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Title page

Online information in Spanish on probiotics, yoghurt, kefir, kombucha, fibre and prebiotics: an analysis of information quality and certainty of evidence of health claims

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ABSTRACT

Objective

To analyse certainty of evidence supporting health claims about probiotics, yoghurt, kefir, kombucha, fibre and prebiotics, and to assess the quality of online information in Spanish.

Methods

We analysed the first 20 webpages returned by searching six popular search phrases in Spanish relating to probiotics, yoghurt, kefir, kombucha, fibre and prebiotics on Google.es and coded them for typology and health claims. We analysed certainty of evidence for health claims from systematic reviews. Information quality was assessed according to 10 criteria, where a webpage: mentions scientific publications and reports their conclusions; quantifies relative and absolute effects; acknowledges some limitations; discusses certainty of evidence; reports the potential harms, alternatives and costs of the intervention; and does not argue based on personal experiences.

Results

There were 114 webpages eligible for analysis. Gastrointestinal health (86.0%), vague claims relating to maintaining health (57.9%), cardiovascular health (53.5%) and immune system health (50.9%) were the most widely mentioned topics. Half of health claims (52.6%, 70/133) were supported by evidence from systematic reviews. Probiotics had the highest number of health claims supported by evidence and kombucha the lowest. The highest certainty was found for antibiotic-associated diarrhoea (moderate) in probiotics and yoghurt, infectious diarrhoea and hepatic encephalopathy (moderate) in prebiotics, and cardiovascular health (high to moderate) and colorectal cancer (moderate) in fibre. On a scale of 0 to 10, the median information quality score for all webpages was 3. Only 18.4% of webpages reported study conclusions, 7.9% quantified the effects, 28.9% acknowledged some limitations in the research and 42.1% reported potential harms.

Conclusions

Most online health claims for dietary interventions intended for improving health through the gut microbiome are supported by low or very low certainty of evidence. Online information does not align with the evidence and is incomplete or unbalanced.

Keywords: diet, probiotics, fermented foods, fibre, prebiotics, health claims, online health information, quality of information, certainty of evidence.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This is the first study that uses certainty of evidence to analyse online information on probiotics, fermented foods, fibre and prebiotics.
- We propose 10 criteria (scored from 0 to 10) for assessing information quality, selected on the basis of the first systematic review of the quality of news reports on the effects of health interventions.
- The content analysis only focuses on some popular searches and the top 20 search results on Google.
- The study is limited in scope, since it only focuses on Spanish-language webpages and does not analyse information available on social media channels.

INTRODUCTION

Research into the microbial ecosystem residing in the gastrointestinal tract, which is collectively known as the gut microbiome, is commanding increasing attention among medical audiences and the general public.[1-4] While the microbiome is now often thought of as a virtual organ of the body due to its influence in many areas of human health, from immunity to energy metabolism and mental health,[5-7] its causal involvement in diseases is mostly unresolved.[8] Recent large-scale studies have shown that diet is among the most important environmental factors to which the gut microbiome is exposed and by which it is modified on a daily basis, even outweighing host genetics.[9-13]

Contemporary audiences are increasingly turning to the internet as a source of information about health and nutrition.[14, 15] Google is the most widely used search engine[16, 17] and one in 20 Google searches seek health-related information.[18] The health and nutrition-related information disseminated by online resources may influence health perception and food practices,[19-22] and the online space in particular has fuelled the promotion of microbiome-related interventions for maintaining health and quality of life.[23] However, information on the microbiome in online resources or websites (e.g., newspapers and Google searches) is often misleading, does not always report limitations and tends to simplify or exaggerate the benefits of microbiome-based interventions.[1, 4, 24-27] That has led to the microbiome being oversold as the main cause of all health and illness, in a phenomenon dubbed 'microbiomania'.[28] Despite the huge amount of health-related information that can be accessed online, there is no universal tool available for evaluating the quality of information on the effects of health interventions. Furthermore, the authors have not found any studies that explore the quality of online information on microbiome-related interventions.

As for health and nutrition in general, the internet is a major source of information among the general population about probiotic and fermented food use for the benefit of gut health.[29-31] During the COVID-19 pandemic, news and commercial websites frequently mentioned the microbiome and gut health in relation to immune boosting strategies, which, nevertheless, were lacking in evidence.[32] Two previous content analyses of webpages on probiotics in English showed poor quality and objective information, with commercial websites providing the lowest score.[33, 34] Whether

those findings can extrapolate to online information for other dietary strategies such as fermented foods, fibre and prebiotics, widely promoted as influencing human health through their effect on the gut microbiome, is unknown.

This study addresses both the scientific basis and the quality of the online information on gut microbiome-related interventions to which the public is exposed. Our first objective was to analyse certainty of evidence from systematic reviews (SRs) that support health claims regarding probiotics, yoghurt, kefir, kombucha, fibre and prebiotics in the top 20 indexed webpages in Spanish. We focused on such interventions for two reasons. First, most of the elements under focus (i.e., probiotics, yoghurt, kefir, fibre and prebiotics) have been studied in at least one human interventional study.[6, 30, 35, 36] Second, it was observed through an analysis on Google Trends[37] that those topics had been increasingly subject to consumer interest from 2010 onwards, while becoming relatively stable between 2019 and 2021. Our second objective was to develop an overall score based on 10 criteria for evaluating the quality of information, according to intervention and webpage typology.

METHODS

Google searches and selection criteria

In line with Neunez *et al.,*[34] we conducted searches on https://google.es using the Google Chrome browser and employing phrases based on search-term popularity as provided by AnswerThePublic.[38] The chosen phrases were: 'por que tomar probioticos', 'qué yogur tiene más probióticos', 'por que tomar kefir', 'por que tomar kombucha', 'fibra beneficios' and 'que son prebioticos y para que sirven'. The searches took place in August 2021 in Tarragona, Spain. We decided to choose phrases containing words without accents because, according to Google Trends,[37] that is the most common way in which users search. Consequently, the results returned are what most users would find (see dataset available from the FigShare repository for the relative popularity of search terms used). Before searching, we logged out from any Google accounts and cleared caches and browsing histories to limit any personalization of the search results.

Since consumers' online information searches are typically limited to initial search results,[39, 40] we limited our sample to the first 20 uniform resource locators (URLs) returned on the search engine results page (SERP). All webpages written in Spanish and providing information on the interventions of interest were included. Webpages that were irrelevant (i.e., the main focus was not the searched-for intervention), videos lasting more than five minutes, retail sites intended for direct purchase and advertisements were all excluded.

Webpage typology

We coded the content of the webpage linked to the URL, but not the content provided in the hyperlinks to other webpages. One author (APB) downloaded the webpage texts as individual PDF files, deleting any reference to source or authors, and coded the

webpages according to Neunez *et al*.'s typology: commercial (C), news (N), health portal (HP), professional (P), governmental (G), non-profit organisation (NP), scientific journal (SJ) and other (O) (see dataset available from the FigShare repository for examples of the classification).[34]

Health claims and certainty of evidence supporting them

Two authors (MB and GC) coded the health claims relating to each intervention (gastrointestinal health, immune system health, cardiovascular health, cancer, mental disorders, urogenital disorders and other). 'Other' was categorised when the webpage stated the intervention was valuable for general health (i.e., using general phrasing such as "helps maintain health or quality of life", "manages stress", "improves sleep", etc.), skin health (including cosmetic and skin disorders such as eczema and psoriasis) and respiratory disorders. APB coded specific indications within each health claim topic mentioned in the webpages. We also noted when an article on a webpage made a clear recommendation to consume or avoid the food or supplement and included the advice to consult a healthcare professional.

To identify which health claims were supported by evidence from SRs, we conducted a search of SRs in PubMed and the Cochrane Database of Systematic Reviews in December 2021. SRs were chosen since they gather and analyse all studies that answer the research question and meet inclusion criteria.[41] We selected SRs that evaluated certainty of evidence using the GRADE approach, which is an established methodology for classifying certainty of evidence for each outcome of interest as high, moderate, low or very low.[42] The claims about the effect (beneficial/harmful/no effect) and certainty of evidence (high/moderate/low/very low)[43] were coded by two authors (APB and MR). When more than one SR was obtained, we prioritized the most recent and for two SRs published the same year, we prioritized the Cochrane SR.[44] If certainty of evidence differed across outcomes stated in webpages for the same intervention, overall certainty of evidence was understood as the lowest GRADE classification registered.[44] When the certainty for an outcome was not reported, the results were contradictory or effects could not be estimated, we coded the effect as uncertain.

Quality of information

MB and GC separately analysed the quality of online information based on whether it met the following 10 criteria (selected on the basis of the only available SR of the quality of information on health interventions and two other relevant papers)[45-47]: 1) provides references or links to scientific publications; 2) explains the conclusions of scientific publications; 3) quantifies relative effects; 4) quantifies absolute effects; 5) acknowledges some research limitations (e.g., preliminary results, small studies, conflicts of interests and differing results between studies); 6) generally discusses certainty of evidence (e.g., aligning wording depending on whether the studies are observational or experimental);[48] 7) reports potential harms; 8) reports on available alternatives; 9) discusses intervention costs; and 10) does not make arguments based on personal experiences or anecdotes. For each criterion, the story was given a rating of 'satisfactory' or 'unsatisfactory'.

All discrepancies in coding were resolved through discussion with a third author (APB) so that the final concordance was 100%. As there were only two raters rating the same sample, Cohen's kappa was used to calculate inter-rater agreement. Data are reported as kappa and its 95% CI. We considered a kappa of between 0.41 and 0.60 as a 'moderate' agreement, between 0.61 and 0.80 as a 'substantial' agreement and between 0.81 and 1.00 as an 'almost perfect' one.[49]

Statistical analysis

Categorical variables were described by their absolute frequencies and percentages and continuous variables were reported as median and interquartile range (IQR) assuming the data did not fit a normal distribution, which was verified using the Shapiro-Wilk test.

We used Fisher's exact test to compare webpage typologies and the χ^2 test applying a Bonferroni correction to compare portrayals of health claims. We used a non-parametric Kruskal-Wallis test to compare information quality score in different interventions and webpage typologies. Statistical significance was set at $p<0.05$ and the actual p value is reported in the results section for each comparison. Version 3.5.2 of the R software (SPSS Inc., Chicago, IL, USA) and version 4.7.0.0 of the Joinpoint Regression Program were used for all analysis work.

Patient and public involvement

No patient involved.

