How the EAT-Lancet commission report 'Food in the Anthropocene' influenced discourse and research on food systems: a systematic review covering the first two years post-publication

How the EAT–*Lancet* Commission on food in the Anthropocene influenced discourse and research on food systems: a systematic review covering the first 2 years post-publication

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In 2019, the EAT–*Lancet* Commission's report on food in the Anthropocene presented a planetary heath diet to improve health while reducing the environmental effect of food systems globally. We assessed EAT–*Lancet's* immediate influence on academic research and debate by conducting a systematic review of articles citing the Commission and others published from January, 2019, to April, 2021. The Commission influenced methods, results, or discourse for 192 (7·5%) of 2560 citing articles, stimulating cross-disciplinary research and debate across life sciences (47%), health and medical sciences (42%), and social sciences (11%). Sentiment analysis of 76 critiquing articles indicated that opinions were, on average, more positive than negative. Positive sentiments centred on benefits for informing policy, public health, and raising public awareness. Negative sentiments included insufficient attention to socioeconomic dimensions, feasibility, and environmental effects other than emissions. Empirical articles predominantly evaluated the effects of changed diets or food production on the environment and wellbeing (29%), compared current diets with EAT–*Lancet* recommendations (12%), or informed future policy and research agendas (20%). Despite limitations in EAT–*Lancet's* method, scope, and implementation feasibility, the academic community supported these recommendations. A broad suite of research needs was identified focusing on the effects of food processing, socioeconomic and political drivers of diet and health, and optimising consumption or production for environment and health.

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Introduction

Universal access to a healthy diet made with food produced without damaging the natural environment is enshrined in the UN Sustainable Development Goal 2 to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture.[1] This goal presents multiple challenges: food production accounts for a quarter of global greenhouse-gas emissions[2] and agricultural expansion is a primary cause of deforestation, biodiversity loss, and ecosystem degradation.[3] Global dietary patterns are not only unsustainable for environmental health,[4] but also for human health.[5] The double burden of health effects of poor diets is substantial: 10% of the world's population are at risk of undernourishment because of a scarcity of calories[6] and one in five deaths in 2017 were related to suboptimal diets.[7] Diet-related diseases like obesity have also rapidly increased in recent decades.[8] There is an urgent need to transform food systems so they are healthy for both people and the natural environment.[9]

In 2019, the EAT–*Lancet* Commission on healthy diets from food systems was launched.[10] The Commission's goal was to develop global scientific targets for achieving healthy and sustainable diets. A universal healthy reference diet (planetary health diet or EAT–*Lancet* diet) was proposed to optimise human health without exceeding planetary boundaries for Earth system processes: climate change, biodiversity loss, freshwater use, interference with global flows of nitrogen and phosphorus, and land-system change.[11] Global scenarios in which the planetary health diet was adopted were modelled and compared against a greenhouse gas target compatible with the 1·5°C mean global temperature increase by 2100, set by the Paris Agreement.[12,13] Findings indicated that a business-as-usual dietary trajectory could double greenhouse-gas emissions by 2050, but the increased consumption of plant-based diets could reduce greenhouse-gas emissions by up to 80%.[10] The Commission concluded that to transform diets by 2050, substantial dietary shifts would be required globally, including halving consumption of foods such as red meat and starchy vegetables, and doubling consumption of legumes, wholegrains, and nuts.

The EAT–*Lancet* Commission has attracted a great deal of attention.[14–16] It was commended for highlighting the urgent need for transforming food systems and the goal of developing a universal framework for integrating scientific targets for both healthy diets and sustainable food systems.[17] However, the Commission also stimulated debate as to how this transformation can be achieved equitably and across varying populations and food system contexts.[18,19] A carefully considered, prioritised approach to future research and policy is needed to address the most important gaps in knowledge and implementation.

The aims of this Health Policy were to identify and examine the debates that arose from the publication of the EAT–*Lancet* Commission, systematically examine how research has been directly influenced by the Commission, and synthesise identified research gaps to build a research agenda for healthy and sustainable food systems.

Methods

Search strategy and selection criteria

We undertook a systematic review of papers citing the EAT–*Lancet* Commission from its publication on

Jan 16, 2019, to April 30, 2021, by performing a cited reference search in PubMed, Web of Science, SCOPUS, and Google Scholar. We used the entire citation for the EAT–*Lancet* Commission's 2019 peer-reviewed publication in the Lancet[10] as the search term for the cited reference function in each database. We included peer-reviewed articles and opinion pieces, but excluded theses, book chapters, conference abstracts, and papers not in English. References were uploaded to the web-based review management software program Covidence, which eliminated duplicate citations (appendix 1 pp 2–4). Two reviewers independently screened titles and abstracts, with conflicts resolved by a third reviewer. The main inclusion criterion at this stage was a primary focus on food systems, food system components (production, marketing and retail, and consumption), or their sustainability, as defined by the Food and Agriculture Organization of the UN.[6] If there was doubt about inclusion, articles were forwarded for full-text screening. Full-text screening was again performed by two independent reviewers with conflicts resolved by a third reviewer. The main exclusion criterion was if the article cited the EAT–*Lancet* Commission only in a general background context (details of exclusion criteria are provided in appendix 1 p 5), with an article only included if it specifically applied EAT–*Lancet* results or recommendations in method, interpretation of results, or discussion.

For more information on **Covidence** see https://www.covidence.org/

See **Online** for appendix 1

Data extraction

A data extraction form was developed with Covidence software and piloted by all investigators on five studies (appendix 1 pp 6–8). Extracted data comprised year of publication, region of study, type of article, funding sources, population group, primary food system sector, study method, type of application of the EAT–*Lancet* Commission and the authors' main aims, conclusions, or key findings, and future research recommendations of which the last three items were copied verbatim from text. Data were extracted by one reviewer and independently checked by a second reviewer. Any conflicts were resolved by a third reviewer. Countries of study were mapped to 2021 World Bank income groups (low, lower middle, upper middle, and high).[20] Article subject categories were allocated according to their respective journal's primary subject category, as defined in either the Web of Science: Science Citation Index Expanded, or the Social Science Citation Index. If a paper was categorised as falling into multiple disciplines, we assigned the article to the category listed first by Web of Science. All data extracted from studies have been made available in the Mendeley public data repository and are available in appendix 2.

