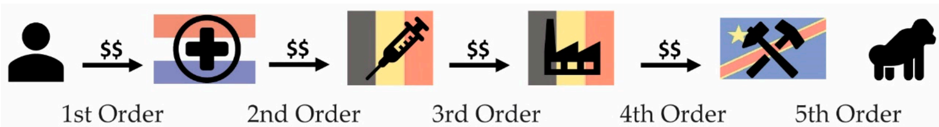

Figure 1. A simplified example of one of health care's 5th order supply chains, with hypothetical product details. At the 1st order a consumer spends money on the Dutch health care sector. The health care sector spends money on glass products from Belgium at the 2nd order, and the supplier of the glass products spends money on cutting and polishing equipment produced by the Belgian manufacturing sector at the 3rd order. In order to manufacture this equipment, the Belgian manufacturer spends money on diamonds mined in the Democratic Republic of the Congo at the 4th order. The direct extinction risk impact is felt at the 5th order, at the location of mining activity. The extinction-risk footprint generated by this supply chain, calculated using structural path analysis, represents 0.01% of the total extinction-risk footprint of the Dutch health care sector.

Footprint deconstruction allows us to isolate the footprint contribution of intermediate expenditure at a particular order of the underlying supply chains. Here we deconstructed the Dutch health care sector's extinction-risk footprint at the third order, the point at which the industry sector begins to spend money on all other sectors, in order to determine the relative contribution of those sectors to its total extinction-risk footprint. This deconstructed footprint uses the intermediate expenditure vector for the second-order sector, adjusted by a net multiplier which captures the relativity between that sector's final demand and its total output [30]. This adjusted expenditure vector is then used to calculate the footprint generated by the intermediate expenditure. Further details on the method used are available in the Supplementary Materials.

Production layer decomposition uncovers the extinction-risk footprint value at each layer of the supply chain. The point of final consumption (when a consumer spends money on a health care product or service) represents the first production layer. The second production layer captures the expenditure of the health care sector on the products and services provided by its suppliers, the third production layer captures the expenditure of those suppliers on their suppliers, and so on. These expenditure interactions can be coupled with the nSTAR data available in satellite block **Q** to derive the extinction-risk footprint generated at each production layer and determine how 'deep' within the supply chain the direct extinction risk impact is borne. This understanding supports the identification of appropriate actions, since the level of influence that an actor has over the extinction risk implicated in their supply chain varies based on the order of that supply chain. For example, if there is a significant impact at the second production layer, interventions targeted at direct suppliers may be possible, whereas if the impact is not significant until higher order layers, direct intervention is less likely to be effective and further analysis will be required.

2.2. Data

Version 2020-2 of the IUCN Red List [23] was chosen for this research to leverage the species area of habitat (AOH) maps employed by previous research [17,19], and provided detailed species information for more than 120,000 species. Following the methodology introduced in Mair et al. [19], the species scope was refined to include only comprehensively assessed species, namely amphibians, mammals, and birds, and those for which terrestrial area of habitat (AOH) data are available. The scope was further limited to species assessed as Near Threatened (NT), Vulnerable (VU), Endangered (EN), or Critically Endangered (CR). These refinements left 5295 species in scope.

The comprehensive economic data available in the Eora MRIO covers 189 countries and one 'rest of world' region and provides detailed transactions for 2013 [25]. Each country's economic transactions are captured according to the sector classifications used in its System of National Accounts. These classifications vary in size from 26 sectors to 1022 sectors by country, creating a total economic structure of 14,839 sectors. Sector classifications used for the Netherlands follow the Eurostat NACE v.1 structure with 61 industry sectors and 61 commodity sectors [31]. The two sectors which are the focus of this research are the Health and Social Work Services Commodity and Health and Social Work Industry sectors, for simplicity they will be referred to collectively as health care. The sub-sectors included within these classifications are Human health activities, Veterinary activities, and Social work activities [31,32]. The full list of sectors included in Eora for the Netherlands is included in the Supplementary Materials (Table S1).

3. Results

The Netherlands, with 0.23% of the global population [33], contributes 0.43% of the global extinction-risk footprint. The extinction risk generated by Dutch consumption is overwhelmingly borne by species located outside of the Netherlands, with 99.94% of the Dutch extinction-risk footprint being imported. The health care sector generates 4.4% of this national extinction-risk footprint, and 99.96% of this sector footprint is imported. Details on the top 40 countries impacted by Dutch health care consumption are included in the Supplementary Materials (Table S3).

