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INFORMING CONSUMERS: A BIBLIOMETRIC AND THEMATIC ANALYSIS OF PACK NUTRITION LABELLING

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ABSTRACT

Aim/Purpose	The focus on human well-being has attracted the attention of consumers, organizations, and marketers to understand the various facets of Front of Pack Nutrition Labelling (FOPNL). This study examines the overall research trends in the FPONL domain and identifies the new research areas.
Background	FOPNL is becoming increasingly popular and its influence has been widely examined. Different label schemes have been introduced across different regions in the world. Nevertheless, such interventions are limited in developing economies.
Methodology	This study uses bibliometric analysis methods to explore Front of Pack Nutrition Labelling (FOPNL) trends using 602 articles published in selected business journals.
Contribution	The paper identifies the new FOPNL research avenues. The study indicates that FOPNL has become a crucial research area, and more research is needed at the organization, managerial, and policy levels.
Findings	The study identifies four themes. The first theme identified is the effect of harmful nutrients on health and the role of FOPNL nutrition in changing eating habits. The second theme focused on the government's policy and implementation of FOPNL nutrition labeling regulations. The third theme is dedicated to the work on attention, perception, understanding, and influence of multiple traffic light schemes. The fourth theme relates to the Health Star Rating, Nutri

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	Score, and Healthier Choice FOPNL nutrition labeling schemes. Overall, the paper informs consumers, manufacturers, and regulators about the recent trends in the FOPNL research.
Recommendations for Researchers	Though FOPNL has been widely examined in the health and nutrition domain, however, limited research has been done in the marketing domain. Research using neuroscientific methods (e.g. eye tracking) should provide more robust findings.
Future Research	There is limited research on FOPNL from emerging economies. Future research can examine how FOPNL may influence people, policy, and private entities.
Keywords	bibliometric analysis, network analysis, thematic analysis, front of pack nutrition labelling (FOPNL), keyword analysis, nutri score

INTRODUCTION

The increased regulation and interest in human well-being have made the academic community highly interested in researching various aspects of Front-of-Pack Nutrition Labelling (FOPNL). FOPNL provides standard, precise information on the nutritional content of packaged food and drinks. FOPNL can be defined as "nutrition information in the principal field of vision on food and drinks packaging that: a) either repeats some or all of the numerical information from the mandatory nutrition declaration in a neutral or an evaluative way; or b) expresses the overall nutritional value of a food, by using some or all of the information from the nutrition declaration and/or other nutritional elements, to be applied on all products or only on products complying with certain nutritional criteria" (Storcksdieck Genannt Bonsmann et al., 2020, p. 18). Proper labeling is likely to inform and persuade consumers, and enable them to choose healthier food options (Feunekes et al., 2008; Jáuregui et al., 2020). Moreover, this can positively change food demand and supply for more nutritious foods (Santos et al., 2020; Zhu et al., 2019) and motivate manufacturers to consider product reformulation (Lowery et al., 2020; Reyes et al., 2020). The World Health Organization (WHO) has been appealing to governments and regulators to promote healthier food choices by introducing effective FOPNL policies across countries (WHO, 2020). The use of nutrition labels is mandatory across many Latin American countries and the Western world (e.g., Ecuador, Chile, Norway, Denmark, Singapore, etc.). In contrast, many other countries follow similar voluntary schemes (e.g., the European Union, Mexico, Australia, etc.) (Kanter et al., 2018). Moreover, the surge in Non-Communicable Diseases (NCDs) arising from increased consumption of cheap and energy-dense nutrient-poor foods leads to additional pressure (Egnell et al., 2019; Jones et al., 2019). There is an increasing push from regulators, doctors, activists, and the public to influence the government and industry bodies to introduce and mandate FOPNL regulations across geographies. Many regions have developed various FOPNL systems based on local socio-demographic profiles. These systems have been designed based on consumer education, general awareness, and health and nutrition literacy of the population at large (Borgmeier & Westenhoefer, 2009). These FOPNL can broadly be categorized into three schema types: Multiple Traffic Light System, Guideline Daily Amounts (GDAs), or health endorsing symbols such as 'Healthy,' 'Choices,' 'Low Calorie' logos (Hersey et al., 2013). Nevertheless, lately, there has been some emphasis on the standardization of these labels globally (Goiana-da-Silva et al., 2019).

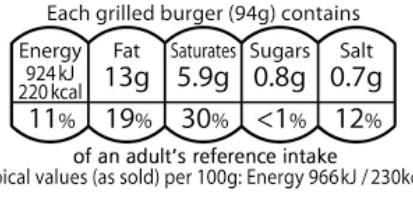
Front-of-pack nutrition labeling has gained enormous research interest in recent years. Most of the research examining FOPNL has been primarily published in health and medicine-related journals by doctors, health researchers, and representatives of various regulatory bodies. Lately, there has been some research interest in this area from other disciplines, such as marketing. The FOPNL research has focused on the efficacy of a particular labeling system in comparison to others (Ares et al., 2018;