See **Online** for appendix 2

Sentiment analysis

Sentiment analyses were performed on text extracts from all articles categorised either by type of application of the EAT–*Lancet* Commission (critique or debate) or type of article (commentary, opinion piece, or editorial). Sentiment analysis, also known as opinion mining, uses natural language processing, text analysis, and computational linguistics to identify and quantify emotional states and subjective information from text. We used sentimentr[21] and tidytext[22] packages in R to access four lexicons, as studies have shown that relying on any single lexicon leads to biased or uninformative results.[23] The sentimentr package uses the Jockers–Rinker sentiment lexicon[24] to assign polarity to words in strings with valence shifters (eg, detects "not happy" as negative instead of simply noting happy). The tidytext package provides access to three sentiment lexicons: Bing,[25] National Research Council Emotion,[26] and AFINN.[27] Negative and positive sentiments of words from Jockers–Rinker (–1 to 1; 0·1 interval) and AFINN (–5 to 5; 1·0 interval) were classified continuously, whereas NRC and Bing lexicons were quantified binomially as –1 or 1, respectively. We followed the methods of Lennox and colleagues[23] to tidy text extracts by manually excluding words whose meanings could be confounded by their implementation in health and sustainability literature—eg, eat, food, and sugar are classified as positive sentiments by the NRC lexicon, whereas fat and gut are classified as negative, but in health and nutrition these terms could represent positive, negative, or neutral opinions depending on context (appendix 1 p 24 for full list). To examine which words contributed most to positive or negative sentiments, we conducted a sensitivity analysis, quantifying the most frequent negative and positive words in the NRC, Bing, and AFINN lexicons.

By classifying all sentiments as negative (<0) or positive (>0), we determined the proportion of positive versus negative sentiments per article. Because text extracts were of different lengths, we transformed each article's total count of negative or positive words to a ratio by dividing each count by the total word count of the text extract. For each lexicon, we calculated the average proportion of sentiments per article that were negative or positive, then standardised the raw sentiment score and calculated the average sentiment score across all articles.

We conducted a quality assessment of each negative critique to evaluate the degree of evidence supporting each negative comment. Each critique was assessed by two independent reviewers and assigned a quality of evidence value of either low (opinion-based and not supported by any additional evidence), medium (supported by expert opinion and citations with no additional data or analyses), or high (evidence-based and supported by new analyses or data), with conflicts resolved by a third reviewer.

Thematic analysis

We performed a thematic review for articles categorised by study method (cross sectional study, modelling, or literature review; appendix 1 pp 25–26). Articles were

independently coded with a descriptive, inductive approach by three researchers with expertise in particular categories (cross-sectional studies, modelling, or reviews). Secondary coding by a single researcher identified cross-cutting analytical themes. We aggregated articles according to their application of the EAT–*Lancet* Commission and re-examined primary codes to assess analytical themes relevant to each application. For articles presenting future policy or research agendas, we summarised key recommendations and conducted a quality assessment (using the criteria described above) to evaluate the level of evidence supporting each recommendation.

Results

The search returned 2560 unique publications. Of these, 1058 were selected for full-text screening and 192 (18·1%) met the inclusion criteria (see appendix 1 pp 2–5 for PRISMA diagram, and pp 9–18 for bibliographic details). The table highlights general characteristics of the included studies, of which 43 (22·4%) of 192 were published in 2019, 100 (52·1%) in 2020, and 50 (26·0%) in 2021, mostly in bioscience or health-related journals. Half of the articles focused on food consumption and another 39% focused on the whole food system; only a small number of articles focused on food production or retailing or marketing. Nine articles (4·7%) declared funding from industry and 33 (17·2%) received funding from private or charity sources.

Just over half the articles had a global focus; among those with a national or region-specific focus, Europe, North America, India, and Australia were more frequently represented than Africa, South America, and most of Asia (figure 1A). 62 (80%) of 79 nationally focused articles were from high-income countries, with 13 (16%) from upper-middle-income and lower-middle-income countries, and four (5%) from low-income countries.

Articles fell under three disciplines. The first discipline included clinical, preclinical, and health articles (n=80) such as cross-sectional surveys comparing population diet with the EAT–*Lancet* diet,[28–31] and modelling and reviews to evaluate the effects of current diets or the EAT–*Lancet* diet on public health.[32] The second discipline was life and physical sciences (n=91), such as new metrics for assessing environmental effects of food production[33,34] and modelling to evaluate environmental footprints of current diets or the EAT–*Lancet* diet.[35–41] Social science articles made up the third discipline (n=22) and consisted of studies that modelled costs and affordability of the EAT–*Lancet* diet,[42] frameworks for policy action,[43] and pathways for food systems change[44] (figures 1B, 1C). The most common type of application of the EAT–*Lancet* Commission in all three disciplines was either a critique or debate (figure 1C).