RESULTS

After excluding 6 webpages (3 irrelevant webpages, 1 long video and 2 online shops), a total of 114 webpages were eligible for analysis. The two primary types of webpages were commercial (23.7%, 27/114) and news webpages (23.7%, 27/114), followed by professional webpages (hospitals, universities and healthcare professionals) (14.0%, 16/114) and health portals (12.3%, 14/114). All other eligible webpage typologies accounted for <10%. Five webpages corresponded to scientific publications relating to fibre (2.6%, 3/114) and prebiotics (1.8%, 2/114).

Certainty of evidence of health claims

All the webpages discussed interventions in relation to at least one health claim. In total, there were 133 different health claims for which probiotics, yoghurt, kefir, kombucha, fibre and prebiotics were portrayed as beneficial (see dataset available from the FigShare repository for a complete list). The most frequently reported reason for eating the food or taking the supplement was to reverse an altered gut microbiome (i.e., 'dysbiosis') secondary to an unbalanced diet or stressful lifestyle, treatment with antibiotics or disease. The four primary and most widely portrayed health claim topics for all interventions were gastrointestinal health (86.0%, 98/114), vague claims about maintaining or improving health without any reference to a specific condition ('Other')

(57.9%, 66/114), cardiovascular health (53.5%, 61/114) and immune system health (i.e., infections, allergies, boosting the immune system) (50.9%, 58/114). The immune system-related health claims for kefir were overrepresented compared to fibre (p=0.008). For fibre, the overrepresentation of health claims related to cardiovascular diseases was higher and statistically significant compared to probiotics (p=0.004) and the overrepresentation of health claims related to cancer was higher and statistically significant compared to probiotics (p=0.009) and prebiotics (p=0.044). The overrepresentation of general health claims ('Other') for kombucha was higher and statistically significant compared to fibre (p=0.002) and prebiotics (p=0.016) (Figure 1).

[Figure 1]

Of the total of 133 health claims, only half (52.6%, 70/133) were supported by evidence from SRs. Probiotics (54.7%, 29/53), yoghurt (42.6%, 20/47) and fibre (37.1%, 13/35) had the highest number of online health claims supported by evidence from SRs. None of the 55 online health claims for kombucha was supported by evidence from SRs (Figure 2).

[Figure 2]

The health claims that appeared on the greatest number of webpages were not necessarily the ones with the highest certainty of evidence (Table 1). In the context of gastrointestinal health, the highest certainty of evidence was found for the prevention of antibiotic-associated diarrhoea for probiotics and yoghurt (moderate certainty of evidence) and the prevention and treatment of infectious diarrhoea and hepatic encephalopathy for prebiotics (moderate certainty of evidence). The prevention of acute otitis media was the immune system-related health claim supported by moderate evidence for probiotics and yoghurt. Fibre was the intervention with the highest number of online health claims supported by high (reduction of cholesterol and triglyceride levels) to moderate (reduction in obesity, type 2 diabetes, cardiovascular disease mortality, hypertension, coronary heart disease incidence and colorectal cancer incidence) certainty of evidence.

Table 1. Effect and certainty of evidence in systematic reviews supporting online health claims for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics.

Intervention	Health claim	# of webpages	Effect*	Certainty of evidence#
Probiotics[a]	**Gastrointestinal health**			
	Antibiotic-associated diarrhoea	15	Favourable	Moderate
	Irritable bowel syndrome	13	No effect	Low
	Infectious diarrhoea	11	Uncertain	Very low
	Ulcerative colitis	8	Uncertain	Very low
	Constipation[b]	7	Favourable	Low
	Crohn's disease	5	No effect	Very low
	Abdominal distension and bloating	4	No effect	Low
	Necrotising enterocolitis	4	Favourable	Moderate
	Infantile colic	3	Favourable	Low
	Pouchitis	3	Uncertain	Very low

	Non-alcohol-related fatty liver disease	2	Uncertain	Very low
	Tooth decay	2	Favourable	Low
	Periodontal disease	2	Uncertain	Very low
	C. difficile-associated diarrhoea	1	Favourable	Low
	Hepatic encephalopathy	1	Favourable	Low
	Immune system health			
	Allergies	7	No effect	Very low
	Vulvovaginal candidiasis	7	Favourable	Very low
	Urinary tract infections	6	No effect	Low
	Otitis	3	Favourable	Moderate
	Cardiovascular health			
	Obesity	2	No effect	Very low
	Hypertension	2	Favourable	Very low
	Gestational diabetes	1	No effect	Low
	Mental disorders			
	Anxiety	4	Uncertain	Very low
	Depression	3	Uncertain	Very low
	Other			
	Atopic dermatitis	5	Uncertain	Very low
	Upper respiratory tract infections	6	Favourable	Very low
	Stress symptoms	2	No effect	Very low
	Asthma	1	No effect	Very low
	Mastitis	1	Uncertain	Low
Yoghurt[a]	**Gastrointestinal health**			
	Infectious diarrhoea	6	Uncertain	Very low
	Constipation[b]	5	Favourable	Low
	Antibiotic-associated diarrhoea	4	Favourable	Moderate
	Irritable bowel syndrome	3	No effect	Low
	Abdominal distension and bloating	2	No effect	Low
	Ulcerative colitis	1	Uncertain	Very low
	Crohn's disease	1	No effect	Very low
	Necrotising enterocolitis	1	Favourable	Moderate
	Immune system health			
	Otitis	3	Favourable	Moderate
	Allergies	1	No effect	Very low
	Cardiovascular health			
	Obesity	6	No effect	Very low
	Hypertension	2	Favourable	Very low
	Mental disorders			
	Anxiety	2	Uncertain	Very low
	Depression	2	Uncertain	Very low
	Alzheimer's disease	1	No effect	Very low
	Other			
	Stress symptoms	1	No effect	Very low
	Abdominal pain	1	No effect	Low
	Upper respiratory tract infections	1	Favourable	Very low
	Cystic fibrosis	1	No effect	Low
	Reduction in blood urea levels	1	Favourable	Very low
Kefir	**Gastrointestinal health**			
	Ulcerative colitis	3	Uncertain	Very low
Fibre	**Gastrointestinal health**			
	Constipation	17	Favourable	Low
	Ulcerative colitis	1	Uncertain	Very low
	Crohn's disease	1	Uncertain	Very low
	Cardiovascular health			

	Reduction in cholesterol	17	Favourable	High
	Glycaemic control	17	Favourable	Low
	Obesity	15	Favourable	Moderate
	Type 2 diabetes	5	Favourable	Moderate
	Cardiovascular disease mortality	3	Favourable	Moderate
	Reduction in triglycerides	3	Favourable	High
	Hypertension	2	Favourable	Moderate
	Coronary heart disease	1	Favourable	Moderate
	Cancer			
	Colorectal cancer	12	Favourable	Moderate
	Other			
	Anti-inflammatory	2	Favourable	Moderate
Prebiotics	**Gastrointestinal health**			
	Constipation[b]	11	Favourable	Low
	Infectious diarrhoea	6	Favourable	Moderate
	Hepatic encephalopathy	3	Favourable	Moderate
	Non-alcohol-related fatty liver disease	2	Uncertain	Very low
	Radiotherapy-induced diarrhoea	1	Uncertain	Uncertain
	Immune system health			
	Allergies	1	No effect	Very low
	Other			
	Eczema	1	No effect	Uncertain

[*]**Favourable effect** means the intervention is associated with a beneficial effect on the outcome of interest; **no effect** means the intervention makes little or no difference to the outcome of interest; **uncertain** means the certainty for an outcome was not reported, the results were contradictory, or effects could not be estimated.

[#]**High certainty** means the authors have a lot of confidence that the true effect is similar to the estimated effect; **moderate certainty** means the authors believe that the true effect is probably close to the estimated effect; **low certainty** means the true effect might be markedly different from the estimated effect; **very low certainty** means the true effect is probably markedly different from the estimated effect; and **uncertain** means certainty could not be estimated.

[a] Probiotics in the form of foods (fermented milks containing probiotic bacteria) and supplements were analysed together in the SRs consulted.

[b] Outcomes reported by probiotics combined with lactulose.

Quality of information

After assessing the quality of the online information by applying the 10 criteria as described in the Methods section, we obtained a score of between 0 and 10 for all webpages. Figure 3 displays the median information quality score by intervention and webpage typology. The median quality score by intervention was 3, IQR [2, 4] and was not significantly different across all interventions. Scientific journal webpages had the highest quality score of all typologies, with a significantly higher median than commercial (p=0.009), health portals (p=0.030), news (p=0.026) and professional webpages (p=0.026).

[Figure 3]

Table 2 shows how quality criteria ranked among all interventions. While 39.5% of all webpages provided references or links to scientific publications, only a minority (18.4%, 21/114) adequately explained the key messages and conclusions of the paper's content.

Table 2. Webpages informing about probiotics, yoghurt, kefir, kombucha, fibre and prebiotics that meet each information quality criterion.

Quality criteria	All webpages (%) n=114	Probiotics (%) n=19	Yoghurt (%) n=17	Kefir (%) n=20	Kombucha (%) n=20	Fibre (%) n=20	Prebiotics (%) n=18
1. Provides references or links to scientific publications	45 (39.5)	11 (57.9)	5 (29.4)	6 (30.0)	5 (25.0)	9 (45.0)	9 (50.0)
2. Explains conclusions of scientific publications	21 (18.4)	5 (26.3)	3 (17.7)	4 (20.0)	2 (10.0)	4 (20.0)	3 (16.7)
3. Quantifies relative effects	9 (7.9)	1 (5.3)	1 (5.9)	2 (10.0)	1 (5.0)	3 (15.0)	2 (11.1)
4. Quantifies absolute effects	2 (1.8)	0	0	0	0	1 (5.0)	1 (5.6)
5. Acknowledges some research limitations	33 (28.9)	8 (42.1)	6 (35.3)	3 (15.0)	3 (15.0)	6 (30.0)	7 (38.9)
6. Generally discusses certainty of evidence	18 (15.8)	5 (5.9)	1 (5.9)	1 (5.0)	4 (20.0)	3 (15.0)	4 (22.2)
7. Reports potential harms	48 (42.1)	5 (26.3)	1 (5.9)	12 (60.0)	13 (65.0)	11 (55.0)	6 (33.3)
8. Reports on available alternatives	49 (43.0)	14 (73.7)	8 (47.1)	7 (35.0)	1 (5.0)	6 (30.0)	13 (72.2)
9. Discusses intervention costs	4 (3.5)	2 (10.5)	1 (5.9)	0	1 (5.0)	0	0
10. Does not argue based on personal experiences or anecdotes	113 (99.1)	18 (94.7)	17 (100.0)	20 (100.0)	18 (90.0)	20 (100.0)	20 (100.0)

Most webpages used verbal descriptions to explain intervention health benefits and did not quantify effects. Only 7.9% (9/114) of webpages quantified relative effects, including the five scientific journal webpages, of which only two included absolute effects.