European countries differ markedly in the extinction-risk footprint of their health care sectors. In a comparison of 30 European nations which use similar sector classifications in their National Accounts reporting, the Netherlands has the highest health care extinction-risk footprint on a per-capita basis, at 3.6 per million people, and Ukraine the lowest at 0.1 per million people. These variations result from a combination of two factors: differences in health care consumption per-capita, and differences in extinction risk intensity per unit of health care consumed. The Netherlands ranks high on both factors:

it has the fourth-highest level of health care consumption (as measured by health care expenditure per-capita) [34], and the third highest extinction risk intensity (measured by extinction-risk footprint per USD spent on health care). Across all economic sectors, the Dutch extinction-risk footprint per-capita is ranked fourth behind Switzerland, Norway, and France, indicating that health care contributes disproportionately to the total extinction-risk footprint of the Netherlands, at 4.4% of total compared with the average of 2.6% across the comparator set. Comparison of extinction-risk footprints and related measures for the ten European countries with the highest health care extinction-risk footprint per-capita are plotted in Figure 2, with further data for these countries and for all 30 countries in scope available in the Supplementary Materials (Figures S1–S5).

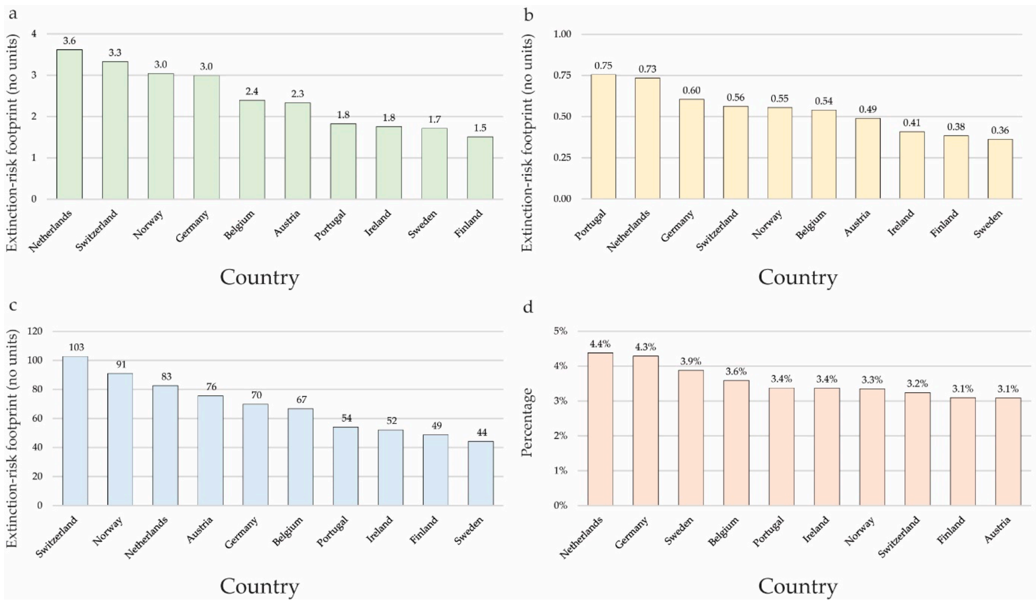

Figure 2. Comparison of extinction-risk footprints for ten European countries. These ten countries have the highest health care extinction-risk footprints per-capita, use a sector classification where health care is separated from education, and have a population greater than one million; (**a**) health care extinction-risk footprint per million people; (**b**) health care extinction-risk footprint per USD billion expenditure on the health care sector; (**c**) total extinction-risk footprint per million people across all sectors; (**d**) health care's extinction-risk footprint as a share of the country total. Across these ten countries, the Dutch health care sector generates the highest extinction-risk footprint per-capita, and the second highest footprint based on expenditure on the sector. Across all sectors, the Netherlands generates the third highest extinction-risk footprint, behind Switzerland and Norway. Note that Germany uses unique sector definitions, so the German footprint values may not be directly comparable with the other countries.