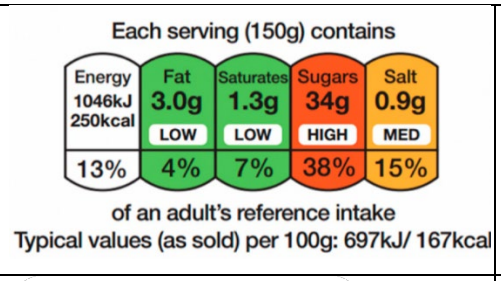
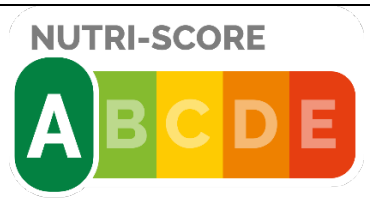
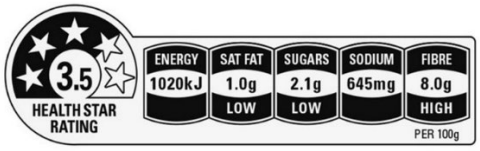
Arrúa, Curutchet, et al., 2017; Findling et al., 2018), consumer attention and usage of FOPNL (Bialkova et al., 2013; Van Herpen & Van Trijp, 2011), and effect of FOPNL on consumer choice of healthier alternatives (Elshiewy & Boztug, 2018; Ikonen et al., 2020). Previous review and meta-analysis studies in the field have examined the effectiveness of interpretive front-of-pack nutritional labels (Feteira-Santos et al., 2020), consumer response to FOPNL (Grunert & Wills, 2007; Ikonen et al., 2020; Temple & Fraser, 2014) and its effect on purchase (An et al., 2021; Croker et al., 2020), role in preventing obesity (Lagerros & Rössner, 2013; Storcksdieck Genannt Bonsmann & Wills, 2012), the methodological quality of FOPNL research (Vyth et al., 2012). Nevertheless, most of these review studies are limited in their scope or have other limitations. For example, a recent narrative review study on FOPNL (Temple, 2020) had limited article coverage with no specific paper selection criteria. The authors themselves acknowledge limitations that "the literature search was less rigorous than a systematic review…It is quite possible some relevant studies were missed." (Temple, 2020, p. 5). Moreover, no review or bibliometric studies systematically assimilate the comprehensive research across the domain. Given the increasing importance of FOPNL nutrition labeling globally, we conduct a detailed bibliometric and thematic review of the literature published in this domain. The objectives of this bibliometric study are threefold. First, it examines the overall research trends in the field of FOPNL (i.e., we examine the number and performance of contributions made by the academic community). Second, it identifies and explores various research themes which have evolved over the years in this domain. Third, we examine the recent hotspots and the gaps in the literature. This paper aims to appraise three key stakeholders – Consumers, Manufactures, and Regulators – on the recent trends in FOPNL across the globe. The study would inform consumers of the importance of nutrition labels and the role they play in choosing healthier food items. For manufacturers, the paper acts as a relevant source to understand consumer usage of FOPNL, and both mandatory or voluntary labeling policies across countries. The bibliometric study should help regulators understand recent trends in FOPNL and change or recommend policies that are likely to benefit various stakeholders at large. Moreover, it also acts as a guide to researchers/scholars by providing a set of research issues, gaps, and directions, that may impact and contribute to this field of research.

LITERATURE REVIEW

Nutrition labels are essential in informing consumers about nutrient composition and aiding them in choosing healthier food options at the point of purchase. Although detailed back-of-pack nutrition labels have been present for many decades, front-of-pack nutrition labels started gaining prominence in the early 2000s (Grunert & Wills, 2007). Over the last two decades, various FOPNL formats have been developed by several public institutions, Non-Governmental Organizations (NGOs), and the private sector, either independently or collaboratively. These FOPNL formats can be divided into five broad categories: Reference intake schemes, color-coded schemes, overall rating schemes, endorsement or positive logo schemes, and warning signs (Storcksdieck Genannt Bonsmann et al., 2020). Table 1 contains examples of popular FOPNL developed in the past across each of these 5 broad categories.

Table 1: Example of FOPNL across each of the 5 broad categories

Scheme Type	Label Name	Label Example	Major Countries
Reference intake schemes	Daily Intake Guide		European Union

Color-coded schemes	Multiple Traffic Lights*		United Kingdom
	Nutri-Score		France, Belgium (Spain, Germany, the Netherlands Luxembourg)
Overall rating schemes	Health Star Rating System		Australia and New Zealand
Endorsement or positive logo Schemes	Healthy Choice		Czech Republic, Poland
	Keyhole		Norway and Sweden
Warning signs	Warning Label		Mexico and the United States

*Multiple Traffic Lights are a hybrid of reference intake and color-coded schemes.

Many FOPNL studies have focused on consumer knowledge, attitudes, behavior, effectiveness, and usage of such labels. The literature reveals that education level (Moore et al., 2018), family size (Basarir & Sherif, 2012), age (Cannoosamy et al., 2014), and shopping for children (Talati et al., 2019) are positively associated with label use. Studies show that many consumers do not use the nutrition label

information as they are disinterested, find it time-consuming, non-credible, or unable to interpret it (De la Cruz-Góngora et al., 2017; Vijaykumar et al., 2013). Few studies have examined industry responses to compliance with label policies. The studies report mixed results from the industry. At the same time, some support the mandatory use of labels on the pretext of increasing obesity (Barquera et al., 2013); primarily, industry bodies lobby against such regulations (Van Camp et al., 2012). For example, it is reported that in the European Union, the food industry spent more than 1.5 billion lobbying against the adoption of traffic-light FOPNL in the region, with even stronger opposition for red light suggestions on foods high on anything specific (Brownell & Koplan, 2011).

Scant literature examines the response to voluntary nutrition labeling initiated by the industry. A study in Singapore reports that voluntary use of the nutrition labeling logo 'Healthier Choices' increased annual sales by 5 percent and was present across 75 product categories (Vijaykumar et al., 2013). FOPNL studies have used varied methodologies to examine underlying research questions. Typical methods include self-reported questionnaire-based surveys, focus groups (Correa et al., 2019; Machín et al., 2018), and objectively measured behavior with the help of technologies such as eye-tracking, MRI, etc. (Tórtora et al., 2019; Varela et al., 2014). Findings suggest that consumers overestimated their use of FOPNL nutrition information in self-reported viewing as compared to objectively measured viewing (Graham & Jeffery, 2011; Tórtora et al., 2019).