Overall, only one third of webpages (28.9%, 33/114) stated some of the limitations of research findings. Mentions of limitations included, for example, acknowledging that research that supports health benefits is still in its early stages; stating that the food can improve a condition for a few people in limited circumstances but it cannot be extrapolated to other people due to the small sample studied; addressing conflicts of interest; and highlighting discrepancies between studies that mean the intervention may not be recommended for all indications. Only 15.8% of webpages (18/114) provided a general discussion of certainty of evidence supporting an intervention's benefits through consistent words and phrases that depended on whether the studies were observational (i.e., using cautionary phrases such as 'The results suggest' and conditional verb tenses) or experimental (i.e., using verbs that indicate causality such as 'lead to', 'reduce' or 'increase'). Other means of properly communicating certainty of evidence included stating that effects were currently under investigation or more research was needed to consider an intervention in the context of a specific condition. There were webpages, for example, that used a language of uncertainty, mentioning that, "The health benefits of the probiotics and prebiotics that are currently available have not been proven conclusively" or "For now, science does not know which of kefir's

components are responsible for its health benefits." A further phrase mentioned how "There is not enough evidence that kombucha tea is as good for your health as some say."

Only 42.1% of webpages mentioned or adequately discussed the potential harms of the intervention. Harms were reported in more than a half of webpages on kombucha (65.0%, 13/20), kefir (60.0%, 12/20) and fibre (55.0%, 11/20), but only in a quarter of webpages on probiotics (26.3%, 5/19). Similarly, less than half of webpages (43.0%, 49/114) reported available alternatives to the main intervention (i.e., in the form of food or food supplements). The reporting of costs only appeared in 3.5% (4/114) of all webpages.

Some commercial (19.3%, 22/114), health portals (9.6%, 11/114), news (7.0%, 8/114) and professional webpages (6.1%, 7/114) included a direct recommendation to consume the food or supplement. Webpages reporting on the potential harms also recommended not consuming the food or supplement under specific circumstances (e.g., avoiding probiotics and kombucha in immunocompromised adults). The recommendation of consulting a healthcare professional was included in a third of all webpages (28.1%, 32/114).

While for the criterion of acknowledging some research limitations the inter-rater agreement was 56% with Cohen's kappa of 0.253 (95% CI: 0.095 to 0.411), for the remaining variables, the inter-rater agreement was higher than 70% with Cohen's kappa of between 0.420 (95% CI: 0.234 to 0.605) and 0.929 (95% CI: 0.849 to 1.008), demonstrating 'moderate' to 'almost perfect' agreement (see dataset available from the FigShare repository for inter-rater agreement results).[49]

DISCUSSION

Our study shows that most online health claims for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics are supported by low to very low certainty of evidence. Furthermore, the overall quality of information on the gut microbiome-related interventions studied was low, with a median quality score of 3 on a scale of 0 to 10 for all interventions when applying our 10 quality criteria.

On webpage typology, results were not surprising. The prominent presence of commercial (23.7%) and news (23.7%) webpages in Spanish is in line with previous results on webpage content on probiotics in English.[33, 34] Our findings reflect companies' interest in therapeutically exploiting the microbiome[33, 34] and the newsworthiness of the topic.[2-4]

Regarding the first objective, both the plethora of beneficial health claims for dietary interventions intended to improve health through the gut microbiome and the weak evidence base supporting such health claims were also expected. All in all, our data add valuable details for better understanding the online information to which audiences are exposed.

First, our research finds that probiotics, fermented foods, fibre and prebiotics might be beneficial for 133 health indications. Similarly, Marcon *et al.* found that American and Canadian general newspapers mentioned up to 138 different health topics for which microbiome-related interventions were portrayed as beneficial.[4] However, very few of those purported benefits are supported by the evidence and integrated into clinical practice. Thus, while fibre has a long history of use in the clinical setting,[50] the degree to which probiotics are recommended to patients by healthcare professionals is variable.[29, 51] Factors explaining why some specialist doctors do not recommend probiotics include the perceived lack of research evidence and poor knowledge regarding use and cost.[52, 53] While uncertainty remains around the optimal use of probiotics,[36] the perception among patients who seek advice from gastroenterologists is that probiotics improve general health, longevity and gastrointestinal symptoms.[54]

Second, we found gastrointestinal health and immune system health-related indications are among the most widely mentioned benefits, which is in line with Neunez *et al.*'s findings for probiotics.[34] However, the concepts of 'boosting gut health' and 'boosting immunity', the latter of which spiked on the internet during the COVID-19 pandemic,[32] are misleading and scientifically inaccurate.[55, 56]

Third, the evidence-based benefit of probiotics and yoghurt for preventing antibiotic-associated diarrhoea that appeared in most webpages is supported by moderate certainty of evidence,[57] while certainty of evidence is low and very low for irritable bowel syndrome[58] and infectious diarrhoea,[59] respectively, both of which appear in a high number of search results. Conversely, although there is moderate certainty of evidence of probiotics' role in preventing mortality and infections secondary to necrotising enterocolitis in very preterm infants or infants with a very low birth weight,[60] that health benefit only appeared in a few of the webpages that discussed probiotics (21.1%, 4/19). When interpreting SRs that perform a meta-analysis of probiotics, it should be acknowledged that said reviews do not usually report outcomes in appropriate probiotic strain-specific sub-groups. That may cloud any potential signalling of the probiotic for preventing or treating diseases and may contribute to explaining why only 54.7% of probiotic-related health claims are supported by evidence from SRs.[61] The low number of health claims for yoghurt (42.6%, 20/47) and kefir (1.8%, 1/55), supported by evidence from SRs, coincides with our previous findings using the GRADE approach, which showed that consuming probiotics in the form of fermented milks such as yoghurt and kefir may not be associated with any health benefits, with either low or very low certainty of evidence.[62] None of the health claims for kombucha was supported by evidence from SRs, which is expected due to the lack of controlled human studies investigating the potential health effects of this popular fermented drink.[30, 63]

Fourth, not surprisingly given its common use among healthcare professionals in gastrointestinal disorders,[50] fibre was the intervention with the most health claims supported by high (reduction of cardiovascular disease risk factors)[64] to moderate (protection against colorectal cancer)[65] certainty of evidence. The efficacy of prebiotics for preventing constipation supported by low certainty of evidence[66]

appeared in a high proportion of webpages. In contrast, the more widely studied indication of prebiotics for managing hepatic encephalopathy, which showed moderate certainty of evidence,[67] appeared in very few webpages (16.7%, 3/18).

Regarding the second objective, the assessment of information quality carried out using our 10-criteria score shows interesting data on both overall quality and some specific shortcomings.

First, the low quality of online information assessed according to our 10 criteria is not surprising. However, it is even lower than estimated for news reports on health interventions in general, using other indices or scales containing common quality criteria. Thus, in our study, 92.1% of the webpages did not quantify the effects of the intervention, compared to 72% of the news items analysed by Schwitzer;[46] 84.2% did not discuss the certainty of the evidence, compared to 65%; and 96.5% did not report the costs of the intervention, compared to 77%. On two other common criteria, the results were more similar: 57% of the webpages did not report alternatives to the intervention, compared to 62% of the news items analysed by Schwitzer; and 57.9% did not report potential harms, compared to 67%.

The first systematic review of the quality of information on health interventions in traditional media outlets and online resources also found room for improvement as regards health news.[45] However, nutrition-related information is especially prone to poor quality and may contribute to public misconceptions about dietary strategies targeting the gut microbiome and health.[68-72] One way to improve that situation might be to promote critical thinking among the public. In other words, it might be better to treat the effects of the current overabundance of information than to prevent it, since prevention is an almost impossible task, with exaggerated scientific findings and discoveries always attracting those who produce and recirculate information.[45, 73]

Second, the strategy of including scientific references embedded in the text or as a list at the end of text (criterion 1) without explaining the conclusions of the scientific publications (criterion 2) is an example of how the 'health halo effect' around gut health and the microbiome is used to validate certain unproven alternative therapies.[4, 32] In addition, webpages also misrepresent the term 'probiotic', which is inadequately used to refer to kombucha and kefir and as an umbrella for all probiotic supplements, when, in actual fact, not all probiotics are backed by science and not all fermented foods can be considered probiotics.[30, 74] Likewise, many webpages use the term 'dysbiosis' as a reason to promote interventions with the connotation that an 'altered' microbiome in someone with a specific disease is causal or contributory, even though it is not always certain that changing the altered microbiome is beneficial[75] and the definition of a healthy microbiome is not known.[76]

Third, it is also worth noting that the majority of webpages only provide a qualitative description of the health claims without quantifying them (criteria 3 and 4). The few webpages that quantified the effects did so only in relative numbers (7.9%, 9/114), which tend to be more eloquent, are often misleading and can lead to a misguided perception of the reported effects.[75, 77] Only two out of five scientific journal

webpages included absolute effects. Indeed, the microbiome field relies too heavily on relative numbers of microorganisms.[75] For instance, one clear example of numerical misinterpretation is the long-assumed ratio, widely disseminated in the media and the scientific literature, that humans have 10 times more microbial cells than body cells.[78]

Fourth, the observation that only a few webpages acknowledged some research limitations (criterion 5) (28.9%, 33/114) and discussed certainty of evidence (criterion 6) (15.8%, 18/114) is common when informing on microbiome-related interventions. For instance, social media content rarely makes critical references to microbiome research findings and the only acknowledgments of limitations found are suggestions around the need for more research.[27] Likewise, previous findings show that only 19% of articles in English-language newspapers[4] and less than 10% of webpages portraying immune boosting strategies, including the use of probiotics and prebiotics,[32] report microbiome-related limitations (e.g., suggesting that the health benefits of and current research on the microbiome might be unproven, ineffective or exaggerated). Probiotics was the intervention with the highest proportion of webpages that provided limitations and comments around certainty of evidence, which might be explained by probiotics' status as the most widely studied subject when compared to fermented foods such as kefir and kombucha.[35, 36]

Fifth, only a minority of webpages on probiotics informed of adverse effects (criterion 7) and included advice against consumption by people with severe illnesses or compromised immune systems.[79] Previous analyses of online messages about probiotics also found that descriptions of their benefits outnumbered the descriptions of their risks, and the latter appeared significantly less on commercial webpages.[33, 34] That may be rooted in the lack of safety data in randomized controlled trials for probiotics.[80] Safety issues are also a concern for kombucha, with reports of varying degrees of adverse effects in relation to kombucha tea consumption,[81] while fibre and prebiotics are limited to mild issues such as abdominal discomfort, bloating and gas.[50]

Our study shows two strengths. First, for the evaluation of online health claims, we relied on systematic reviews and assessments of the degree of certainty of evidence using the GRADE approach, which is a systematic, explicit and transparent methodological framework for grading certainty of evidence.[82, 83] Second, the authors have extensive knowledge of and experience in the fields of nutrition, evidence-based medicine, science journalism and microbiome research communication.