The disproportionate contribution that the health care sector makes to the total Dutch extinction-risk footprint can be further explored by examining the supply chains on which it depends to deliver its final products and services. Starting with the footprint deconstruction analysis, an assessment can be made of all the sectors contributing to these supply chains, across all countries. This analysis reveals that the Dutch health care sector's intermediate expenditure on the agriculture and food and beverage sectors makes a disproportionate contribution to its extinction-risk footprint. These sectors receive only 5.9% of the health care sector's intermediate expenditure but contribute 47% of the footprint. In contrast, expenditure on business, real estate and other services represents 33.7% of the health care sector's intermediate expenditure but contributes only 11% of the extinction-risk footprint. Figure 3 plots each sector's contribution to the Dutch health care sector's extinction-risk footprint against its share of health care's intermediate expenditure. Those sectors plotted in the top left have a higher share of health care's extinction-risk footprint than their share of intermediate expenditure, while those sectors plotted in the bottom right have a lower share of the sector's extinction-risk footprint than their share of intermediate expenditure.

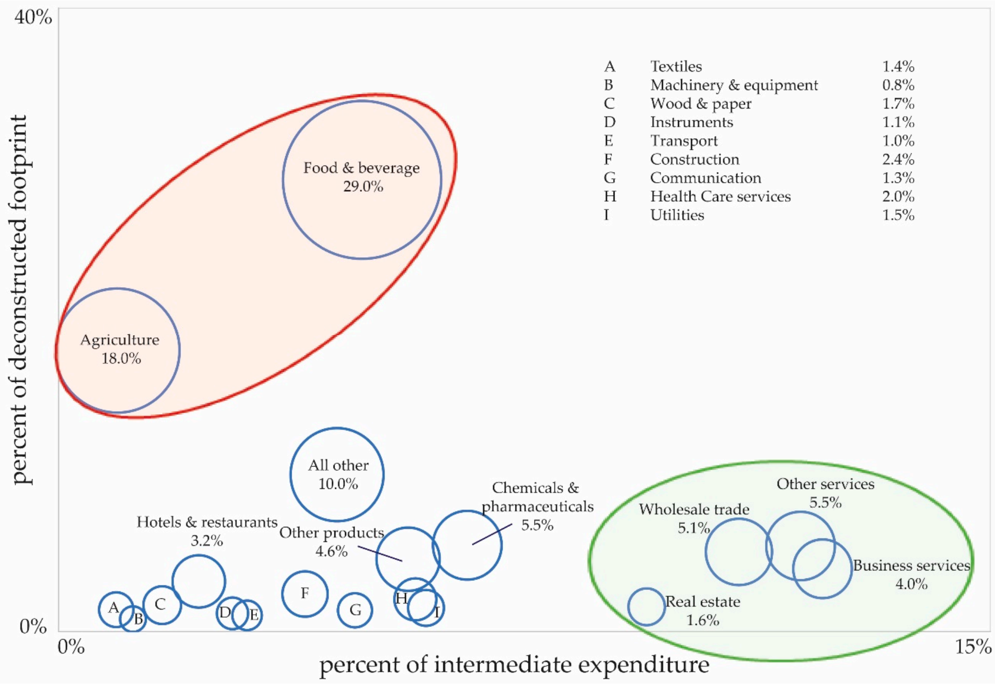

Figure 3. Deconstruction analysis of the extinction-risk footprint. A visual representation of the intermediate sectors which make the highest contribution to the health care sector's extinction-risk footprint, with each sector's contribution to the extinction-risk footprint plotted against its share of intermediate expenditure. The circle size is determined by the sector's contribution to health care's extinction-risk footprint, with these values included on the chart. Sectors highlighted in red are disproportionate contributors to the extinction-risk footprint, receiving only 5.9% of the sector's intermediate expenditure but generating 47% of its extinction-risk footprint. In contrast, sectors highlighted in green receive 45% of the sector's intermediate expenditure but generate only 16% of the footprint.

Turning next to the production layer decomposition analysis to understand how deep into the supply chains the extinction-risk footprint materializes, we find that the Dutch health care sector does not generate any extinction risk at the point of operation, or first production layer, where products and services provided by the sector are purchased by households, government, or non-profit institutions. It is not until the third production layer that the extinction-risk footprint materializes, and the largest contribution to the extinction-risk footprint is at the fifth production layer. The direct extinction risk impact is embedded so deep in the transactions that the top five layers only represent 52.4% of the total extinction-risk footprint, compared to 70% for all sectors in the Netherlands, and the global, all sector average of 85.7%. This indicates that any local interventions to address the extinction risk impact of the health care sector may be ineffective, and efforts would be better focused on supply chain interventions. Figure 4 details the production layer decomposition up to the 15th production layer for the health care sector in the Netherlands, all sectors in the Netherlands, and all sectors globally.