Of 76 articles included in the sentiment analysis (46 [60·5%] were commentary, opinion piece, or editorial, and 30 [39·5%] were original research), 48 (63·2%) had at least one positive sentiment related to the report and 54 (71·1%) had at least one negative sentiment, although the average sentiment score was always positive regardless of which lexicon was used (figure 2A). This finding was consistent across all three disciplines (figure 2B). The most common positive theme focused on policy implications of the EAT–*Lancet* Commission and diet (figure 2D)—eg, the potential for the results to guide healthy and sustainable dietary advice and the benefits of linking science to policy with science-informed targets for food system change[15,17,45–48] (appendix 1 pp 19–23). Other frequent positive themes include the likely positive outcomes of the EAT–*Lancet* diet for human and environmental health,[14,44,49–56] raising public awareness for crucial health and sustainability issues,[47,57,58] and progress made towards coordinated holistic food system transformation.[14,48,51,59] The importance of the EAT–*Lancet* Commission's goal to identify a global solution to food systems that meets the Sustainable Development Goals was emphasised.[43,55,60,61]

	All articles (n=192)	Clinical, preclinical, and health (n=80)	Life sciences and physical sciences (n=90)	Social sciences (n=22)
Study method				
Modelling	56 (29%)	16 (20%)	32 (36%)	8 (36%)
Literature review	54 (28%)	23 (29%)	24 (27%)	7 (32%)
Commentary, opinion piece, and editorial	46 (24%)	23 (29%)	20 (22%)	3 (14%)
Cross-sectional study	23 (12%)	12 (15%)	9 (10%)	2 (9%)
Case study, cohort study, and intervention	5 (3%)	2 (3%)	2 (2%)	1 (5%)
Tool and framework development	2 (1%)	0	2 (2%)	0
Other (audit, mixed methods, and data science)	6 (3%)	4 (5%)	1 (1%)	1 (5%)
Region				
Global	101 (53%)	38 (48%)	49 (54%)	14 (64%)
National	79 (41%)	37 (46%)	36 (40%)	6 (27%)
Regional (multiple nations)	12 (6%)	5 (6%)	5 (6%)	2 (9%)
Population				
General population	138 (72%)	59 (74%)	64 (71%)	15 (68%)
Specific group	34 (18%)	15 (19%)	15 (17%)	4 (18%)
None specified	20 (10%)	6 (8%)	11 (12%)	3 (14%)
Food system sector				
Food consumption	97 (51%)	57 (71%)	33 (37%)	7 (32%)
Whole-system approach	77 (40%)	19 (24%)	46 (51%)	12 (55%)
Food production	11 (6%)	1 (1%)	7 (8%)	3 (14%)
Food retail and marketing	3 (2%)	0	3 (3%)	0
Other (trade, energy, health care, and media)	4 (2%)	3 (4%)	1 (1%)	0
Funding*				
Public	74 (39%)	24 (30%)	40 (44%)	10 (45%)
Private and charity	33 (17%)	15 (19%)	16 (18%)	2 (9%)
Industry	9 (5%)	6 (8%)	3 (3%)	0
No external funding	18 (9%)	10 (13%)	6 (7%)	2 (9%)
Undisclosed	71 (37%)	31 (39%)	32 (36%)	8 (36%)

*Several studies mentioned more than one funding source; therefore, n=205 not n=192.