There are also several limitations to this study. First, we used single search phrases to perform the searches. That meant we could not explore differences in results for other search terms, which can vary in the current context of the COVID-19 pandemic. Second, the data set only includes Spanish-language webpages and focuses on the initial search results, although it must be acknowledged that the top 20 search results have a higher chance of being read.[39, 40] Third, we only focused on 10 parameters for assessing quality of information. Fourth, we did not analyse information published on social media channels, which provide relevant sources for people seeking nutrition advice online. Last, we analysed the certainty of the evidence behind online health claims based only

on systematic reviews, which are currently the evidence synthesis tool that offers the highest level of evidence.

CONCLUSION

Online information on probiotics, fermented foods, fibre and prebiotics does not reflect the available body of scientific evidence and is often incomplete and of a poor quality. The observation that the majority of health claims that appeared on the largest number of webpages were not necessarily the ones with the highest certainty of evidence may contribute to distorting the message about the impact of foods on health linked to their effects on the gut microbiome. Furthermore, the fact that research results and the quantification of the effects, limitations and uncertainty of evidence, along with the adverse effects, cost and alternatives of interventions, are not usually addressed can distort public perception of the topic.

CONTRIBUTORS

APB and GC designed the research with input from MR and MB. APB, MR, MB and GC performed the research and analysed the data. APB and GC interpreted the data. APB wrote the manuscript. MR, MB and GC were involved in drafting and revising the manuscript. All authors approved the final version to be published and agreed to be accountable for all aspects of the work.

COMPETING INTERESTS

APB works as a health writer for companies commercially involved in the gut microbiota and probiotics. MR, MB and GC have declared no competing interests.

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DATA AVAILABILITY STATEMENT

All data relevant to the study are included in a public, open access repository. The data set is available:
https://figshare.com/projects/Online_information_in_Spanish_on_probiotics_yoghurt_kefir_kombucha_fibre_and_prebiotics/135935

ETHICS APPROVAL

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Legends of the figures cited within the main text:

Figure 1. Online health claim topics portrayed for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics.

Figure 2. Number of online health claims for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics supported or not by evidence from systematic reviews (SRs).

Figure 3. Information quality score by intervention (A) and webpage typology (B). Data are reported as median and interquartile range. C, commercial; HP, health portal; N, news; NP, non-profit organisation; P, professional; SJ, scientific journal; G, governmental; O, other. *$p<0.05$ vs scientific journals according to a Kruskal-Wallis test.

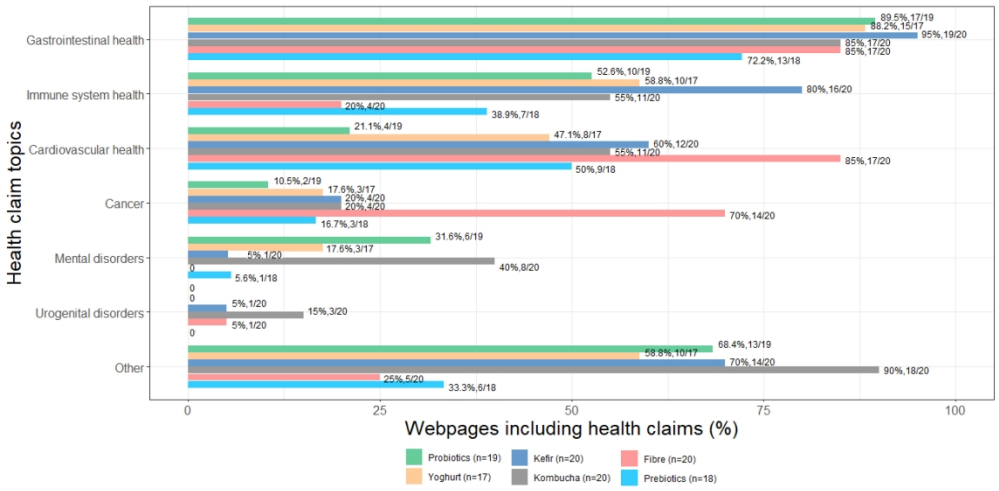

Figure 1. Online health claim topics portrayed for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics.

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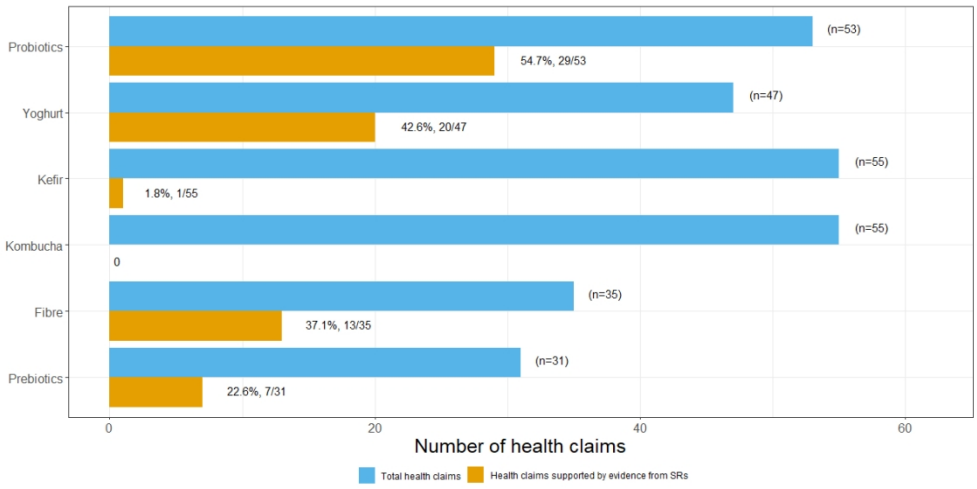

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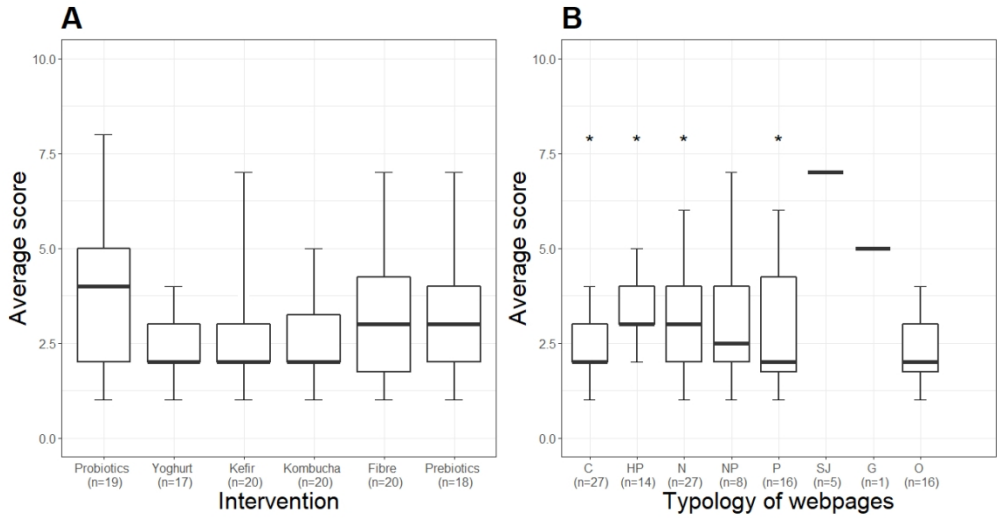

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BMJ Open

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Title page

Online information in Spanish on probiotics, yoghurt, kefir, kombucha, fibre and prebiotics: an analysis of the quality of information and the certainty of the evidence supporting health claims

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ABSTRACT

Objective

To examine the certainty of the evidence supporting health claims about probiotics, yoghurt, kefir, kombucha, fibre and prebiotics, and to assess the quality of online information in Spanish.

Design

Content analysis.

Methods

We compiled a dataset of 114 webpages returned by searching six popular search phrases in Spanish relating to probiotics, yoghurt, kefir, kombucha, fibre and prebiotics on Google.es and coded them for typology and health claims. We examined the certainty of the evidence for health claims from systematic reviews. Information quality was assessed according to 10 criteria, where a webpage: mentions scientific publications and reports their conclusions; quantifies relative and absolute effects; acknowledges some limitations; discusses certainty of evidence; reports the potential harms, alternatives and costs of the intervention; and does not argue based on personal experiences.

Results

Gastrointestinal health (86.0%), vague claims relating to maintaining health (57.9%), cardiovascular health (53.5%) and immune system health (50.9%) were the most widely mentioned topics. Half of health claims (52.6%, 70/133) were supported by evidence from systematic reviews. Probiotics had the highest number of health claims supported by evidence and kombucha the lowest. The highest certainty was found for antibiotic-associated diarrhoea (moderate) in probiotics and yoghurt, infectious diarrhoea and hepatic encephalopathy (moderate) in prebiotics, and cardiovascular health (high to moderate) and colorectal cancer (moderate) in fibre. On a scale of 0 to 10, the median information quality score for all webpages was 3. Only 18.4% of webpages reported study conclusions, 7.9% quantified the effects, 28.9% acknowledged some limitations in the research and 42.1% reported potential harms.

Conclusions

Most online health claims for dietary interventions intended for improving health through the gut microbiome are supported by low or very low certainty of evidence. Online information does not align with the evidence and is incomplete or unbalanced.

Keywords: diet, probiotics, fermented foods, fibre, prebiotics, health claims, online health information, quality of information, certainty of evidence.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study examines the extent to which online health claims for popular dietary interventions related to the gut microbiome are aligned with certainty of evidence evaluated using the GRADE approach.
- We propose 10 criteria (scored from 0 to 10) for assessing information quality, selected on the basis of the first systematic review of the quality of news reports on the effects of health interventions.
- The content analysis only focuses on some popular searches and the top 20 search results on Google.
- The study is limited in scope, since it only focuses on Spanish-language webpages and does not analyse information available on social media channels.