Structural path analysis uncovers further detail about the supply chains through which the Dutch health care extinction-risk footprint accumulates. The 5000 structural paths with the highest footprint values generate 61% of the total extinction-risk footprint, with 75% of these paths inducing a direct impact in the agriculture sector across 106 countries. In one third of these 5000 paths, expenditure at the third-order production layer is on the food and beverage sector in either the Netherlands or its trading partners. At the fifth-order, identified earlier as the most significant production layer, the agriculture sector features in 51% of the paths, and the food and beverage sector in 20%.

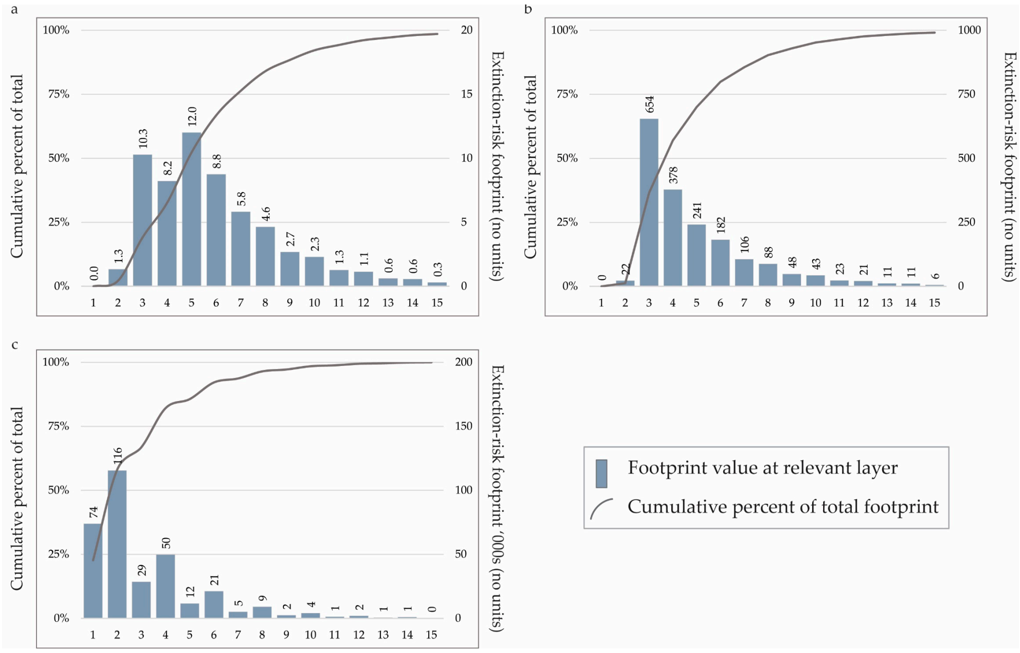

Figure 4. Production layer decomposition of the extinction-risk footprint. Production layers are represented along the x-axis with layer 1 representing the point of operation. Results are plotted for (**a**) the health care sector in the Netherlands, where the first layer's extinction-risk footprint is negligible, indicating that the sector does not generate any extinction risk at the point of operation. It is not until the 3rd production layer that any material extinction-risk footprint is generated, and the largest contributor to the extinction-risk footprint surfaces at the 5th production layer; (**b**) all sectors based in the Netherlands, where again the first layer's extinction-risk footprint is negligible, and the most significant extinction-risk footprint is generated at the 3rd production layer; and (**c**) all sectors globally, where the 2nd production layer makes the most significant contribution to the extinction-risk footprint. Note that there are no units for extinction-risk footprint.

More detail on the connection between the agriculture sector and health care's extinction-risk footprint is found by examining the top ten supply chains which support the health care sector and have at least five production layers. As shown in Table 1, the direct impact induced by consumption through these supply chains is recorded against the agriculture sector, across nine different countries, and in all cases comes via expenditure on either the Dutch or Belgian food and beverage sectors. The top ranked fifth-order supply chain, contributing 1.57% of the sector's total extinction-risk footprint, starts with demand for Dutch health care commodities, which creates demand for the Dutch health care industry sector, whose demand for Dutch food and beverage commodities creates demand on the Dutch food and beverage industry sector, which sources products provided by the agriculture sector in Madagascar, where the direct extinction risk impact is experienced.