In 2018, a Cochrane review assessed 'the impact of nutritional labeling for food and non-alcoholic drinks on purchasing and consumption of healthier items' (Crockett et al., 2018, pp. 1). The review was based on six independent experimental studies, which examined the impact of labeling on the consumption of pre-packaged foods. This evidence suggests that FOPNL encourages healthier purchasing. Mandle et al. (2015), in their narrative review study, examined peer-reviewed literature published on consumers' usage and attitudes towards nutrition labels and the food industry's response to labeling regulations from countries other than North America, Europe, and Australia. The authors suggested that more research is needed to understand the use of FOPNLs across different consumer demographics. The authors also reported that limited studies used methods such as in-store observation, which are necessary to understand the actual use of FOPNLs better. Croker et al. (2020) conducted a systematic review and meta-analysis of studies published after the Cochrane review and examined the impact of FOPNL on consumer purchase and consumption behavior. Based on 14 studies included in the meta-analysis, authors found that sodium and sugar content on product purchases made with FOPNL present was significantly less than without the FOPNL label. Overall, the authors found evidence supporting FOPNL's impact on promoting healthier purchasing and improving the population's diet. In a recent systematic review, An et al. (2021) analyzed studies examining the effect of FOPNL on food purchases. Based on the fifteen studies included in the review, the authors conclude that FOPNL had a mixed impact on motivating consumers to choose healthier products. The authors suggested that the mere presence of FOPNL on food items may not necessarily encourage consumers to include it in their shopping carts, as many other factors such as price, brand name, etc., jointly impact the purchase decision. Though the existing review studies access and summarize the scholarly work to a great extent, a detailed bibliometric analysis can provide a more comprehensive overview of knowledge published in the FOPNL research and bring forth other exciting insights. In the next section, we discuss the importance of bibliometric analysis and the methods used to conduct it. Subsequently, we present the findings and relevant implications.

METHODS

BIBLIOMETRIC ANALYSIS

Bibliometric analysis is a scientific and computer-assisted method of reviewing literature by identifying core research areas, authors, author affiliations, countries, etc., and uncovering their relationship with each other by analyzing publications related to a given topic or field. Overall, it generates a meaningful overview of the literature, aids in recognizing relevant contributions, and identifies

knowledge gaps. Thus, it helps decipher and map the evolving scientific knowledge by analyzing large volumes of research publication data (bibliometric records) in rigorous ways (Allen et al., 2009; Regolini & Jannès-Ober, 2013).

As part of this bibliometric study, we conducted performance and scientific analysis to understand the research trends in FOPNL. The performance analysis focused on the *contributions* of the research entities (i.e., publication and citation-related metrics) (Donthu et al., 2021). In contrast, the scientific study focused on the *relationship* between research entities (i.e., co-citation analysis, co-word analysis, co-author and co-country analysis, etc.). Furthermore, we performed a thematic analysis based on the domain's most common themes and topics (Hassan Shah et al., 2022).

Data Identification and Extraction

The necessary data was downloaded from the SCOPUS database during the second week of October 2021. We chose the SCOPUS database across several available databases (e.g., Web of Science, Google Scholar, etc.) as it provides the most comprehensive coverage of multi-disciplinary peer-review literature (Caviggioli & Ughetto, 2019; Khanra et al., 2020). As the area of interest for this study was specific to the FOPNL, the inclusion criteria considered various keywords that represent papers in this area of research. Thus, articles containing the words 'front-of-pack' or 'front-of-pack' and 'nutrition' in their title, abstract, or keywords were identified by us. The SCOPUS database returned 851 results (including both articles and review papers), out of which 43 results were duplicates. The authors manually screened all the titles and abstracts to ensure all the remaining articles belonged to the area of interest (i.e., they were primarily focused on front-of-pack nutrition labeling) as per the inclusion criteria. In total, 206 articles were found to be irrelevant and were removed from the final database. Many of these documents focused on topics such as 'back of pack' labels, packaging quality, or the term front-of-pack was not used concerning packaged food or drink, etc. The final database resulted in 602 documents. Figure 1 describes the inclusion criteria and the process for selecting relevant articles. The characteristics of the final database used for the bibliometric analysis are summarized in Table 2.

The analysis was done in various stages. First, we examined the overall research productivity and prominent authors (e.g., year of publication, total citations, top authors, etc.), reviewed countries publishing in this domain and their collaborations, and finally analyzed key themes, terms, and the associated relationships.