INTRODUCTION

Research into the microbial ecosystem residing in the gastrointestinal tract, which is collectively known as the gut microbiome, is commanding increasing attention among medical audiences and the general public.[1-4] While the microbiome is now often thought of as a virtual organ of the body due to its influence in many areas of human health, from immunity to energy metabolism and mental health,[5-7] its causal involvement in diseases is mostly unresolved.[8] Recent large-scale studies have shown that diet is among the most important environmental factors to which the gut microbiome is exposed and by which it is modified on a daily basis, even outweighing host genetics.[9-13]

Probiotics, fermented foods, fibre and prebiotics are dietary interventions that influence human health in terms of their effect on the gut microbiome. The health benefits of probiotics include their effect on digestive ailments (i.e., treating acute diarrhoea and antibiotic-associated diarrhoea, managing symptoms of lactose intolerance, treating pouchitis, preventing *Clostridioides difficile* infection and preventing necrotising enterocolitis in preterm infants). They also provide benefits in relation to non-alcoholic fatty liver diseases and some immune-related conditions (i.e., preventing or treating infectious diseases and preventing atopic dermatitis).[14, 15] Fermented foods have also undergone a surge in popularity, although not all have a proven impact on clinical health outcomes. The most widely investigated fermented foods are yoghurt, with evidence for managing symptoms of lactose intolerance and reducing the risk of metabolic syndrome, and kefir, with beneficial effects in both lactose malabsorption and *H. pylori* eradication.[16] Fibre can aid with gut disorders (i.e., irritable bowel syndrome, inflammatory bowel diseases, diverticular disease and functional constipation), reducing the risk of cardiovascular diseases and lowering all-cause mortality rate.[17-19] Prebiotics have been studied for reducing constipation and diarrhoea, promoting metabolic health, modulating satiety, helping with symptoms of irritable bowel syndrome, treating hepatic encephalopathy and reducing risk of allergy.[14, 20]

Contemporary audiences are increasingly turning to the internet as a source of information about health and nutrition.[21, 22] Google is the most widely used search engine[23, 24] and one in 20 Google searches seek health-related information.[25] The

health and nutrition-related information disseminated by online resources may influence health perception and food practices,[26-29] and the online space in particular has fuelled the promotion of microbiome-related interventions for maintaining health and quality of life.[30] However, information on the microbiome in online resources or websites (e.g., newspapers and Google searches) is often misleading, does not always report limitations and tends to simplify or exaggerate the benefits of microbiome-based interventions.[1, 4, 31-34] That has led to the microbiome being oversold as the main cause of all health and illness, in a phenomenon dubbed 'microbiomania'.[35] Despite the huge amount of health-related information that can be accessed online, there is no universal tool available for evaluating the quality of information on the effects of health interventions. Furthermore, the authors have not found any studies that explore the quality of online information on microbiome-related interventions.

The gut microbiome-related food and dietary supplement industry is largely unregulated in the United States and Europe and marketing of such products is often geared directly at consumers without consistent evidence of efficacy and safety.[36, 37] On the one hand, regulatory authorities do not allow health claims to be made for probiotics and prebiotics, but on the other, there is little regulation of the manufacturing process and marketing actions,[38] which can contribute to the spread of misleading information on these products.

As for health and nutrition in general, the internet is a major source of information among the general population about probiotic and fermented food use for the benefit of gut health.[16, 39, 40] During the COVID-19 pandemic, news and commercial websites frequently mentioned the microbiome and gut health in relation to immune boosting strategies, which, nevertheless, were lacking in evidence.[41] Two previous content analyses of webpages on probiotics in English showed poor quality and objective information, with commercial websites providing the lowest score.[42, 43] Whether those findings can extrapolate to online information for other dietary strategies such as fermented foods, fibre and prebiotics, widely promoted as influencing human health through their effect on the gut microbiome, is unknown.

This study addresses both the scientific basis and the quality of the online information on gut microbiome-related interventions to which the public is exposed. Our first objective was to examine the certainty of the evidence from systematic reviews (SRs) that support health claims regarding probiotics, yoghurt, kefir, kombucha, fibre and prebiotics in the top 20 indexed webpages in Spanish. We focused on such interventions for two reasons. First, most of the elements under focus (i.e., probiotics, yoghurt, kefir, fibre and prebiotics) have been studied in at least one human interventional study.[6, 14-16] Second, it was observed through an analysis on Google Trends[44] that those topics had been increasingly subject to consumer interest from 2010 onwards, while becoming relatively stable between 2019 and 2021. Our second objective was to develop an overall score based on 10 criteria for evaluating the quality of information, according to intervention and webpage typology.

METHODS

Google searches and selection criteria

In line with Neunez *et al.,*[43] we conducted searches on https://google.es using the Google Chrome browser and employing phrases based on search-term popularity as provided by AnswerThePublic.[45] The chosen phrases were: 'por que tomar probioticos', 'qué yogur tiene más probióticos', 'por que tomar kefir', 'por que tomar kombucha', 'fibra beneficios' and 'que son prebioticos y para que sirven'. The searches took place in August 2021 in Tarragona, Spain. We decided to choose phrases containing words without accents because, according to Google Trends,[44] that is the most common way in which users search. Consequently, the results returned are what most users would find (for the relative popularity of the search terms used, see reference [46]). Before searching, we logged out from any Google accounts and cleared caches and browsing histories to limit any personalization of the search results.

Since consumers' online information searches are typically limited to initial search results,[47, 48] we limited our sample to the first 20 uniform resource locators (URLs) returned when searching for the aforementioned six search phrases. As there were six interventions in total, the initial dataset consisted of 120 webpages. Based on previous studies on information about health interventions,[41, 43, 49-51] all webpages written in Spanish, which were freely accessible (i.e., they did not have paywalls and/or login requirements) and which provided information on each intervention of interest were considered eligible. The following webpages were excluded: any irrelevant webpages (i.e., the main focus was not the searched-for intervention), webpages only featuring video content, retail sites intended for direct purchase, and advertisements. After excluding six webpages (three irrelevant webpages, one webpage offering only video information and two online shops), a total of 114 webpages were classed as being eligible for analysis.

Webpage typology

We coded the content of the webpage linked to the URL, but not the content provided in the hyperlinks to other webpages. One author (APB) downloaded the webpage texts as individual PDF files, deleting any reference to source or authors, and coded the webpages according to Neunez *et al*.'s typology: commercial (C), news (N), health portal (HP), professional (P), governmental (G), non-profit organisation (NP), scientific journal (SJ) and other (O).[43] For examples of the classification, see reference [52].

Health claims and the certainty of the evidence that supports them

Two authors (MB and GC) coded the health claims relating to each intervention (gastrointestinal health, immune system health, cardiovascular health, cancer, mental disorders, urogenital disorders and other). 'Other' was categorised when the webpage stated the intervention was valuable for general health (i.e., using general phrasing such as "helps maintain health or quality of life", "manages stress", "improves sleep", etc.), skin health (including cosmetic and skin disorders such as eczema and psoriasis) and respiratory disorders. APB coded specific indications within each health claim topic mentioned in the webpages. We also noted when an article on a webpage made a clear

recommendation to consume or avoid the food or supplement and included the advice to consult a healthcare professional.

To identify which health claims were supported by evidence from SRs, we conducted a search of SRs for each intervention in PubMed and the Cochrane Database of Systematic Reviews in December 2021. We did not restrict the search to specific health claims and it was performed after the online health claims were identified. The two authors who identified the SRs (APB and MR) were not involved in coding the health claims made on the webpages. SRs were chosen since they gather and analyse all studies that answer the research question and meet inclusion criteria.[53]

We selected SRs that used systematic methods when searching for and identifying the evidence in two databases and which evaluated certainty of evidence using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach.[54] Briefly, GRADE is a reproducible and transparent methodology widely adopted by organisations such as the World Health Organization and the Cochrane Collaboration for making clinical practice recommendations. It classifies certainty or quality of evidence—that is, the degree of confidence in the results of research on a given outcome of interest (e.g., irritable bowel syndrome, cancer or obesity)—as high, moderate, low or very low, according to factors that include the study methodology, consistency and precision of the results, and directness of the evidence supporting health claims on webpages.[54] Very low means the true effect is probably substantially different from the estimated effect; low means the true effect might be markedly different from the estimated effect; moderate means the true effect is probably close to the estimated effect and high means the true effect is similar to the estimated effect.[54-56] Regarding an intervention effect, favourable effect means the intervention is associated with a beneficial effect on the outcome of interest; no effect means the intervention is associated with little or no difference to the outcome of interest; and uncertain means the certainty for an outcome was not reported, the results were contradictory or effects could not be estimated.[57] The claims about the effect (favourable effect/no effect/uncertain effect) and certainty of evidence (high/moderate/low/very low) were coded by two authors (APB and MR). When more than one SR was obtained, we prioritized the most recent and for two SRs published the same year, we prioritized the Cochrane SR.[56] If certainty of evidence differed across outcomes stated in webpages for the same intervention, overall certainty of evidence was understood as the lowest GRADE classification registered.[56] For search phrases used in the search for SRs in the Cochrane Library and PubMed, see reference [58].

Quality of information

MB and GC separately analysed the quality of online information based on whether it met the following 10 criteria. The selection of said criteria was based on the only available SR of the quality of information on health interventions [59] and two other relevant papers [60, 61]. The criteria used were: 1) provides references or links to scientific publications; 2) explains the conclusions of scientific publications; 3) quantifies relative effects; 4) quantifies absolute effects; 5) acknowledges some research limitations (e.g., preliminary results, small studies, conflicts of interests and differing

results between studies); 6) generally discusses certainty of evidence (e.g., aligning wording depending on whether the studies are observational or experimental);[62] 7) reports potential harms; 8) reports on available alternatives; 9) discusses intervention costs; and 10) does not make arguments based on personal experiences or anecdotes. For each criterion, the story was given a rating of 'satisfactory' or 'unsatisfactory'.

All discrepancies in coding were resolved through discussion with a third author (APB) so that the final concordance was 100%. As there were only two raters rating the same sample, Cohen's kappa was used to calculate inter-rater agreement. Data are reported as kappa and its 95% CI. We considered a kappa of between 0.41 and 0.60 as a 'moderate' agreement, between 0.61 and 0.80 as a 'substantial' agreement and between 0.81 and 1.00 as an 'almost perfect' one.[63]

Statistical analysis

Categorical variables were described by their absolute frequencies and percentages and continuous variables were reported as median and interquartile range (IQR) assuming the data did not fit a normal distribution, which was verified using the Shapiro-Wilk test.