At the species level, 4769 threatened or Near Threatened species, from 250 countries, are impacted by the consumption of products and services provided by Dutch health care. The ten impacted species with the highest extinction-risk footprint from Dutch health care include the Critically Endangered mammals *Piliocolobus waldroni* (Miss Waldron's Red Colobus), *Colobus vellerosus* (White-thighed Colobus), *Cercopithecus roloway* (Roloway Monkey), and *Cercocebus lunulatus* (White-naped Mangabey), with the consumption of Dutch health care products and services contributing 0.1% of each species' global extinction-risk footprint. These monkeys are all found in the west Africa region, which primarily supplies the Netherlands with cocoa products. For example, more than USD 830 million worth of cocoa products were imported to the Netherlands from Côte d'Ivoire in the time-period analyzed here [35]. The direct extinction risk impact of agricultural activity in this region transfers through the supply chains which produce food and beverage products to the Dutch health care sector through its direct and indirect purchase of these products. Further information on the top 10 species impacted by the consumption of products and services provided by Dutch health care is available in the Supplementary Materials (Table S4).

Table 1. Structural path analysis of the top ten fifth-order supply chains into the Dutch health care sector [1].

Rank	Supply Chain	% Total Footprint
1	NLD HCC → NLD HCI → NLD FBC → NLD FBI → MDG Agriculture	1.57%
2	NLD HCC → NLD HCI → NLD FBC → NLD FBI → GTM Agriculture	0.66%
3	NLD HCC → NLD HCI → NLD FBC → NLD FBI → GHA Agriculture	0.60%
4	NLD HCC → NLD HCI → NLD FBC → NLD FBI → TZA Agriculture	0.54%
5	NLD HCC → NLD HCI → NLD FBC → NLD FBI → ETH Agriculture	0.52%
6	NLD HCC → NLD HCI → NLD FBC → NLD FBI → HND Agriculture	0.42%
7	NLD HCC → NLD HCI → NLD FBC → NLD FBI → CRI Agriculture	0.37%
8	NLD HCC → NLD HCI → NLD FBC → NLD FBI → LKA Agriculture	0.33%
9	NLD HCC → NLD HCI → NLD FBC → NLD FBI → CMR Agriculture	0.31%
10	NLD HCC → NLD HCI → BEL FBC → BEL FBI → MDG Agriculture	0.29%

[1] Abbreviations used: HCC—Health care commodity sector; HCI—Health care industry sector; FBC—Food and beverage commodity sector; FBI—Food and beverage industry sector; NLD—Netherlands; BEL—Belgium; MDG—Madagascar; GTM—Guatemala; GHA—Ghana; TZA—Tanzania; ETH—Ethiopia; HND—Honduras; CRI—Costa Rica; LKA—Sri Lanka; CMR—Cameroon.

4. Discussion

Together, these analyses highlight the significance of the Dutch health care sector's intermediate expenditure on food and beverages as the primary contributor to its extinction-risk footprint. This expenditure generates demand for the outputs of the agriculture sector, which creates the direct activity that threatens species, increasing the likelihood of extinction. Despite representing a small percentage of the Dutch health care sector's intermediate expenditure, at 4.9%, this expenditure contributes 29% of its extinction-risk footprint. Comparison to other countries indicates that there are structural differences in the supply chains which support the food and beverage sector in the Netherlands. For example, the Swiss health care sector directs a greater share of its intermediate expenditure to food and beverages, at 6.4%, but this only generates 27% of its extinction-risk footprint, while in Norway, expenditure on food and beverages represents 3.7% of the health care sector's intermediate expenditure and generates only 9.8% of its footprint, representing the fourth most significant intermediate expenditure sector. The top five intermediate sectors for the 10 countries included in Figure 2 can be found in the Supplementary Materials (Table S2).

Comparison with studies that have analyzed health care's footprint based on other environmental indicators uncovers differences in the sectors contributing to its cumulative environmental impact. The intermediate sectors identified as key contributors to health care's global carbon footprint make a relatively insignificant contribution to the sector's extinction-risk footprint in the Netherlands. For example, transport contributes 22% of the sector's global carbon footprint but only 1% of its extinction-risk footprint in the Netherlands, while chemicals and pharmaceuticals contribute 10% of the sector's global carbon footprint but only 5.5% of the sector's extinction-risk footprint in the Netherlands [9]. Most notably, the provision of electricity, heating, and water, identified as the most significant contributor to the health care sector's carbon footprint globally, constitutes only 1.5% of the extinction-risk footprint in the Netherlands [8,9].

