Uncertainties in the impact of small targeted dietary changes on human health and environmental sustainability

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1 A recent analysis by Stylianou et al. (2021) estimated the impact of small dietary changes in
2 the consumption of individual foods on human health and the environment, expressed as
3 minutes of healthy life lost or gained daily and dietary carbon footprint, respectively. While
4 an appealing concept for its simplistic interpretation, we propose that this analysis is
5 unwarranted based on existing evidence and produces results that fail to recognize the
6 importance of essential nutrient density and disregard the risks associated with ultra-
7 processed foods, sugar, and refined starches. The environmental impact assessment
8 undoubtedly adds novelty to the growing field of nutritional-life cycle assessments;
9 however, the use of “ready-made” environmental systems is concerning when drawing such
10 decisive conclusions. We therefore caution against use of this food classification system to
11 inform consumer choices, front-of-package labelling, policies, and programs.

12 Unhealthy diets and environmental degradation are two of the greatest global challenges of our
13 time. A common scientific focus has thus been developing diets that simultaneously improve
14 human health and wider sustainability of food production. It is generally recommended to
15 substantially limit intake of animal-source foods (ASFs) in favor of plant-source foods (PSFs).¹
16 Given the low intakes of minimally processed PSFs, such as fruits and vegetables, in many diets
17 across the world, increased consumption certainly holds potential to improve population health;
18 however, issues of nutrient adequacy, affordability, and acceptability have not yet been fully
19 integrated into these recommendations.² Stylianou et al. (2021) recently proposed an approach
20 focused on making small dietary changes in the consumption of single foods rather than overall
21 diets.³ The authors developed the Health Nutritional Index (HENI) to quantify the minutes of
22 healthy life gained (+) or lost (–) per serving of individual foods (or mixed dishes). HENI scores
23 were then paired with pre-calculated life-cycle assessments (LCAs) to classify foods based on
24 their combined health and environmental impacts. While the idea of providing consumers and
25 other stakeholders with simple guidance on the health and environmental effects of individual
26 foods is appealing, we suggest that current scientific evidence does not warrant this type of
27 analysis, particularly in the context of the authors’ interpretation.

28 Stylianou et al. (2021) calculated HENI scores by combining the marginal health burden
29 associated with 15 dietary risk factors (DRFs) from the 2016 Global Burden of Disease (GBD)
30 study. This approach is founded on the assumption that it is possible to reasonably estimate the
31 health burden of individual dietary components. However, the relationship between food and
32 health is complex, and effects of foods on health are rarely binary. Foods are consumed as part of
33 the broader diet, which is one of the many individual-level determinants of health, together with
34 other lifestyle (for example, exercise, tobacco and alcohol use, stress, sleep quality) and
35 biological (for example, genetics, age, sex) factors. These elements interact with numerous
36 socio-economic and environmental determinants (for example, education, income, access to
37 healthcare, pollution) over the course of a lifetime.⁴ Given the intricateness of the relationship
38 between food and health, quantifying the minutes of healthy life gained or lost per serving of
39 individual foods consumed is problematic, particularly when using estimates from the GBD
40 study, which has several important limitations and weaknesses.⁵ Indeed, concerns have been
41 raised on the transparency, methodological robustness, and credibility of results of the GBD
42 study, which assumes causal relationships between single dietary components and health
43 outcomes, producing a sense of confidence in uncertain estimates.⁵ Stylianou et al. (2021) add an
44 additional layer of uncertainty by applying population-level health burden estimates at the
45 individual level, disregarding factors contributing to individual variability.

Importantly, HENI scores are based on the assumption that dietary components not included in the GBD have neutral health effects.³ Yet, several food components and attributes associated with health benefits or risks are not covered by the GBD.⁵ For example, calcium is the only micronutrient included among beneficial DRFs, while all other essential vitamins and minerals are not considered. Protein and essential amino acids are also omitted. Further, milk is listed as a beneficial DRF, whereas other nutrient dense ASFs such as yogurt and eggs are not. Among harmful DRFs, sugar and refined starches are not considered, yet they are associated with the non-communicable disease (NCD) epidemic.⁵ Sugar-sweetened beverages are the only ultra-processed food (UPF) included, despite the substantial evidence linking UPFs with negative health outcomes.^{6,7} On the contrary, red meat is listed as a harmful DRF regardless of its level of processing, with no consideration for its density in high-quality protein and bioavailable micronutrients commonly lacking in diets globally, including iron, zinc, and vitamin B₁₂.⁸