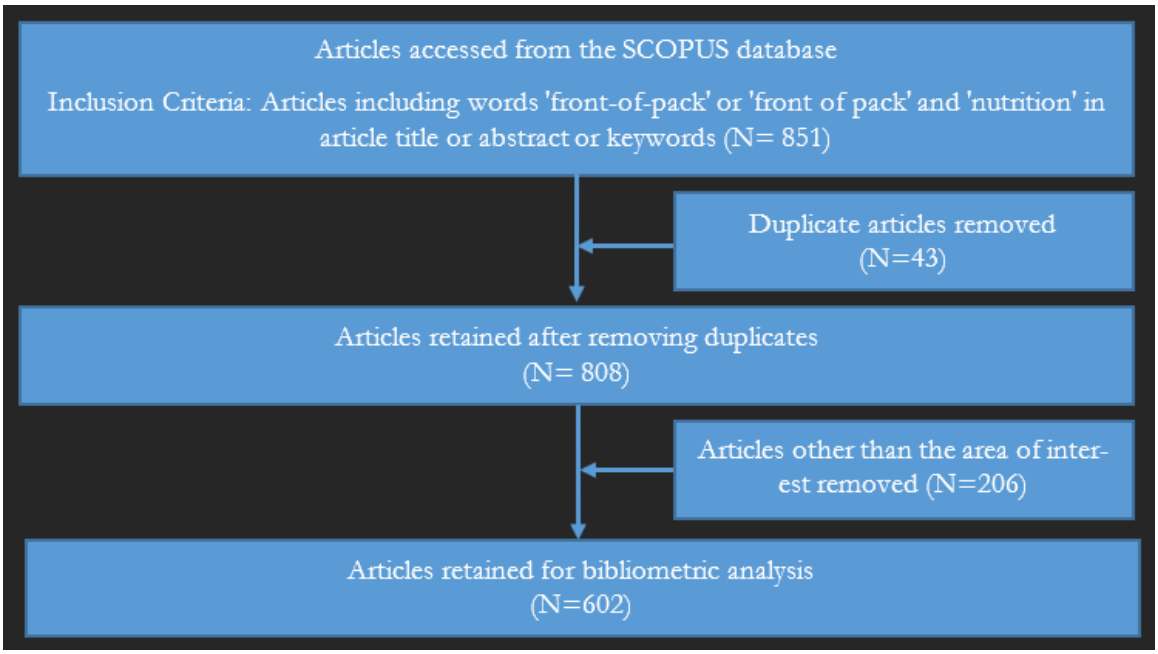


Figure 1: Process followed for Selecting Relevant Articles

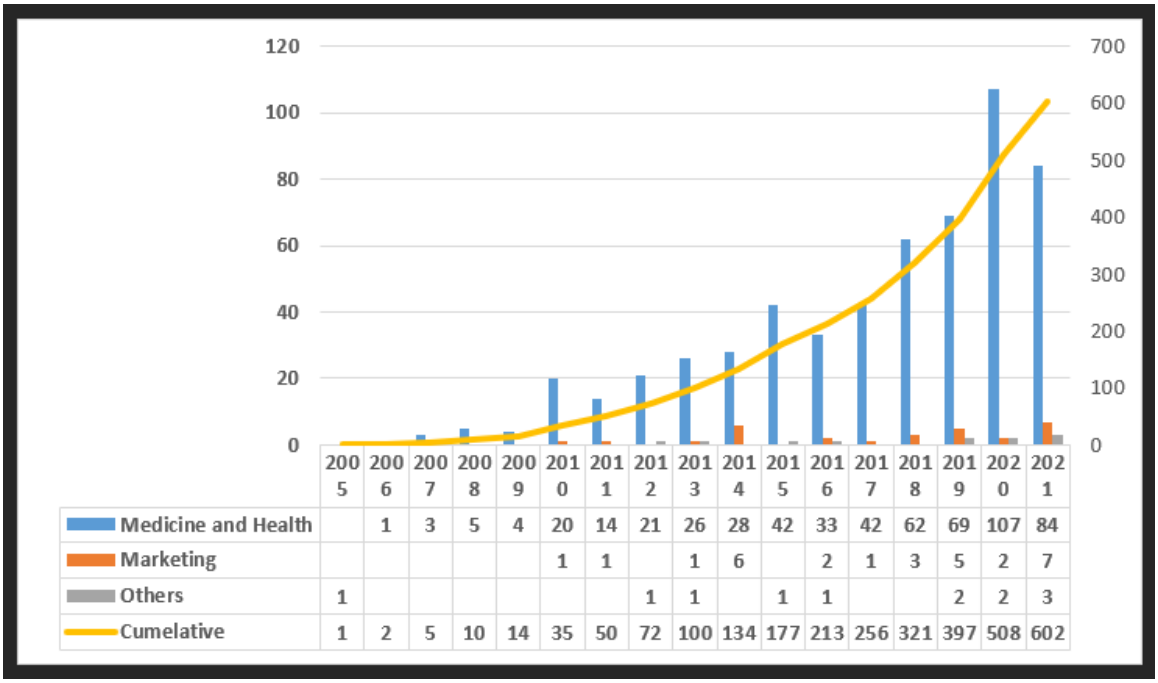
Table 2: Basic Characteristics of Data Collected

Field	**Details**
Timespan	2005:2021 (September 2021)
Sources (Journals etc.)	181
Documents	602
Average years from publication	3.81
Average citations per document	23.2
Average citations per year per doc	3.987
References	24073
Countries	58
DOCUMENT TYPES	
Article	540
Conference paper	11
Review	51
DOCUMENT CONTENTS	
Keywords Plus (ID)	1711
Author's Keywords (DE)	1091
AUTHORS	
Authors	1747
Author Appearances	3087
Authors of single-authored documents	29
Authors of multi-authored documents	1718
AUTHORS COLLABORATION	
Single-authored documents	34
Authors per Document	2.9
Co-Authors per Documents	5.13
Collaboration Index	3.02

RESULTS AND DISCUSSION

EMERGENCE AND GROWTH OF FOPNL RESEARCH

The initial use of FOPNL dates a few years before the first publication is included in the database. Although very trivial, FOPNL was used for the first time as a Warning Label in Finland on foods (Storcksdieck Genannt Bonsmann et al., 2020). In the mid-2000s, countries like Singapore, Netherlands, Belgium, Poland, etc., started introducing FOPNL programs. Our bibliometric database identified the first mainstream study on FOPNL in 2005 (Williams, 2005). However, the analysis reveals that research on nutrition-based FOPNL gained increased research interest in 2010 (Refer to Figure 2). The cumulative average growth rate (CAGR) from the year 2010 (Number of cumulative publications = 35) to 2020 (Number of cumulative publications = 508) was more than 30 percent. Moreover, based on the number of studies published in the later years, it is evident that the scholarly interest in this domain has increased exponentially in recent years (e.g., in 2018, 34 percent more studies were published as compared to the previous year). Thus, it is apparent that FOPNL is an emerging research domain, and the research interest is likely to increase further over the years. Moreover, as an increasing number of countries have either recently introduced or plan to introduce front-of-pack nutrition label policies in the coming years, there is expected to be increased inquiry by both academia and practitioners (Mazzù et al., 2021).