These differences highlight the need for a holistic approach to sustainability practice since they indicate that the consumption behaviors that predominantly generate extinction risk are different from those that predominantly generate greenhouse gas emissions. Our findings suggest that any strategies to reduce the health care sector's total environmental footprint will need to consider multiple indicators and a broad range of interventions. Interventions which address greenhouse gas emissions, for example, are unlikely to have a direct impact on reducing the sector's impact on species extinction risk.

The import-reliant structure of the Dutch economy presents a challenge in addressing the extinction risk generated by health care consumption, and in fact all economic sectors in the Netherlands. The extinction risk induced by health care consumption is taking place outside of the Netherlands, therefore local interventions are unlikely to drive significant change. However, the influence of the food and beverage sector on health care's extinction-risk footprint provides a starting point for action, which could be focused on two opportunities. First, an audit of the current food and beverage supply chains supporting Dutch health care could be undertaken to identify the origin location of key raw materials. With this understanding, supply chains which source raw materials from countries with high numbers of threatened species, and/or limited environmental safeguards could be substituted for supply chains which source materials from countries with stricter environmental protections and/or fewer threatened species.

The second opportunity indicated is an analysis of food waste in the Dutch health care sector. The Food and Agriculture Organization of the United Nations estimates that one third of the food produced globally each year is lost or wasted, and studies on food waste in the Netherlands reveal that, at a household level, 13% of solid food is discarded [36,37]. Research into the levels of food waste associated with hospitals has found that it is significant, ranging from 6% to 66% of the total food served [38–40]. Understanding the order of magnitude of food waste in the Dutch health care sector could identify opportunities to further reduce the extinction risk associated with the provision of this food, with potential flow-on effects for other environmental indicators such as greenhouse gas emissions [41].

5. Limitations

The key strength of this study is the use of input–output methodology which allows us to examine all global economic activity, and therefore quantify the extinction-risk footprint for each species–sector–country combination. This provides coverage of all supply chains in which Dutch health care is implicated and enables in-depth analysis of its extinction-risk footprint. Limitations are introduced with the need to define a quantifiable measure of biodiversity loss, since any choice will be insufficient to capture the breadth of biodiversity, which incorporates ecosystem and genetic diversity as well as species diversity. Our choice to focus on the extinction risk of species means that other indicators of biodiversity, such as species richness and ecosystem intactness, are not in-scope and therefore any impact on those indicators induced by the consumption of Dutch health care products and services are not included in this analysis.

Furthermore, our use of the threat information in the IUCN Red List to connect economic activity to the extinction risk of species may understate the total extinction risk of a particular species, since not every threat can be connected to economic activity. This may mean that the connection between activities which generate greenhouse gas emissions and those that generate extinction risk is stronger than it would appear based on these results, and that there may be an opportunity to streamline intervention strategies aimed at reducing the Dutch health care sector's total environmental footprint. In addition, the threat information which forms the basis of the nSTAR metric does not provide for differences in the presence, severity, or scope of a threat across each species' area of habitat or consider interactions between the threats acting on a species.

Finally, the difference in time periods used for our two main data sources creates a potential disconnect between the extinction risk of a species and the economic activity which induced it. A species' extinction risk category may be the result of many years of economic activity, while we only use economic activity from one year to quantify the connection between this activity and extinction risk. This is consistent with the approach employed by related studies [16–18] but does not account for the impact of past activity on the current extinction risk of a species.

6. Conclusions

We have found that the patterns of expenditure that predominantly generate extinction risk differ from those that predominantly generate greenhouse gas emissions, providing a fuller picture of the environmental impact of the health care sector. The significance of Dutch health care's intermediate expenditure on the food and beverage sector as a contributor to its extinction-risk footprint suggests that this sector could be a focus for any interventions seeking to reduce the environmental impact of health care. Minimizing food waste, and auditing health care's food and beverage supply chains to identify which raw materials and countries are most implicated may be an appropriate starting point to reduce the extinction-risk impact of Dutch health care consumption.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16031343/s1, S1: Detailed methods; S2: Sectoral structure of the Dutch economy; S3: Extinction-risk footprint data for additional countries; S4: Additional data for top 10 countries; S5: Top 40 countries impacted by consumption of Dutch health care; S6: Top 10 species impacted by consumption of Dutch health care. References [17,19,23,25,30,34,42–44] are cited in Supplementary Materials.

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Conflicts of Interest: The authors declare no conflicts of interest.

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