We used Fisher's exact test to compare webpage typologies and the χ^2 test applying a Bonferroni correction to compare portrayals of health claims. We used a non-parametric Kruskal-Wallis test to compare information quality score in different interventions and webpage typologies. Statistical significance was set at $p<0.05$ and the actual p value is reported in the results section for each comparison. Version 3.5.2 of the R software (SPSS Inc., Chicago, IL, USA) and version 4.7.0.0 of the Joinpoint Regression Program were used for all analysis work.

Patient and public involvement

This research was carried out without patient or public involvement in the design of the study, the interpretation of the results, or the writing or editing of this document.

RESULTS

The two primary types of webpages were commercial (23.7%, 27/114) and news webpages (23.7%, 27/114), followed by professional webpages (hospitals, universities and healthcare professionals) (14.0%, 16/114) and health portals (12.3%, 14/114). All other eligible webpage typologies accounted for <10%. Five webpages corresponded to scientific publications relating to fibre (2.6%, 3/114) and prebiotics (1.8%, 2/114).

The certainty of the evidence supporting health claims

All the webpages discussed interventions in relation to at least one health claim. In total, there were 133 different health claims for which probiotics, yoghurt, kefir, kombucha, fibre and prebiotics were portrayed as beneficial (for a complete list, see reference [64]). The most frequently reported reason for eating the food or taking the supplement was to reverse an altered gut microbiome (i.e., 'dysbiosis') secondary to an unbalanced diet

or stressful lifestyle, treatment with antibiotics or disease. The four primary and most widely portrayed health claim topics for all interventions were gastrointestinal health (86.0%, 98/114), vague claims about maintaining or improving health without any reference to a specific condition ('Other') (57.9%, 66/114), cardiovascular health (53.5%, 61/114) and immune system health (i.e., infections, allergies, boosting the immune system) (50.9%, 58/114). The immune system-related health claims for kefir were overrepresented compared to fibre (p=0.008). For fibre, the overrepresentation of health claims related to cardiovascular diseases was higher and statistically significant compared to probiotics (p=0.004) and the overrepresentation of health claims related to cancer was higher and statistically significant compared to probiotics (p=0.009) and prebiotics (p=0.044). The overrepresentation of general health claims ('Other') for kombucha was higher and statistically significant compared to fibre (p=0.002) and prebiotics (p=0.016) (Figure 1).

[Figure 1]

Of the total of 133 health claims, only half (52.6%, 70/133) were supported by evidence from SRs. Probiotics (54.7%, 29/53), yoghurt (42.6%, 20/47) and fibre (37.1%, 13/35) had the highest number of online health claims supported by evidence from SRs. None of the 55 online health claims for kombucha was supported by evidence from SRs (Figure 2).

[Figure 2]

The health claims that appeared on the greatest number of webpages were not necessarily the ones with the highest certainty of evidence (Figure 3). In the context of gastrointestinal health, the highest certainty of evidence was found for the prevention of antibiotic-associated diarrhoea for probiotics and yoghurt (moderate certainty of evidence) and the prevention and treatment of infectious diarrhoea and hepatic encephalopathy for prebiotics (moderate certainty of evidence). The prevention of acute otitis media was the immune system-related health claim supported by moderate evidence for probiotics and yoghurt. Fibre was the intervention with the highest number of online health claims supported by high (reduction of cholesterol and triglyceride levels) to moderate (reduction in obesity, type 2 diabetes, cardiovascular disease mortality, hypertension, coronary heart disease incidence and colorectal cancer incidence) certainty of evidence (for the complete dataset, see reference [64]).

[Figure 3]

Quality of information

After assessing the quality of the online information by applying the 10 criteria as described in the Methods section, we obtained a score of between 0 and 10 for all webpages. Figure 4 displays the median information quality score by intervention and webpage typology. The median quality score by intervention was 3, IQR [2, 4] and was not significantly different across all interventions. Scientific journal webpages had the highest quality score of all typologies, with a significantly higher median than

commercial (p=0.009), health portals (p=0.030), news (p=0.026) and professional webpages (p=0.026).

[Figure 4]

Table 1 shows how quality criteria ranked among all interventions. While 39.5% of all webpages provided references or links to scientific publications, only a minority (18.4%, 21/114) adequately explained the key messages and conclusions of the paper's content.

Table 1. Webpages informing about probiotics, yoghurt, kefir, kombucha, fibre and prebiotics that meet each information quality criterion.

Quality criteria	All webpages (%) n=114	Probiotics (%) n=19	Yoghurt (%) n=17	Kefir (%) n=20	Kombucha (%) n=20	Fibre (%) n=20	Prebiotics (%) n=18
1. Provides references or links to scientific publications	45 (39.5)	11 (57.9)	5 (29.4)	6 (30.0)	5 (25.0)	9 (45.0)	9 (50.0)
2. Explains conclusions of scientific publications	21 (18.4)	5 (26.3)	3 (17.7)	4 (20.0)	2 (10.0)	4 (20.0)	3 (16.7)
3. Quantifies relative effects	9 (7.9)	1 (5.3)	1 (5.9)	2 (10.0)	1 (5.0)	3 (15.0)	2 (11.1)
4. Quantifies absolute effects	2 (1.8)	0	0	0	0	1 (5.0)	1 (5.6)
5. Acknowledges some research limitations	33 (28.9)	8 (42.1)	6 (35.3)	3 (15.0)	3 (15.0)	6 (30.0)	7 (38.9)
6. Generally discusses certainty of evidence	18 (15.8)	5 (5.9)	1 (5.9)	1 (5.0)	4 (20.0)	3 (15.0)	4 (22.2)
7. Reports potential harms	48 (42.1)	5 (26.3)	1 (5.9)	12 (60.0)	13 (65.0)	11 (55.0)	6 (33.3)
8. Reports on available alternatives	49 (43.0)	14 (73.7)	8 (47.1)	7 (35.0)	1 (5.0)	6 (30.0)	13 (72.2)
9. Discusses intervention costs	4 (3.5)	2 (10.5)	1 (5.9)	0	1 (5.0)	0	0
10. Does not argue based on personal experiences or anecdotes	113 (99.1)	18 (94.7)	17 (100.0)	20 (100.0)	18 (90.0)	20 (100.0)	20 (100.0)

Most webpages used verbal descriptions to explain intervention health benefits and did not quantify effects. Only 7.9% (9/114) of webpages quantified relative effects, including the five scientific journal webpages, of which only two included absolute effects.

Overall, only one third of webpages (28.9%, 33/114) stated some of the limitations of research findings. Mentions of limitations included, for example, acknowledging that research that supports health benefits is still in its early stages; stating that the food can improve a condition for a few people in limited circumstances but it cannot be extrapolated to other people due to the small sample studied; addressing conflicts of interest; and highlighting discrepancies between studies that mean the intervention may not be recommended for all indications. Only 15.8% of webpages (18/114) provided a general discussion of the certainty of the evidence supporting an intervention's benefits through consistent words and phrases that depended on whether the studies

were observational (i.e., using cautionary phrases such as 'The results suggest' and conditional verb tenses) or experimental (i.e., using verbs that indicate causality such as 'lead to', 'reduce' or 'increase'). Other means of properly communicating the certainty of the evidence included stating that effects were currently under investigation or more research was needed to consider an intervention in the context of a specific condition. There were webpages, for example, that used a language of uncertainty, mentioning that, "The health benefits of the probiotics and prebiotics that are currently available have not been proven conclusively" or "For now, science does not know which of kefir's components are responsible for its health benefits." A further phrase mentioned how "There is not enough evidence that kombucha tea is as good for your health as some say."

Only 42.1% of webpages mentioned or adequately discussed the potential harms of the intervention. Harms were reported in more than a half of webpages on kombucha (65.0%, 13/20), kefir (60.0%, 12/20) and fibre (55.0%, 11/20), but only in a quarter of webpages on probiotics (26.3%, 5/19). Similarly, less than half of webpages (43.0%, 49/114) reported available alternatives to the main intervention (i.e., in the form of food or food supplements). The reporting of costs only appeared in 3.5% (4/114) of all webpages.

Some commercial (19.3%, 22/114), health portals (9.6%, 11/114), news (7.0%, 8/114) and professional webpages (6.1%, 7/114) included a direct recommendation to consume the food or supplement. Webpages reporting on the potential harms also recommended not consuming the food or supplement under specific circumstances (e.g., avoiding probiotics and kombucha in immunocompromised adults). The recommendation of consulting a healthcare professional was included in a third of all webpages (28.1%, 32/114).

While for the criterion of acknowledging some research limitations the inter-rater agreement was 56% with Cohen's kappa of 0.253 (95% CI: 0.095 to 0.411), for the remaining variables, the inter-rater agreement was higher than 70% with Cohen's kappa of between 0.420 (95% CI: 0.234 to 0.605) and 0.929 (95% CI: 0.849 to 1.008), demonstrating 'moderate' to 'almost perfect' agreement.[63] See reference [52] for inter-rater agreement results.

DISCUSSION

Our study shows that most online health claims for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics are supported by low to very low certainty of evidence. Furthermore, the overall quality of information on the gut microbiome-related interventions studied was low, with a median quality score of 3 on a scale of 0 to 10 for all interventions when applying our 10 quality criteria.

On webpage typology, results were not surprising. The prominent presence of commercial (23.7%) and news (23.7%) webpages in Spanish is in line with previous results on webpage content on probiotics in English.[42, 43] Our findings reflect

companies' interest in therapeutically exploiting the microbiome[42, 43] and the newsworthiness of the topic.[2-4]

Regarding the first objective, both the plethora of beneficial health claims for dietary interventions intended to improve health through the gut microbiome and the weak evidence base supporting such health claims were also expected. All in all, our data add valuable details for better understanding the online information to which audiences are exposed.