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Medicine and Health		1	3	5	4	20	14	21	26	28	42	33	42	62	69	107	84
Marketing						1	1		1	6		2	1	3	5	2	7
Others	1							1	1		1	1			2	2	3
Cumelative	1	2	5	10	14	35	50	72	100	134	177	213	256	321	397	508	602

Figure 2: Number of publications on FOPNL

PROMINENT JOURNALS

Journal-specific analysis reveals that 12.8 percent (77 articles) were published in the journal *Nutrients,* published by MDPI based out of Switzerland (Refer to Table 3). The second most productive journal was *Public Health Nutrition*, with 8.8 percent (53 articles). Out of the top 10 most productive journals, Elsevier (4 journals) and BioMed Central (2 journals) were the most prominent publishers. Out of the top 10 journals in which FOPNL research is published, four journals had a CiteScore of more than 5, with *the International Journal of Behavioural Nutrition and Physical Activity* having the highest cite score of 6.3. The metric CiteScore was developed by Elsevier-Scoups and is an alternative to Clariant

Analytic's (formerly Web of Science) Impact Factor metric (da Silva, 2020). CiteScore measures the journal impact based on citation data from the Scopus database.

Interestingly, *Nutrients* also had the highest Average Publication Year (APY). APY is calculated by summing the article publication year and dividing it by the total articles published in a particular journal, thus reflecting the journal's productivity of recent publications (Van Eck & Waltman, 2011). The software VOS Viewer provides this metric as part of its default reports.

Moreover, most research in FOPNL has been published in health and medicine-related journals (Number of journals = 162, 89.5%; Number of articles = 561, 93.1%), while marketing and other domains together have shown growing interest (Number of journals =29, 10.5%; Number of articles =41, 6.8%) in the recent years. Some of the marketing journals that published FOPNL research included the *Journal of Public Policy and Marketing* (Articles = 4), *Journal of Academy of Marketing Science* (Articles = 4), *Journal of Food Products Marketing* (Articles = 3), *Journal of Consumer Affairs* (Articles = 3), and *International Journal of Consumer Studies* (Articles = 3) among others. Overall, we found that the research on FOPL was relatively a niche area but should become more extensive as participation increases.

Table 3: Top Journals Publishing FOPNL Research

Journal	**Number of Articles**	**Average Number of Citation**	**Average Publication Year (APY)**	**Scopus Journal Rank (SJR)**	**Cite Score**	**Publisher**	**Country**
Nutrients	77	12.1	2019.3	1.42	5.43	MD	Switzerland
Public Health Nutrition	53	25.4	2016.6	1.17	3.34	Cambridge University Press	United Kingdom
Appetite	41	46.9	2016.6	1.13	3.67	Academic Press	United States
Food Quality and Preference	25	29.0	2017.8	1.14	5.43	Elsevier	United Kingdom
Food Policy	16	24.4	2017.0	2.09	4.54	Elsevier	United Kingdom
International Journal of Behavioral Nutrition and Physical Activity	15	31.5	2017.7	2.65	5.94	BioMed Central	United Kingdom
BMC Public Health	14	26.9	2016.8	1.23	3.18	BioMed Central	United Kingdom
Food Research International	14	34.9	2017.7	1.48	6.3	Elsevier	United Kingdom
Journal of Nutrition Education and Behavior	12	16.3	2016.3	0.84	2.19	Elsevier	United States

Journal	Number of Articles	Average Number of Citation	Average Publication Year (APY)	Scopus Journal Rank (SJR)	Cite Score	Publisher	Country
PLoS ONE	11	16.4	2017.3	0.99	3.04	Public Library of Science	United States

Citations Analysis

Publication impact is usually determined by the number of times a publication is cited. Thus, citation analysis helps in identifying the most influential research in a particular field (Appio et al., 2014). In our database, the most cited article (Grunert & Wills, 2007) (Citations = 680) was published in the *Journal of Public Health* in 2007. The article reviewed European studies examining consumer responses to nutrition information presented on food labels. The second most cited article (Popkin & Hawkes, 2016) published in *The Lancet Diabetes and Endocrinology* journal was comparatively more recent, with 343 citations at the time of this analysis. The article examined the trend of sales of sugar-sweetened beverages in North America, Latin America, Australasia, and Europe and its possible effect on health. The article also discussed the role and challenges faced by the government and policymakers in implementing FOPNL regulations. Figure 3 shows an overlay network visualization map of all the papers with more than 50 citations (N=61). It can be observed that articles such as Kanter et al. (2018) (Citation = 111), Egnell, Ducrot et al. (2018) (Citations =82), and Ikonen et al. (2020) (Citations =53), among others, have amassed more than 50 citations in a short period.