Table: **Characteristics of included studies**

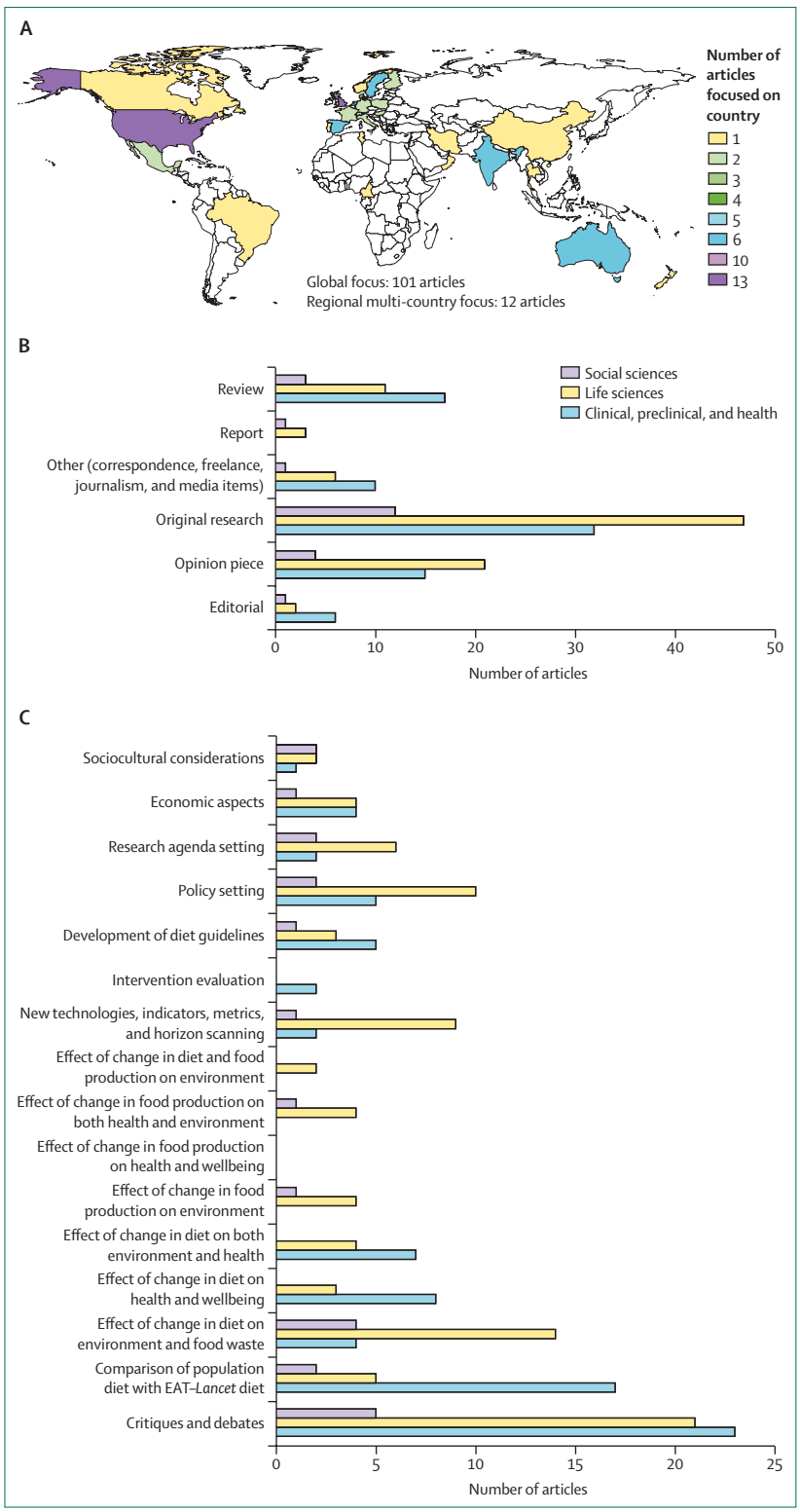


Figure 1: **Characteristics of the included studies**
(A) Global distribution of included studies. (B) Article type of included studies, grouped by discipline. (C) Studies grouped by discipline and their type of application of the EAT–*Lancet* report.

Across nine broad themes of negative critiques, the most common (34%) was inadequate consideration of the socioeconomic dimensions of global health and wellbeing (figure 2C; appendix 1 pp 19–21). Several issues stood out, the first being that the EAT–*Lancet* diet lacks appreciation of cultural values, consumer preferences, and food dependencies, meaning that local adaptations are required.[55,57,62–67] Second, that the EAT–*Lancet* diet is unaffordable especially to those on subsistence diets,[47,53,64,65,68–72] ignores access and availability gaps,[16,17,43,57,69,73] and does not consider livelihood effects of food system changes.[47,52,55,65,70,74] Issues pertaining to global health and wellbeing were most often opinion-based rather than being supported by high-quality evidence (figure 3). Three other negative themes were common: feasibility and policy implications of operationalising and coordinating the EAT–*Lancet* diet across governments and supply chains (16% of critiques),[17,43,61,68,74–76] inadequacies in how food nutritional characteristics and palatability were considered (12%), or in how the environment and natural resources were considered (12%). Within the theme of nutritional inadequacies, the most common issue was potential unintended health consequences of the EAT–*Lancet* diet, particularly micronutrient deficiencies.[46,54,64,72,73,77,78] The most common environmental issue raised was the challenge of shifting agricultural production to fulfil changing food demand[52,62,69,76] (appendix 1 pp 25–26).

Articles commenting on the EAT–*Lancet* Commission's methods raised positive and negative points. Positive statements commended the quantification of scientific targets for sustainable human diets[45,55,79] and effective scientific evidence synthesis.[63,74,80] Negative concerns focused on data collection, suggesting that incorrect or biased data were used to infer health effects of diets[18,73,81] and that insufficient transparency led to poor reproducibility,[16,64] or modelling whereby the analytical process was flawed (eg, by omitting key supply chain stages, including food processing and retailing,[17,82,83] or by incorrect assumptions about causal relationships between food risk factors and mortality).[67] Claims about methodological and presentation flaws were most often supported by high-quality evidence (figure 3).

In 126 observational, modelling, and literature review articles applying EAT–*Lancet* Commission recommendations, seven broad themes were identified: environmental effects of the EAT–*Lancet* diet; health and wellbeing effects of the diet; economic aspects of food systems; animal-source foods; plant-based foods; behavioural change; and cooperation, collaboration, and integration (appendix 1 pp 25–26).

Articles investigating the environmental effects of dietary or production shifts towards the EAT–*Lancet* diet predominantly focused on greenhouse-gas emissions as an environmental indicator.[40,60,84,85] Although some emphasised the need to focus on other environmental environments, such as nutrient pollution[32,35,37] and water