First, our research finds that probiotics, fermented foods, fibre and prebiotics might be beneficial for 133 health indications. Similarly, Marcon *et al.* found that American and Canadian general newspapers mentioned up to 138 different health topics for which microbiome-related interventions were portrayed as beneficial.[4] However, very few of those purported benefits are supported by the evidence and integrated into clinical practice. Thus, while fibre has a long history of use in the clinical setting,[17] the degree to which probiotics are recommended to patients by healthcare professionals is variable.[39, 65] Factors explaining why some specialist doctors do not recommend probiotics include the perceived lack of research evidence and poor knowledge regarding use and cost.[66, 67] While uncertainty remains around the optimal use of probiotics,[15] the perception among patients who seek advice from gastroenterologists is that probiotics improve general health, longevity and gastrointestinal symptoms.[68]

Second, we found gastrointestinal health and immune system health-related indications are among the most widely mentioned benefits, which is in line with Neunez *et al.*'s findings for probiotics.[43] However, the concepts of 'boosting gut health' and 'boosting immunity', the latter of which spiked on the internet during the COVID-19 pandemic,[41] are misleading and scientifically inaccurate.[50, 69]

Third, the evidence-based benefit of probiotics and yoghurt for preventing antibiotic-associated diarrhoea that appeared in most webpages is supported by moderate certainty of evidence,[70] while certainty of evidence is low and very low for irritable bowel syndrome[71] and infectious diarrhoea,[72] respectively, both of which appear in a high number of search results. Conversely, although there is moderate certainty of evidence of probiotics' role in preventing mortality and infections secondary to necrotising enterocolitis in very preterm infants or infants with a very low birth weight,[73] that health benefit only appeared in a few of the webpages that discussed probiotics (21.1%, 4/19). When interpreting SRs that perform a meta-analysis of probiotics, it should be acknowledged that their conclusions can be misleading if different strains or combinations of probiotics at different doses are grouped together inappropriately and studies include different patient populations and measure different outcomes.[37, 74] That may cloud any potential signalling of the probiotic for preventing or treating diseases and may contribute to explaining why only 54.7% of probiotic-related health claims are supported by evidence from SRs.[74] The low number of health claims for yoghurt (42.6%, 20/47) and kefir (1.8%, 1/55), supported by evidence from SRs, coincides with our previous findings using the GRADE approach, which showed that consuming probiotics in the form of fermented milks such as yoghurt and kefir may not

be associated with any health benefits, with either low or very low certainty of evidence.[75] None of the health claims for kombucha was supported by evidence from SRs, which is expected due to the lack of controlled human studies investigating the potential health effects of this popular fermented drink.[16, 76]

Fourth, not surprisingly given its common use among healthcare professionals in gastrointestinal disorders,[17] fibre was the intervention with the most health claims supported by high (reduction of cardiovascular disease risk factors)[18] to moderate (protection against colorectal cancer)[77] certainty of evidence. The efficacy of prebiotics for preventing constipation supported by low certainty of evidence[78] appeared in a high proportion of webpages. In contrast, the more widely studied indication of prebiotics for managing hepatic encephalopathy, which showed moderate certainty of evidence,[79] appeared in very few webpages (16.7%, 3/18).

Regarding the second objective, the assessment of information quality carried out using our 10-criteria score shows interesting data on both overall quality and some specific shortcomings.

First, the low quality of online information assessed according to our 10 criteria is not surprising. However, it is even lower than estimated for news reports on health interventions in general, using other indices or scales containing common quality criteria. Thus, in our study, 92.1% of the webpages did not quantify the effects of the intervention, compared to 72% of the news items analysed by Schwitzer;[60] 84.2% did not discuss the certainty of the evidence, compared to 65%; and 96.5% did not report the costs of the intervention, compared to 77%. On two other common criteria, the results were more similar: 57% of the webpages did not report alternatives to the intervention, compared to 62% of the news items analysed by Schwitzer; and 57.9% did not report potential harms, compared to 67%.

The first systematic review of the quality of information on health interventions in traditional media outlets and online resources also found room for improvement as regards health news.[59] However, nutrition-related information is especially prone to poor quality and may contribute to public misconceptions about dietary strategies targeting the gut microbiome and health.[80-84] In our study, retail sites intended for direct purchase and advertisements were excluded from the analysis; nevertheless, a quarter of the analysed webpages were commercial. The regulatory status of commercial information about gut microbiome-related foods and dietary supplements on webpages is not the same as for a pharmaceutical product. In the case of Spain, in spite of current legislation on commercial information related to foods and food supplements,[85-87] misleading food marketing prevails. Regulating digital marketing is not straightforward because of its cross-border nature,[88] but it is critical for making informed decisions about health. Ongoing voluntary implementation measures involving the food industry, communications agencies and advertisers are insufficient in preventing misinformation about popular gut microbiome-related dietary interventions.[89, 90] To allow consumers to make informed food choices, stricter regulation of any probiotics, fermented foods, fibre and prebiotics promoted on websites is required, especially to ensure that the dietary advice to which the public is

exposed is based on evidence that is either convincing or probable.[81] Steering clear of the practice by scientific societies of endorsing prebiotic or probiotic products that have dubious health benefits may also help with avoiding the spread of inaccurate information.[91]

Another way to improve that situation might be to promote critical thinking among the public. In other words, it might be better to treat the effects of the current overabundance of information than to prevent it, since prevention is an almost impossible task, with exaggerated scientific findings and discoveries always attracting those who produce and recirculate information.[59, 92] In that regard, we present our suggested 10 criteria for quality of information, aimed at three different groups. First, healthcare providers as a tool for recommending reliable webpages on gut microbiome-related interventions to their patients; second, journalists and communicators involved in disseminating microbiome research findings; and third, the lay public to guide them every time they face a piece of online information related to the gut microbiome.

Second, the strategy of including scientific references embedded in the text or as a list at the end of text (criterion 1) without explaining the conclusions of the scientific publications (criterion 2) is an example of how the 'health halo effect' around gut health and the microbiome is used to validate certain unproven alternative therapies.[4, 41] In addition, webpages also misrepresent the term 'probiotic', which is inadequately used to refer to kombucha and kefir and as an umbrella for all probiotic supplements, when, in actual fact, not all probiotics are backed by science and not all fermented foods can be considered probiotics.[16, 93] Likewise, many webpages use the term 'dysbiosis' as a reason to promote interventions with the connotation that an 'altered' microbiome in someone with a specific disease is causal or contributory, even though it is not always certain that changing the altered microbiome is beneficial[94] and the definition of a healthy microbiome is not known.[95]

Third, it is also worth noting that the majority of webpages only provide a qualitative description of the health claims without quantifying them (criteria 3 and 4). The few webpages that quantified the effects did so only in relative numbers (7.9%, 9/114), which tend to be more eloquent, are often misleading and can lead to a misguided perception of the reported effects.[94, 96] Only two out of five scientific journal webpages included absolute effects. Indeed, the microbiome field relies too heavily on relative numbers of microorganisms.[94] For instance, one clear example of numerical misinterpretation is the long-assumed ratio, widely disseminated in the media and the scientific literature, that humans have 10 times more microbial cells than body cells.[97]

Fourth, the observation that only a few webpages acknowledged some research limitations (criterion 5) (28.9%, 33/114) and discussed the certainty of the evidence (criterion 6) (15.8%, 18/114) is common when informing on microbiome-related interventions. For instance, social media content rarely makes critical references to microbiome research findings and the only acknowledgments of limitations found are suggestions around the need for more research.[34] Likewise, previous findings show that only 19% of articles in English-language newspapers[4] and less than 10% of webpages portraying immune boosting strategies, including the use of probiotics and

prebiotics,[41] report microbiome-related limitations (e.g., suggesting that the health benefits of and current research on the microbiome might be unproven, ineffective or exaggerated). Probiotics was the intervention with the highest proportion of webpages that provided limitations and comments around the certainty of the evidence, which might be explained by probiotics' status as the most widely studied subject when compared to fermented foods such as kefir and kombucha.[14, 15]

Fifth, only a minority of webpages on probiotics informed of adverse effects (criterion 7) and included advice against consumption by people with severe illnesses or compromised immune systems.[98] Previous analyses of online messages about probiotics also found that descriptions of their benefits outnumbered the descriptions of their risks, and the latter appeared significantly less on commercial webpages.[42, 43] That may be rooted in the lack of safety data in randomized controlled trials for probiotics.[99] Safety issues are also a concern for kombucha, with reports of varying degrees of adverse effects in relation to kombucha tea consumption,[100] while fibre and prebiotics are limited to mild issues such as abdominal discomfort, bloating and gas.[17]

As dietary interventions that target the gut microbiome are usually regulated as foods and dietary supplements and not drugs, none of the health claims promoted on the internet need to be backed up by studies in humans. In addition, what it is actually in a probiotic or dairy product does not necessarily coincide with what it is declared on the label.[101] In the best-case scenario, the product may be ineffective and the only likely harm is to the consumer's wallet. In the worst-case scenario, however, a product can have significant side effects. That is the case with the hepatotoxic effects reported from kombucha intake[100], the increased risk of pre-eclampsia with probiotic administration[102] and the increased risk of mortality in adult patients with acute pancreatitis who receive probiotics.[103] Finally, self-consumption of these kind of foods and supplements as a non-prescribed alternative treatment due to the consumer's unfounded expectations, which outpace the scientific evidence, can lead to a delay in the presentation and resolution of a medical diagnosis and the search for effective treatment.

Our study shows two strengths. First, for the evaluation of online health claims, we relied on systematic reviews and assessments of the degree of certainty of evidence using the GRADE approach, which is a systematic, explicit and transparent methodological framework for grading certainty of evidence.[104, 105] Second, the authors have extensive knowledge of and experience in the fields of nutrition, evidence-based medicine, science journalism and microbiome research communication.

There are also several limitations to this study. First, we used single search phrases to perform the searches. That meant we could not explore differences in results for other search terms, which can vary in the current context of the COVID-19 pandemic. Second, the data set only includes Spanish-language webpages and focuses on the initial search results, although it must be acknowledged that the top 20 search results have a higher chance of being read.[47, 48] Third, we only focused on 10 parameters for assessing quality of information. Fourth, we did not analyse information published on social media

channels, which provide relevant sources for people seeking nutrition advice online. Last, we analysed the certainty of the evidence behind online health claims based only on systematic reviews, which are currently the evidence synthesis tool that offers the highest level of evidence.

CONCLUSION

Online information on probiotics, fermented foods, fibre and prebiotics does not reflect the available body of scientific evidence and is often incomplete and of a poor quality. The observation that the majority of health claims that appeared on the largest number of webpages were not necessarily the ones with the highest certainty of evidence may contribute to distorting the message about the impact of foods on health linked to their effects on the gut microbiome. Furthermore, the fact that research results, the quantification of the effects, limitations and uncertainty of the evidence, and the adverse effects, cost and alternatives of interventions are not usually addressed can distort public perception of the topic. Consequently, online information about the six interventions considered in this study may, in some cases, create a potentially harmful distraction rather than a key element for maintaining health and quality of life.

CONTRIBUTORS

APB and GC designed the research with input from MR and MB. APB, MR, MB and GC performed the research and analysed the data. APB and GC interpreted the data. APB wrote the manuscript. MR, MB and GC were involved in drafting and revising the manuscript. All authors approved the final version to be published and agreed to be accountable for all aspects of the work.