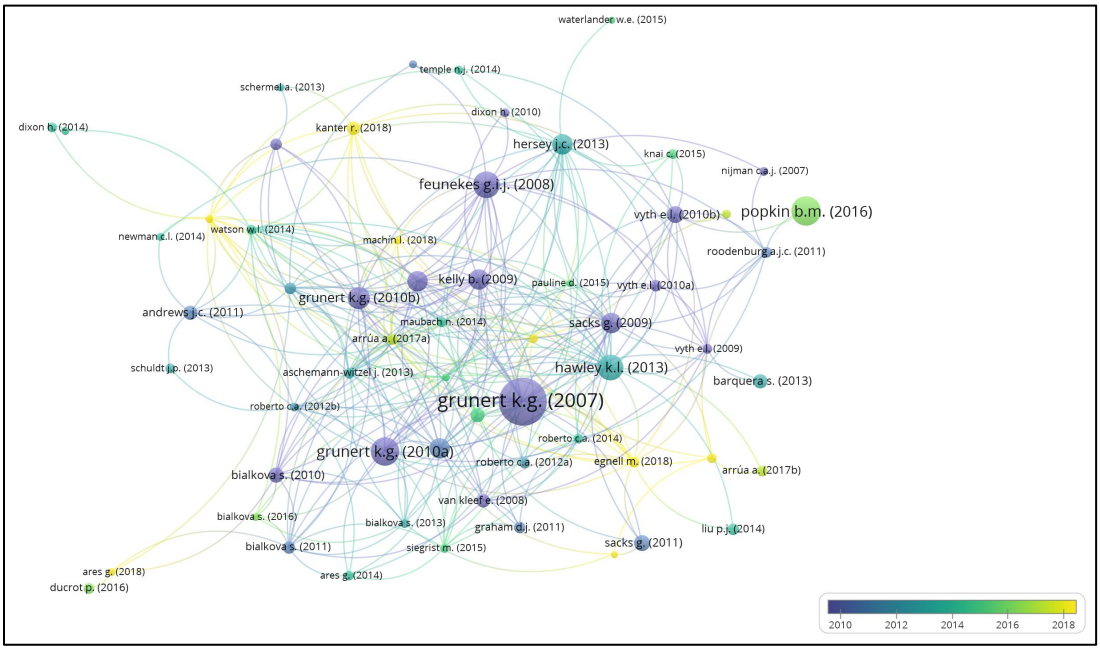


Figure 3: Most Cited Papers Overlay Visualization Network

Co-authorship and International Collaboration

Co-authorship analysis examines formal intellectual collaboration among scholars (Cisneros et al., 2018). It is well-recognized that collaborations among scholars can improve research quality and provide better insights (Tahamtan et al., 2016). Our analysis revealed 1747 authors for the 602 articles in the database. A network graph was created to visualize and examine the co-authorships. As it was not pragmatic to plot the network with so many authors (items), a network consisting of authors with 5 or more publications was created (Donthu et al., 2021). Overall, 93 authors met the criteria. To arrive at fair linkage values (link strength), the fractional counting method was used. As fractional counting reduces the influence of documents with authors from several countries, it was more appropriate for our analysis (Zanotto et al., 2016). In terms of publication productivity, Serge Hercberg from the University Sorbonne Paris Nord, France had authored the maximum number of publications (N=48) with 935 citations. The second, fourth, and seventh most productive authors were also affiliated with the University Sorbonne Paris Nord, France. The other authors featured in the top 10 were affiliated with institutions in Uruguay, and the United Kingdom (Refer to Table 4).

The network structure (Refer to Figure 4) revealed attractive co-authorship clusters. Most productive authors acted as anchors and co-authored publications with many authors within and between neighboring clusters. For example, though Bruce Charles Neal from Imperial College London, United Kingdom had authored only 22 articles, his collaboration across clusters was evident. Similarly, Mike Rayner (Yellow Cluster) from The University of Oxford, United Kingdom, collaborated with 20 other authors while publishing 12 articles in this area. The co-authorship network visualization provides many interesting insights and a clear view of the authors' authorship network.

Nevertheless, it is important to note that most of the top researchers in the domain of FOPNL share the same affiliation, specifically the University Sorbonne Paris Nord, France, which may influence the very sacrosanct nature of academic research. For example, Nutri-Score – the official label in France and many other European countries – has been challenged for its legitimacy, due to both technical and political reasons (Fialon et al., 2022). Thus, the top contributors to this area must become more diverse in the future.

Table 4: Top 10 Authors

S/N	Author's Name	Number of Publications	Total Citations	Cluster Membership	Links	Total Link Strength	Normalized Link Strength	Primary Affiliation
1	Serge Hercberg	48	935	Green	21	48	19.5	University Sorbonne Paris Nord, France
2	Chantal Julia	46	831	Green	22	45	18.1	University Sorbonne Paris Nord, France
3	Ares Gastón	42	946	Blue	12	40	22.5	University of the Republic, Montevideo, Uruguay
4	Touvier Mathilde	30	616	Green	17	30	20.5	University Sorbonne Paris Nord, France

S/N	Author's Name	Number of Publications	Total Citations	Cluster Membership	Links	Total Link Strength	Normalized Link Strength	Primary Affiliation
5	Pettigrew Simone	26	504	Purple	22	26	19.4	George Institute of Global Health, Australia
6	*EMMANUELLE* Kesse-Guyot	25	607	Green	15	25	24.3	University Sorbonne Paris Nord, France
7	Manon Egnell	24	314	Green	18	24	13.1	University Sorbonne Paris Nord, France
8	Ana María Giménez	23	750	Blue	10	23	32.6	Universidad de la República Facultad de Química, Uruguay
9	Mariá Rosa Curutchet	22	549	Blue	10	22	24.9	Ministerio de Desarrollo Social, Uruguay
10	Bruce Charles Neal	22	479	Red	19	20	21.8	Imperial College London, London

Note: *Links attribute indicates the number of co-authorship links of a given researcher with other researchers. The Total link strength attribute indicates the total strength of the co-authorship links of a given researcher with other researchers. Normalized link strength uses the association strength method to arrive at the link strength (Eck & Waltman, 2009).*