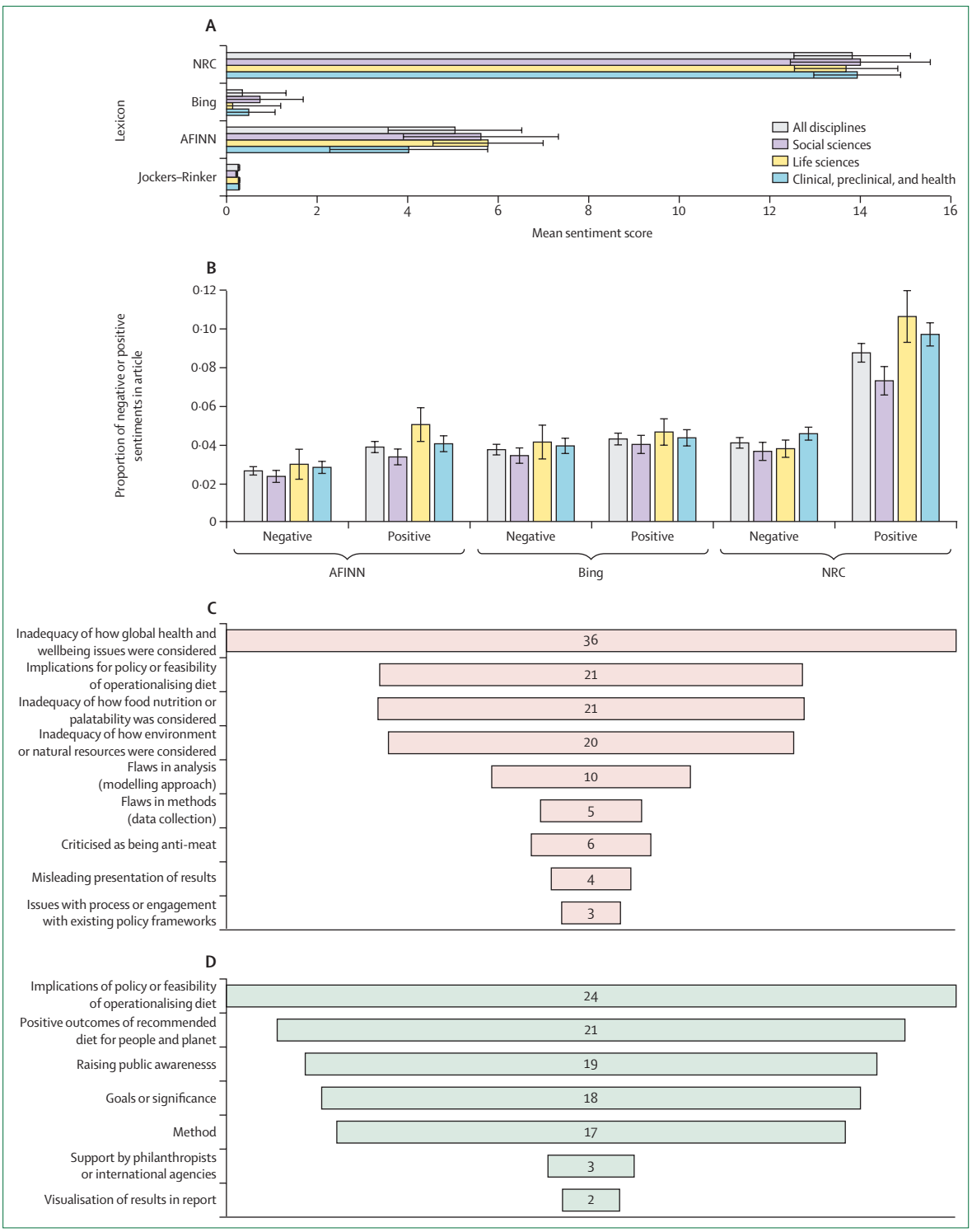
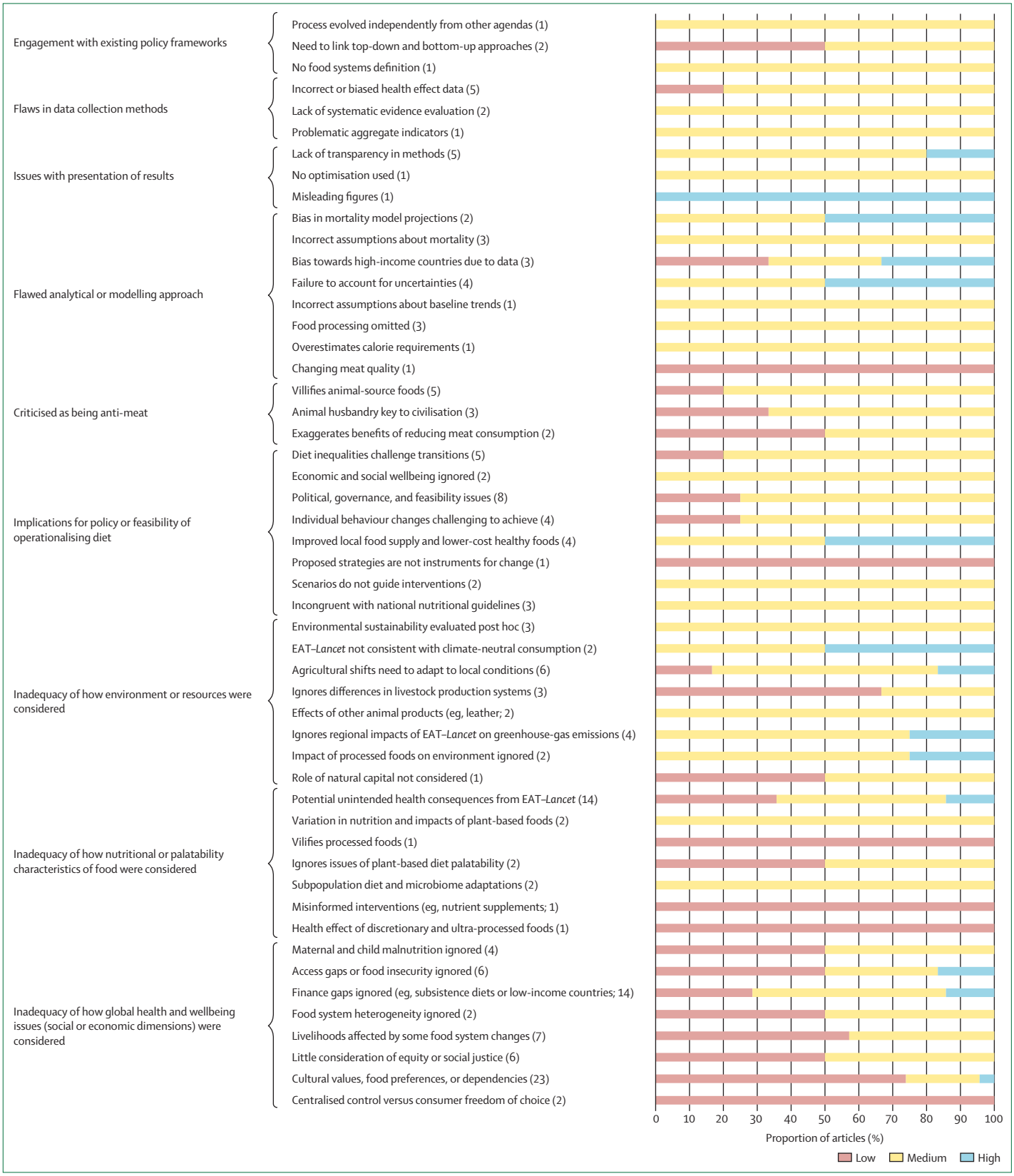


Figure 2: **Results of sentiment analysis for 76 articles critiquing the EAT–*Lancet* Commission**
(A) Mean sentiment scores for four sentiment lexicons: NRC, Jockers–Rinker, Bing, and AFINN. (B) Mean (SE) proportion of sentiments in each article that were negative or positive, excluding Jockers–Rinker lexicon, which quantifies polarity versus sentiments. (C) Number of negative critiques summarised by broad category. (D) Number of positive critiques by broad category. NRC=National Research Council.