The little-to-no consideration for the type of processing and its health implications, and the assessment of foods' nutritional performance based on a limited number of DRFs, illustrates a common issue in nutritional science, namely that of reductionism.⁹ For instance, vegetables, legumes, and whole grains are only considered in terms of fiber content, disregarding the added value of the food matrix, which goes beyond single nutrients. Further, no distinction is made between naturally occurring or fortified nutrients, even though fortification is unlikely to fully replicate the potential benefits of the food matrix.¹⁰

The aforementioned limitations result in numerous unjustified HENI scores (**Figure**). For example, peanut butter and jelly sandwiches—the vast majority of which are made with bread from refined grains and jelly with added sugars—are the food category with the highest median score (+33 min), only remotely comparable to nuts and seeds (+25 min). Non-starchy vegetables (+3 min) receive a similar score to ready-to-eat cereals (+4 min) and snack/meal bars (+3 min); whereas candy (0 min), sugar (0 min), and sweet bakery products (0 min) all score higher than poultry (−2 min), eggs (−3 min), and red meat (−6 min).

Figure. Illustrative examples of unjustified HENI scores (non-exhaustive list)

Concerning the environmental assessment, Stylianou et al. (2021) combined nutritional scores with LCA datasets in the emerging field of nutritional LCA (nLCA). LCA is a data-intensive method involving numerous calculations to determine environmental impacts. Agri-food systems are, by nature, heterogeneous; for example, farmers use differing amounts of fertilisers, pesticides, and, in the case of animal-based farming, apply different stocking densities and produce various feed conversion ratios, all of which affect yield and overall efficiency. We commend the authors for their extensive attention to environmental concerns, both at the midpoint and endpoint level of LCA (for example, see Supplementary Table 7), which is not common in agri-food LCAs.

However, a limitation of Stylianou et al. (2021)'s analysis, and arguably many (n)LCAs more broadly, is an oft-applied simplistic approach,¹¹ which typically uses nationally or regionally averaged values that do not reflect the complexities inherent in agriculture. Indeed, the environmental impacts of both PSFs and ASFs vary substantially depending on production methods, as well as agroclimatic and ecological characteristics.^{12,13} Yet, in Stylianou et al. (2021)'s food classification most PSFs are included in the “green zone” (to increase), while most ASFs fall within the “amber” (tolerable) or “red zone” (to decrease), based on national- or regional-level data lacking sufficient consideration of agricultural heterogeneity. Additionally, the definition of these color zones is problematic, generating important trade-offs between nutrition and sustainability. For instance, the “red zone” includes foods assumed to be *either* highly nutritionally detrimental *or* highly environmentally detrimental. Given that foods with high nutritional value do not always produce low environmental impacts, they risk being labelled as “to decrease.”

Previous studies have highlighted that “pairing” nutritional and environmental datasets—which are not derived directly from the same supply-chain—in nLCAs risks adding uncertainty that is difficult to account for, because of the aforementioned heterogeneity.¹⁴ However, avoiding this issue is not always possible, and developing tailored LCA inventories, which would be ideal in nLCAs, is excessively time-consuming. Nevertheless, Stylianou et al. (2021)'s food classification could influence both health and environmental policy under unideal circumstances, namely the fact that the study is methodological rather than applied.

While the authors' Taylor expansion assessment *might* capture sufficient environmental calculation uncertainties of the systems examined, their choice of sensitivity analysis requires justification. Despite acknowledging that ASFs (particularly ruminant-based) present large variability regarding impacts to nature and human health,¹⁵ Stylianou et al. (2021) conducted a sensitivity analysis on greenhouse-produced vegetables which generate less environmentally useful information, and did not explore multiple production systems for the same product.¹⁵ Despite the authors' admirable attention to system-wide errors, they do not appear to have addressed complexities associated with their choice of allocation (that is, economic), which does not adhere to LCA best practice.