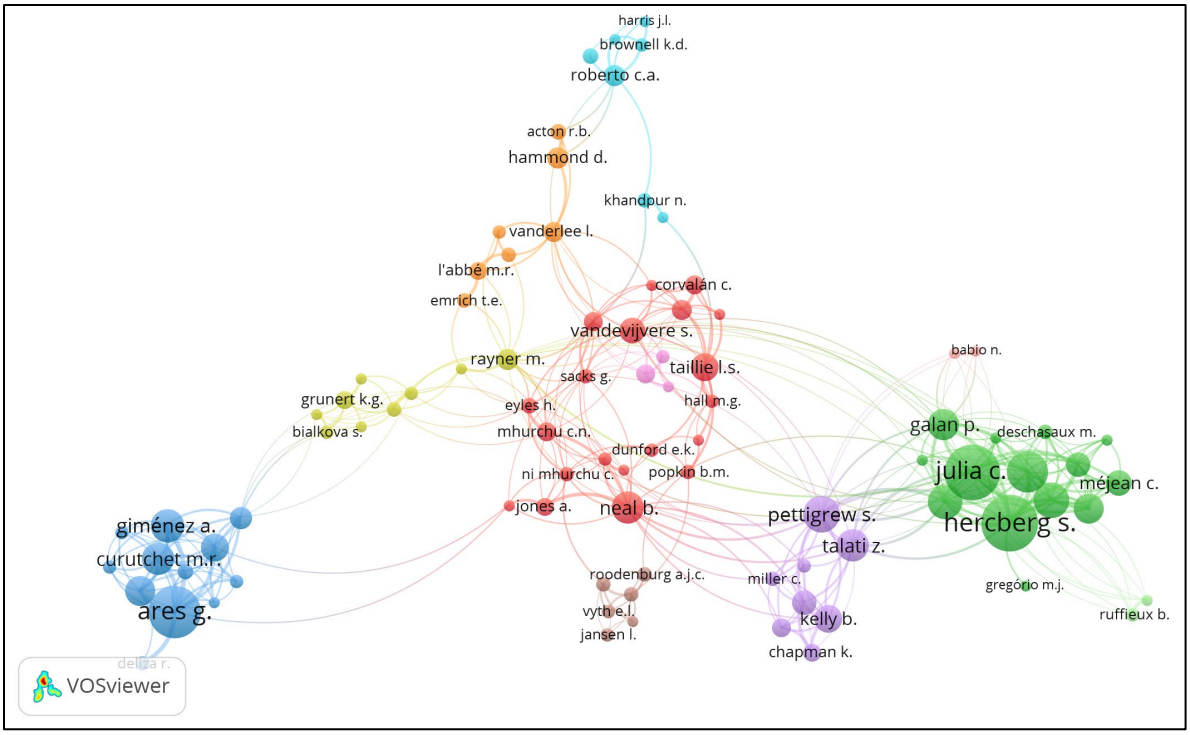


Figure 4: Co-author Collaborations

It is suggested that articles authored by researchers from multiple countries tend to have a higher impact and are more insightful than publications authored by authors from a single country (Knobel et al., 2013). Although country-specific laws, practices, or norms usually govern FOP nutritional labels, a large proportion of articles (N=210, 34.9%) were co-authored by researchers from more than one country. Further, we found that 28 (4.6%) articles had authors from more than three countries, while 4 studies (less than 1%) had authors from more than 10 countries. In one such article (Deschasaux et al., 2020), 57 authors with 40 affiliations collaborated from 13 different countries. The article was based on a study done on an exponentially large sample size (N=521,324) and examined if the Nutri-Score led to healthier food choices and was associated with life mortality.

Network analysis based on co-authorship across countries revealed the distribution of countries and the respective collaborations (Refer to Figure 5). The network graph reveals the distance between the two countries relatedness research with each other. At the same time, the thickness of the line connecting the two countries reflected the strength of the link between the two countries (Khudzari et al., 2018). The results revealed that authors from the UK collaborated with the maximum number of countries (Links = 27; Link strength = 54), despite having a lower number of publications (Articles Published = 72) when compared to the US (Articles Published = 137) and Australia (Articles Published = 113). The authors from the US and UK collaborated with authors from 28 (Link strength = 56) and 20 other countries (Link strength = 50), respectively. Authors from other countries which actively collaborated internationally were the Netherlands (Link = 23; Link strength =21; Articles published =38), France (Link =21; Link strength = 26; Articles published = 65), and Denmark (Link = 21; Link strength = 31; Articles published = 32).

Furthermore, an analysis was done to see authors from which countries had relatively more recent publications. We created an overlay network visualization based on average publication Year (APY) to understand the contribution of authors from different countries using the VOSViewer Software. The color code identity on the overlay network visualization helps in identifying the APY on the continuum from blue (lowest), green (medium), to yellow (highest). Thus, the countries with the lowest APY (oldest average publication year) were shaded as blue, while those with the highest APY (latest

publication year) were shaded as yellow. As apparent in Table 5 and Figure 3, the Netherlands (APY =2014.7), Germany (APY = 2015.6), Belgium (APY = 2016), and Norway (APY = 2016.1) were some of the countries where authors published more articles in the initial years, whereas India (APY =2020.7), Egypt (APY = 2020.7), Colombia (APY = 2019.9), and China (APY =2019.8) had contributed articles in the recent years. The analysis highlights the countries from which research is FOPNL has emerged in recent years (Refer to Table 5).

Table 5: Top 10 Countries Based on Most Published Articles Internationally

S/N	Country	Co-authorships	Total Citations	Links	Total Link Strength	Average Citations	Average Publication Year
1	United States	137	3627	28	56	26.54	2016.7
2	Australia	113	2235	20	50	19.77	2017.4
3	United Kingdom	72	1930	29	54	26.80	2017.3
4	France	65	1128	21	26	17.35	2017.9
5	Canada	45	806	14	15	17.91	2017.2
6	New Zealand	43	1017	17	28	23.65	2017
7	Uruguay	42	946	10	23	22.52	2018.2
8	Netherlands	38	2012	23	21	52.94	2014.7
9	Denmark	32	2119	20	31	66.21	2017.2
10	Belgium	30	1854	18	23	61.80	2016