Engagement with existing policy frameworks
Process evolved independently from other agendas (1)
Need to link top-down and bottom-up approaches (2)
No food systems definition (1)
Flaws in data collection methods
Incorrect or biased health effect data (5)
Lack of systematic evidence evaluation (2)
Problematic aggregate indicators (1)
Issues with presentation of results
Lack of transparency in methods (5)
No optimisation used (1)
Misleading figures (1)
Flawed analytical or modelling approach
Bias in mortality model projections (2)
Incorrect assumptions about mortality (3)
Bias towards high-income countries due to data (3)
Failure to account for uncertainties (4)
Incorrect assumptions about baseline trends (1)
Food processing omitted (3)
Overestimates calorie requirements (1)
Changing meat quality (1)
Criticised as being anti-meat
Villifies animal-source foods (5)
Animal husbandry key to civilisation (3)
Exaggerates benefits of reducing meat consumption (2)
Implications for policy or feasibility of operationalising diet
Diet inequalities challenge transitions (5)
Economic and social wellbeing ignored (2)
Political, governance, and feasibility issues (8)
Individual behaviour changes challenging to achieve (4)
Improved local food supply and lower-cost healthy foods (4)
Proposed strategies are not instruments for change (1)
Scenarios do not guide interventions (2)
Incongruent with national nutritional guidelines (3)
Inadequacy of how environment or resources were considered
Environmental sustainability evaluated post hoc (3)
EAT–Lancet not consistent with climate-neutral consumption (2)
Agricultural shifts need to adapt to local conditions (6)
Ignores differences in livestock production systems (3)
Effects of other animal products (eg, leather; 2)
Ignores regional impacts of EAT–Lancet on greenhouse-gas emissions (4)
Impact of processed foods on environment ignored (2)
Role of natural capital not considered (1)
Inadequacy of how nutritional or palatability characteristics of food were considered
Potential unintended health consequences from EAT–Lancet (14)
Variation in nutrition and impacts of plant-based foods (2)
Vilifies processed foods (1)
Ignores issues of plant-based diet palatability (2)
Subpopulation diet and microbiome adaptations (2)
Misinformed interventions (eg, nutrient supplements; 1)
Health effect of discretionary and ultra-processed foods (1)
Inadequacy of how global health and wellbeing issues (social or economic dimensions) were considered
Maternal and child malnutrition ignored (4)
Access gaps or food insecurity ignored (6)
Finance gaps ignored (eg, subsistence diets or low-income countries; 14)
Food system heterogeneity ignored (2)
Livelihoods affected by some food system changes (7)
Little consideration of equity or social justice (6)
Cultural values, food preferences, or dependencies (23)
Centralised control versus consumer freedom of choice (2)
0
10
20
30
40
50
60
70
80
90
100
Proportion of articles (%)
Low
Medium
High

use,[36,86,87] and to consider environmental trade-offs,[34,64,88] only eight (15·4%) of 52 modelling articles explored environmental effects other than those related to greenhouse gases. Six articles investigated the water footprints of food systems, either from a particular food group (eg, nuts),[89] under current population diets,[90,30] or from following the EAT–*Lancet* diet.[32] Important findings included showing that incorporating water as an environmental effect indicator makes it challenging to find dietary patterns with low effects in all determinants, because low-meat and no-meat diets could increase water effects.[91] Two empirical articles[39,92] investigated land-use effects and concluded that switching to the EAT–*Lancet* diet would decrease total global agricultural land use.[39] One article highlighted the importance of understanding food production effects on biodiversity, given the projected species losses due to agricultural expansion by 2050.[41] Studies indicated a need to understand regional differences in environmental effects driven by production heterogeneity and cultural preferences.[76,86,93]

Articles exploring the effects on health and wellbeing of dietary shifts towards the EAT–*Lancet* diet emphasised considering the need for and development of targeted guidance for specific sociodemographic groups (eg, older people and different ethnicities) and regions (eg, low-income countries and emerging economies).[94] Review-based studies warned that recommended dietary shifts might not resolve health issues such as obesity, or might not have the desired effects in particular populations.[39,95] Concerns about micronutrient deficiencies associated with dietary changes were discussed in five (10·2%) of 49 reviews.[64,94,96,97] Other articles highlighted the potential health benefits of the EAT–*Lancet* diet: modelling confirmed that following the EAT–*Lancet* recommendations would reduce some diet-related health issues in addition to environmental effects.[32,38,98,99] Wider wellbeing issues such as workers' rights, community welfare, or health and safety in production were not evaluated despite these being acknowledged as global issues.[100]

In articles investigating economic aspects of the EAT–*Lancet* recommendations, the EAT–*Lancet* diet was more affordable than the population diet in high-income countries,[101–103] but was expensive and potentially unaffordable for people with low income.[39,42,102,104] For example, in Ethiopia, 146% of the poorest households' income is required to meet EAT–*Lancet* diet recommendations.[104]

Several articles focused on EAT–*Lancet's* recommendation to reduce animal-source food consumption and reported reduced greenhouse-gas emissions plus the potential public health benefits.[40,105] One study from Cameroon found that bushmeat consumption was higher than the EAT–*Lancet* diet recommendations, and that hunting was driving biodiversity loss.[106] Studies discussed the EAT–*Lancet* diet recommendations for fish as an alternative protein, highlighting high variability in nutritional quality, accessibility, and affordability of fish.[107,108] A key theme emerging from articles focused on animal-source foods was the need for nuance,[109] since animal-source food production and consumption varies considerably worldwide.[103,110] This heterogeneity means that the relationship between location-based reductions in animal-source food production and consumption and the reduction in greenhouse-gas emissions is uncertain.[64,108,109,111] Concern over reductions in available protein and micronutrients with reduced animal-source food consumption was another common theme.[34,94,96,111] There was an absence of consensus about the effect of reductions in animal-source foods and substitutions on specific populations due to assumptions made about the effects of livestock systems and unclear availability of suitable plant-based substitutes.