To conclude, Stylianou et al. (2021) attempted to translate complex nutritional and environmental information into simple scores to inform consumers and other stakeholders. While their classification of foods into color zones and their recommendations for targeted dietary changes might be relatively easy for consumers and other stakeholders to understand and act upon, many of the obtained scores are arguably unjustified. The proposed method is undoubtedly

117 of theoretical interest to the novel field of nLCAs; however, if used to inform consumer choices,
118 front-of-package labelling, policies, and programs, the resulting food classification may have
119 negative implications on nutrient adequacy and could reinforce the consumption of UPFs, added
120 sugar, and refined starches—all associated with NCDs.

Competing Interests statement

FO, GAM, SN, and TB declare no competing interests. SvV reports grant support from USDA (2020-38640-31521; 2021-67034-35118), the Turner Institute of Ecoagriculture, and the Greenacres foundation for work linking production methods of both plant and animal-sourced foods to human health outcomes. SvV reports financial remuneration for academic talks, but does not accept honoraria, consulting fees, or other personal income from food industry groups/companies. FL reports financial support of the Research Council of the Vrije Universiteit Brussel, including the SRP7, IOF3017 and IRP11 projects. FL is a board member of various academic non-profit organizations including the Belgian Association for Meat Science and Technology (president), the Belgian Society for Food Microbiology (secretary), and the Belgian Nutrition Society. On a non-remunerated basis, he also has a seat in the scientific committee of the Institute Danone Belgium and the Scientific Board of the World Farmers' Organization. The views he expresses in this commentary are his alone and not necessarily those of the aforementioned organizations. AdP in his role as researcher within BC3 reports having received funds from CAPSA Food, The Global Dairy Platform and Friends of the Earth Spain.

Author contributions

FO, GAM and TB prepared the initial manuscript. All authors critically reviewed and approved the final manuscript.

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References

1. Willett, W. *et al.* Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet* **393**, 447–492 (2019).
2. Beal, T. Achieving dietary micronutrient adequacy in a finite world. *One Earth* **4**, 1197–1200 (2021).
3. Stylianou, K. S., Fulgoni, V. L. & Jolliet, O. Small targeted dietary changes can yield substantial gains for human health and the environment. *Nat Food* **2**, 616–627 (2021).
4. Social determinants of health. <https://www.who.int/westernpacific/health-topics/social-determinants-of-health>.
5. Beal, T., Neufeld, L. M. & Morris, S. S. Uncertainties in the GBD 2017 estimates on diet and health. *The Lancet* **394**, 1801–1802 (2019).
6. Hall, K. D. *et al.* Ultra-Processed Diets Cause Excess Calorie Intake and Weight Gain: An Inpatient Randomized Controlled Trial of Ad Libitum Food Intake. *Cell Metabolism* **30**, 67–77.e3 (2019).
7. Lane, M. M. *et al.* Ultraprocessed food and chronic noncommunicable diseases: A systematic review and meta-analysis of 43 observational studies. *Obesity Reviews* **22**, e13146 (2021).
8. Binnie, M. A., Barlow, K., Johnson, V. & Harrison, C. Red meats: time for a paradigm shift in dietary advice. *Meat Sci* **98**, 445–451 (2014).
9. Fardet, A. & Rock, E. Exclusive reductionism, chronic diseases and nutritional confusion: the degree of processing as a lever for improving public health. *Critical Reviews in Food Science and Nutrition* **0**, 1–16 (2020).
10. Jacobs, D. R. & Tapsell, L. C. Food, Not Nutrients, Is the Fundamental Unit in Nutrition. *Nutrition Reviews* **65**, 439–450 (2007).
11. Leroy, F., Beal, T., Gregorini, P., Graham, M. & van Vliet, S. Nutritionism in a food policy context: the case of “animal protein”. *Animal Production Science* (2021).
12. Lark, T. J., Spawn, S. A., Bougie, M. & Gibbs, H. K. Cropland expansion in the United States produces marginal yields at high costs to wildlife. *Nat Commun* **11**, 4295 (2020).
13. Kremen, C. & Miles, A. Ecosystem Services in Biologically Diversified versus Conventional Farming Systems: Benefits, Externalities, and Trade-Offs. *Ecology and Society* **17**, (2012).
14. McAuliffe, G. A., Takahashi, T. & Lee, M. R. F. Framework for life cycle assessment of livestock production systems to account for the nutritional quality of final products. *Food and Energy Security* **7**, e00143 (2018).
15. Poore, J. & Nemecek, T. Reducing food’s environmental impacts through producers and consumers. *Science* **360**, 987–992 (2018).