COMPETING INTERESTS

APB works as a health writer for companies commercially involved in the gut microbiota and probiotics. MR, MB and GC have declared no competing interests.

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DATA AVAILABILITY STATEMENT

All data relevant to the study are included in a public, open access repository. The data set is available:
https://figshare.com/articles/journal_contribution/Supplemental_material_1/20203415
https://figshare.com/articles/journal_contribution/Table_S2/19425824
https://figshare.com/articles/journal_contribution/Supplemental_material_3/20204021

https://figshare.com/articles/journal_contribution/Supplemental_material_4/20204270

ETHICS APPROVAL

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Legends of the figures cited within the main text:

Figure 1. Online health claim topics portrayed for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics.

Figure 2. Number of online health claims for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics supported or not by evidence from systematic reviews (SRs).

Figure 3. Effect and certainty of evidence in systematic reviews supporting online health claims for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics.

Figure 4. Information quality score by intervention (A) and webpage typology (B). Data are reported as median and interquartile range. C, commercial; HP, health portal; N, news; NP, non-profit organisation; P, professional; SJ, scientific journal; G, governmental; O, other. *p<0.05 vs scientific journals according to a Kruskal-Wallis test.

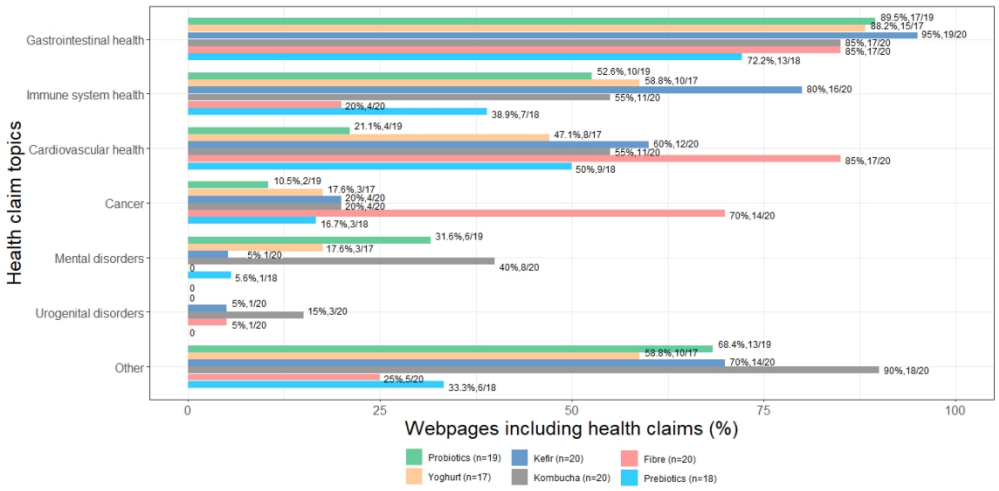

Figure 1. Online health claim topics portrayed for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics.

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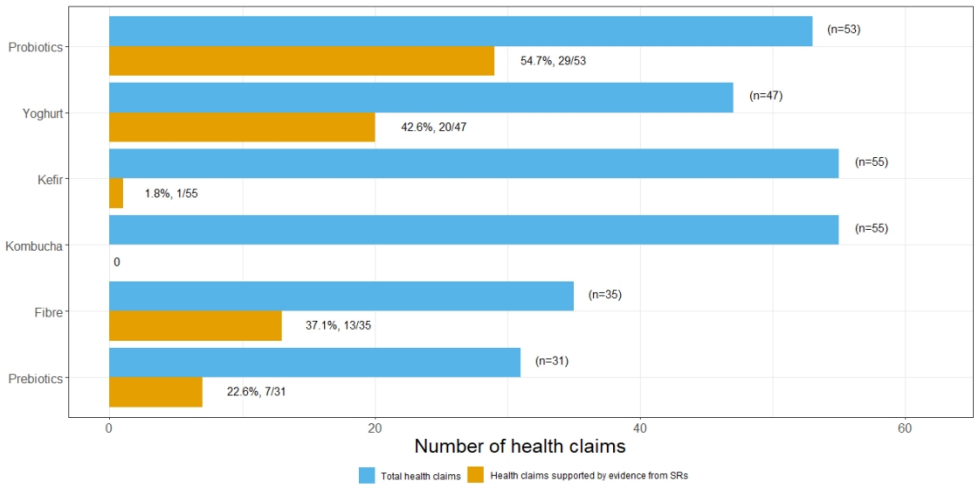

Figure 2. Number of online health claims for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics supported or not by evidence from systematic reviews (SRs).

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Topic	Health claim	# webs	Effect*	Certainty*
Probiotics[a]				
Gastro	Antibiotic-assoc. diarrhoea	15	+	Moderate
Gastro	Irritable bowel syndrome	13	0	Low
Gastro	Infectious diarrhoea	11	?	Very low
Gastro	Ulcerative colitis	8	?	Very low
Gastro	Constipation[b]	7	+	Low
Gastro	Crohn's disease	5	0	Very low
Gastro	Abdominal distension	4	0	Low
Gastro	Necrotising enterocolitis	4	+	Moderate
Gastro	Infantile colic	3	+	Low
Gastro	Pouchitis	3	?	Very low
Gastro	Non-alcoholic fatty liver	2	?	Very low
Gastro	Tooth decay	2	+	Low
Gastro	Periodontal disease	2	?	Very low
Gastro	*C. difficile* diarrhoea	1	+	Low
Gastro	Hepatic encephalopathy	1	+	Low
Immune	Allergies	7	0	Very low
Immune	Vulvovaginal candidiasis	7	+	Very low
Immune	Urinary tract infections	6	0	Low
Immune	Otitis	3	+	Moderate
Cardio	Obesity	2	0	Very low
Cardio	Hypertension	2	+	Very low
Cardio	Gestational diabetes	1	0	Low
Mental	Anxiety	4	?	Very low
Mental	Depression	3	?	Very low
Other	Eczema	5	?	Very low
Other	Upper respir. infections	6	+	Very low
Other	Stress	2	0	Very low
Other	Asthma	1	0	Very low
Other	Mastitis	1	?	Low
Prebiotics				
Gastro	Constipation[b]	11	+	Low
Gastro	Infectious diarrhoea	6	+	Moderate
Gastro	Hepatic encephalopathy	3	+	Moderate
Gastro	Non-alcoholic fatty liver	2	?	Very low
Gastro	Radiotherapy diarrhoea	1	?	Uncertain
Immune	Allergies	1	0	Very low
Other	Eczema	1	0	Uncertain

Topic	Health claim	# webs	Effect*	Certainty*
Yoghurt[a]				
Gastro	Infectious diarrhoea	6	?	Very low
Gastro	Constipation[b]	5	+	Low
Gastro	Antibiotic-assoc. diarrhoea	4	+	Moderate
Gastro	Irritable bowel syndrome	3	0	Low
Gastro	Abdominal distension	2	0	Low
Gastro	Ulcerative colitis	1	?	Very low
Gastro	Crohn's disease	1	0	Very low
Gastro	Necrotising enterocolitis	1	+	Moderate
Immune	Otitis	3	+	Moderate
Immune	Allergies	1	0	Very low
Cardio	Obesity	6	0	Very low
Cardio	Hypertension	2	+	Very low
Mental	Anxiety	2	?	Very low
Mental	Depression	2	?	Very low
Mental	Alzheimer's disease	1	0	Very low
Other	Stress	1	0	Very low
Other	Abdominal pain	1	0	Low
Other	Upper respir. infections	1	+	Very low
Other	Cystic fibrosis	1	0	Low
Other	Reduction blood urea	1	+	Very low
Kefir				
Gastro	Ulcerative colitis	3	?	Very low
Fibre				
Gastro	Constipation	17	+	Low
Gastro	Ulcerative colitis	1	?	Very low
Gastro	Crohn's disease	1	?	Very low
Cardio	Cholesterol reduction	17	+	High
Cardio	Glycaemic control	17	+	Low
Cardio	Obesity	15	+	Moderate
Cardio	Type 2 diabetes	5	+	Moderate
Cardio	Cardiovascular mortality	3	+	Moderate
Cardio	Triglyceride reduction	3	+	High
Cardio	Hypertension	2	+	Moderate
Cardio	Coronary heart disease	1	+	Moderate
Cancer	Colorectal cancer	12	+	Moderate
Other	Anti-inflammatory	2	+	Moderate

*Derived from conclusions of systematic reviews. +, favourable effect; 0, no effect; ?, uncertain effect.

[a]Probiotics in the form of foods (fermented milks containing probiotic bacteria) and supplements were analysed together in the SRs consulted.

[b]Outcomes reported by probiotics combined with lactulose.

Figure 3. Effect and certainty of evidence in systematic reviews supporting online health claims for probiotics, yoghurt, kefir, kombucha, fibre and prebiotics.

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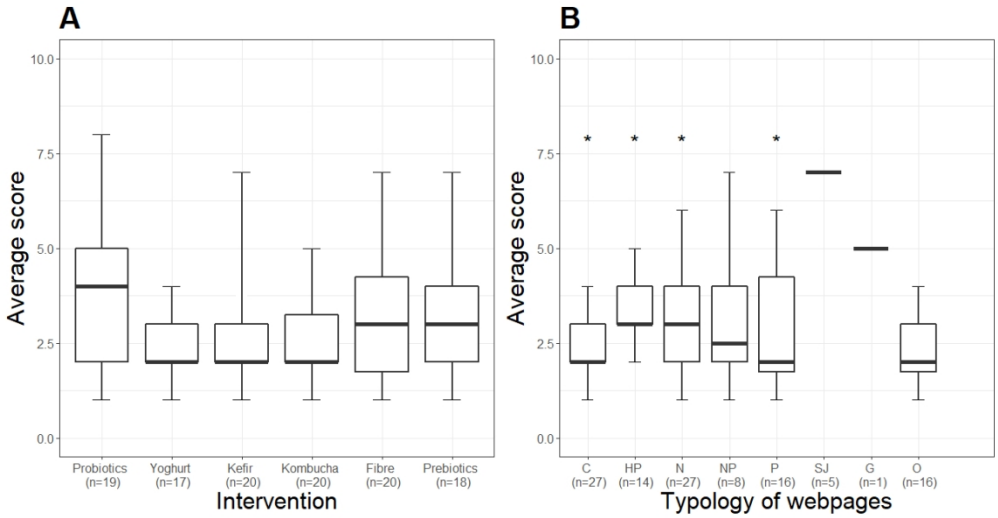

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