Several reviews focused on the recommendation by the EAT–*Lancet* Commission to switch to predominantly plant-based diets. Cross-sectional articles focused on the health outcomes of including specific plant groups in diets, such as legumes[112] or seaweed.[113] The role of wild plants was highlighted for further study,[114] given their importance in many food systems. Articles highlighted the considerable global yield increases in vegetables[115] and legumes[112] that are needed to meet EAT–*Lancet* diet guidelines. Some articles presented practical approaches to achieving recommended plant-based dietary switches, including a multi-criteria evaluation of plant-based products to guide consumer choices[33] and gastronomical design to make plant-based foods more appealing to consumers.[116]

Six articles investigated individual consumer perceptions and behaviours and related these to the shifts required to meet the EAT–*Lancet* diet recommendations.[28,29,31,49,117,118] Consumer behaviour was also a key theme emerging from review articles.[28,31,44,49,108,117–119] Consumer preferences, habits, tastes, and attitudes were discussed in cross-sectional studies as important aspects of the behavioural changes required to shift towards the EAT–*Lancet* diet.

A recurring theme in the review articles was an urgent need for cooperation across food systems, between governments, international agencies, industry and health bodies, and other decision-making and policy actors when developing actions that shift diets to meet environmental and health concerns.[43,44,57,63,76,83,119]

Figure 3: **Assessment of the quality of each negative critique of the EAT–*Lancet* Commission**

Each critique was assessed by two independent reviewers for the level of evidence supporting the recommendation, with conflicts resolved by a third reviewer. Red indicates no evidence (opinion only), yellow indicates medium-quality evidence (cited references), and blue indicates high-quality evidence (new analyses or data presented to support claims). Figure in brackets indicates the number of articles citing each critique.

Panel: Future research and policy agenda recommendations

Applied research

- Reduce animal production effects: research and development to curtail greenhouse-gas emissions[70,120]
- Reduce plant production effects: increase efficiency of crop water use and recycling, and conservation agriculture practices[68]
- Reduce food processing effects: innovation to reduce effects of processing on environment and health[68]
- Precision agriculture: development of precision agriculture, processing, and fermentation systems[68,83,130]
- Precision nutrition: identify nutrient sources that fulfil nutrient requirements[83]
- Innovative plant-based protein production: development of affordable, accessible, and innovative plant-based protein foods that are palatable and fulfil all micronutrient needs[77]
- Agriculture for diverse foods: research and development to increase production of non-staple, nutritious foods[47]
- Evidence-based behavioural interventions: experimental interventions to educate and promote behavioural change[121,131]

Informing policy

- Sustainable agriculture: build consensus on most effective sustainable farming techniques and technologies[70]
- Resilience to stressors: design diets and production systems that are adaptable to environmental change and resilient to system shocks[68,124]
- Global food trade: understand the role of global food trade in food systems[68,75]
- Equity and justice: policy and research that improves equity across resources and access to healthy, sustainable, and affordable foods[47,55,58,68,72]
- Environmental trade-offs: avoid unintended production, consumption consequences, and negative trade-offs considering different environmental effects[58,120]
- Evidence-based policy interventions: policy interventions to synergistically transition to more sustainable diets and food systems, such as incentivising incremental improvements in sustainable food production,[121] targeted policy related to food sourcing, and healthy and sustainable consumption choices (eg, national dietary guidelines)[43]

Fundamental knowledge generation

- Food composition data: build knowledge on composition of indigenous, wild, processed, and non-staple foods; examine substitutability particularly between animal-source and plant-source foods[55,68,73,78,83,110,124]
- Health risks data: improve evidence base for relationships between diet and disease[67,124,130]
- Food processing and effects: build knowledge on the effects of food preparation and processing on health and the environment[17,68,83,130]
- Wild foods effects: build knowledge on effects of diets obtained from the wild[73,124]
- Determine social, environmental, and health effects of interventions: build evidence for the effects of different interventions to promote human health within planetary boundaries[55,130,131]
- Drivers of behaviour change: establish the factors that enable switches to healthy diverse diets[124]
- Socioeconomic dimensions of food system transformation: build knowledge on human wellbeing implications of different dietary and agricultural practices, such as the effects on income and employment[55,83,132]
- Costs of food system transformation: build knowledge on the costs of food system transformation[47,72]
- Political and cultural aspects of food systems: improve representation of low-income and middle-income populations in global analyses[75,78,124]
- Biodiversity–agriculture interactions: build knowledge on how biodiversity is affected by the food system[75]

Improving methods

- Optimise diet design: build optimisation methods that account for full range of uncertainties[16]
- Integrated supply chain analysis to account for food processing and retail: build consensus definitions of different food processing operations used at household, culinary and catering, and industrial levels[83]
- Interdisciplinary supply chain effect assessment: integrate entire food chain to understand the whole-system effects of production and consumption choices on health and the environment[46,49,57,75,83]
- Traceability: standardisation of traceability and authentication of food origin and quality[68]
- New tools for data collection: build high-quality analytical methods and decision-support tools[47,83]

Associated with this need for cooperation was recognition of the absence of overarching governance enabling such coordination.

Recommendations for research and policy from 23 articles providing research and policy agendas were grouped into four broad strategies: applied research, filling evidence gaps in the knowledge base, improving methodology, and informing future policy (panel). Recommendations related to fundamental knowledge gain were the most prevalent (45% of all recommendations), and most often supported by high-quality evidence (22%; appendix 1 p 28). Nine knowledge gaps were identified, including understanding relationships between nutrition and disease risk, effects of country-specific dietary patterns on sustainability and health, and socioeconomic factors affecting EAT–*Lancet* diet uptake or efficacy (panel). Recommendations for applied research focused on innovation to reduce the

environmental effects of food production, precision nutrition and agriculture, innovation in producing novel proteins and non-staple foods, and evidence-based experimental behavioural interventions. To improve methodology, recommendations focused on interdisciplinary supply-chain effect assessment, traceability, and multi-objective optimisation (panel).

Many articles commented that agriculture and food policies perpetuate unsustainable systems as well as trigger more sustainable ones since they influence farming and business practices, costs, prices, and consumer choices. Six areas for policy research and action were identified, including finding consensus on best-practice sustainable agriculture and country-specific dietary guidelines that simultaneously consider the need for diets to be economical, social, equitable, healthy, and environmentally sustainable[43,58,120,121] (panel). Policy interventions, such as sustainable agriculture incentives that transition food systems to being more sustainable, were also recommended.[43,121]

Discussion

Our findings highlight wide academic interest in the EAT–*Lancet* Commission and its recommendations. The results from the sentiment analysis indicate support from the academic community despite the identified limitations in the EAT–*Lancet* Commission's method, scope, and lack of sensitivity to cultural, economic, social, and political contexts. New empirical analyses and data were presented in critiques of the EAT–*Lancet* Commission's lack of reproducibility,[122] failure to account for uncertainties,[16,18] bias towards high-income countries, and lack of awareness of food affordability, accessibility, and insecurity issues.[70,71] The potential for unintended health consequences from the EAT–*Lancet* diet was supported by high-quality evidence.[73] To address these limitations, the selected articles provided specific recommendations across 30 topics, including knowledge generation, development of novel methods and tools, applied experimental and empirical studies, and policy-focused research.

Outputs from articles published immediately following the EAT–*Lancet* Commission show some alignment with the identified research needs. For example, the most common suggested methodological improvement for sustainability research was for interdisciplinary effect assessment across social, environmental, and health realms to refine normative dietary recommendations; 16 (29%) of 56 articles exploring the effects of dietary changes towards EAT–*Lancet* recommendations took this interdisciplinary approach. However, attention mostly focused on only one environmental effect, which was greenhouse-gas emissions, despite well known effects on other environmental aspects, such as water, soil, and biodiversity.[4] These environmental effects were acknowledged but were uncommon in the reviewed studies. Another noticeable gap in both the EAT–*Lancet* Commission and citing articles was the use of antimicrobials in specific food systems that contribute to increasing antibiotic resistance of pathogenic bacteria.[123]

To deliver the "Great Food Transformation" referred to by the EAT-*Lancet* Commission,[10] research and innovation systems need to change. For example, several authors discussed the need for operations research that optimises diets or production methods by simultaneously maximising environmental and health outcomes rather than one group of outcomes alone,[16] and adapting to future environmental change.[68,124] To our knowledge, no studies have yet undertaken such analyses. Other gaps not addressed in the research outputs we evaluated include building data on food product micronutrient and macronutrient composition and palatability, assessment of environmental and health effects of food preparation and processing, and intervention-focused research. Most intervention-focused research would require longer than the 2 years of research that we evaluated to design, implement, and assess an intervention (eg, reducing environmental effects of food processing and packaging). However, other intervention-focused research would have been possible during this timeframe—for example, synthesising outcomes of existing agricultural or behavioural interventions to build an evidence base for intervention outcomes. We did not identify any such studies.

Given that dietary shifts towards EAT-*Lancet* recommendations would require major changes in global attitudes, plus behavioural shifts by producers and consumers, it was interesting that so few articles (3%) focused on social and cultural research. This gap was noticeable given that improving knowledge about drivers of behaviour change, socioeconomic dimensions of food system transformation, and wellbeing outcomes of policy change (including equity and justice) were among the most cited future research needs and backed by high-quality evidence.

Eight times more applications of the EAT-*Lancet* Commission focused specifically on consumption than on food production. Given its focus on healthy diets, applications that test assumptions and potential limitations of EAT-*Lancet* dietary recommendations are useful for validating predicted public health outcomes, and identifying socioeconomic, cultural, and political differences and needs.[31,93,119,125] However, a major shift in global diets would also require a similar shift in food production,[126] from advances in crop science to reallocation of agricultural land from pasture to cropping.

Our review has several limitations as it focused on studies published in the 2 years following the publication of the EAT–*Lancet* Commission and will not have included research requiring longer timeframes, such as evaluation of behavioural interventions. We excluded non-English articles (the percentage of relevant non-English articles excluded at full-text screening was only 2%), and omitted evidence from non-peer-reviewed publications and grey

literature, which could have led to the exclusion of some governmental and non-government organisation reports. Therefore, we cannot comment on the real-world effects of the Commission on non-academic discourse, such as policy and public opinion. Policy agenda items identified in this study represent researchers' views and are not necessarily reflective of real policy needs (only 8% of policy recommendations were supported by high-quality evidence; appendix 1 p 28). A similar analysis focused on the influence of the EAT–*Lancet* Commission on policy and grey literature would provide useful complimentary information. However, many national dietary guidelines pre-date the EAT–*Lancet* Commission and have not been updated since its publication, including those of major developed and developing nations carrying severe diet-related disease burdens such as the USA,[127] the UK,[128] and India.[129]

We found that academic articles published within 2 years after the EAT–*Lancet* Commission covered a broad range of research topics across health, life sciences, and social sciences. Our research and policy agenda should not only improve the methods and outcomes of future EAT–*Lancet* Commission reports, but also serve to guide healthy and sustainable food systems research globally.

Contributors

DB, FB, SB, DE, ME, AG, GM, and AITT were responsible for study design, data collection, and investigation. FB, SB, AG, GM, and AITT wrote the original draft. All authors were involved in writing, review, and editing. DE and GM performed the literature search. SB and GM acquired funding. DE and AITT were responsible for visualisation. AITT performed the data analysis.

Declaration of interests

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