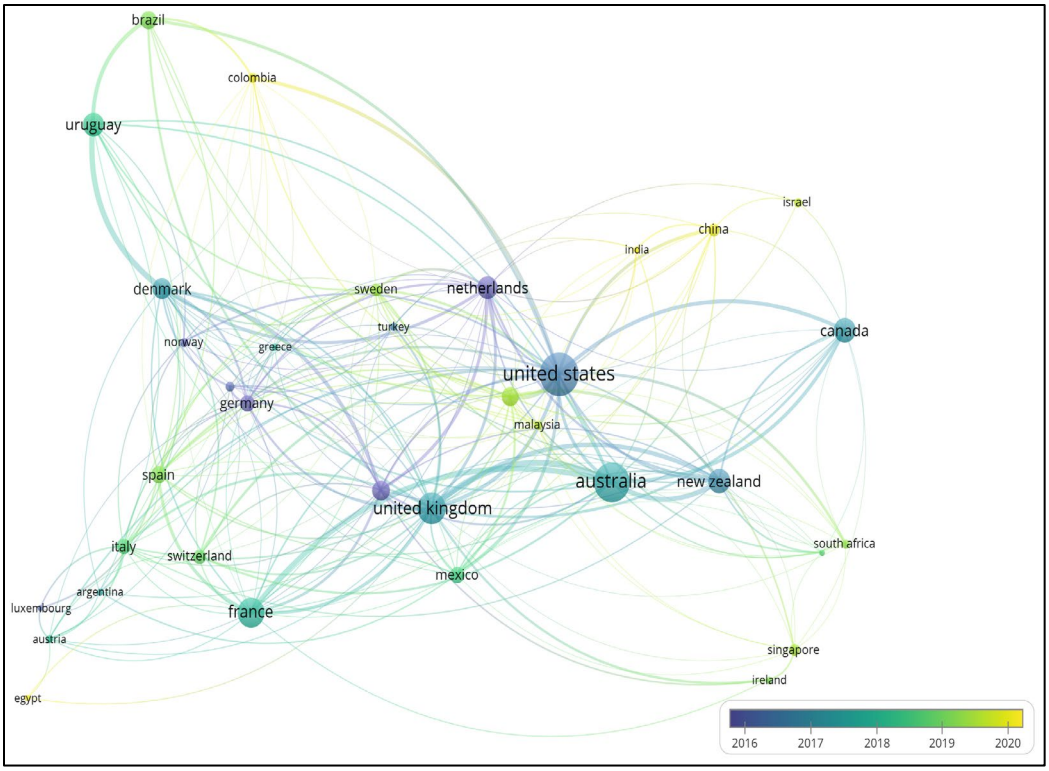


Figure 5: Country-Wise Collaboration and Average Publication Year

Common Terms, Co-word Analysis, and Emerging Research Themes in FOPNL

The next part of the analysis focused on the most common terms and topics used in the literature. Examining common topics helps explore various research themes and terminologies used in a broader research domain (Donthu et al., 2021). With the help of Vosviewer, we identified the most common terms from article titles and abstracts. The software identified 11609 terms, but only 782 (6.73 percent) appeared more than 6 times. Concurrently, only 414 (percent) terms appeared more than 10 times, while only 262 (percent) terms appeared more than 15 times. The best terms describing the domain were shortlisted using the term relevance score (Lancho-Barrantes & Cantú-Ortiz, 2019). Terms that tend to represent specific topics are given higher relevance scores. In contrast, half of the 262 terms (i.e., 131) were shortlisted based on the term relevance scores.

The network map becomes more representative and valuable when terms with low relevance are excluded from the analysis (Van Eck & Waltman, 2011). After selecting the 131 terms, a manual review was done to identify any other generic terms that were still irrelevant. We have removed 23 terms such as article, set, example, etc., finally leaving 108 terms that were included in the network diagram (Refer to figure 6A and 6B). The top 60 most occurring terms and their relevance scores are given in Table 6.

The analysis reveals that words such as sugar, nutritional quality, policy, perception, and sodium were present in most articles. Country/region-specific mandatory or voluntary label formats such as Health Star Rating, Multiple Traffic Light, Nutri-Score, etc., were also common. Another common group of words included stakeholders such as manufacturers, retailers, supermarkets, government, etc. Another set of words represented the associated diseases such as obesity, and non-communicable diseases, and the negative associations presented by terms such as mcondition, risk, concern, control, unhealthy food, lack, etc.

Table 6: 60 Most Occurring Terms based on their occurrences in Title and Abstracts

SN	Term	O	RS	Term	O	RS	Term	O	RS
1	Sugar	158	0.38	Regulation	75	1.28	Total	55	0.54
2	Nutrient	120	0.25	multiple traffic light	74	1.55	Healthfulness	54	2.03
3	nutritional quality	113	0.55	Experiment	72	1.38	Task	52	2.06
4	Policy	110	0.54	Influence	72	1.22	warning label	51	0.38
5	Perception	107	1.46	Scheme	67	0.57	Fat	50	1.01
6	Diet	106	0.45	Energy	66	0.86	Review	50	0.67
7	Difference	104	0.82	Supermarket	65	0.38	Risk	49	0.49
8	Nutrition	97	0.25	Attention	64	0.97	Symbol	49	0.86
9	nutrition information	96	0.84	Format	63	1.27	Calory	48	0.28
10	Sodium	95	0.74	Population	63	0.42	food industry	48	1.21
11	health star rating	91	0.63	Ability	61	1.16	Recommendation	48	0.41
12	Change	87	0.23	Development	61	1.16	Concern	47	0.67
13	Obesity	84	0.76	Government	61	0.96	Reduction	47	0.58
14	Child	83	0.50	Implication	60	0.89	Australia	46	0.69
15	Beverage	82	0.67	Manufacturer	60	0.44	food category	46	0.48
16	Claim	81	0.45	Criterium	59	0.59	Marketing	46	1.35
17	Implementation	80	0.56	Healthiness	58	0.87	fop label system	45	0.35
18	Understanding	80	1.32	Nutri-Score	58	1.43	Role	45	0.70
19	Condition	78	1.62	Person	56	0.56	Question	43	1.04
20	Category	76	0.44	Proportion	55	0.95	Interest	42	0.49

(O- Occurrence, RS- Relevance Score)

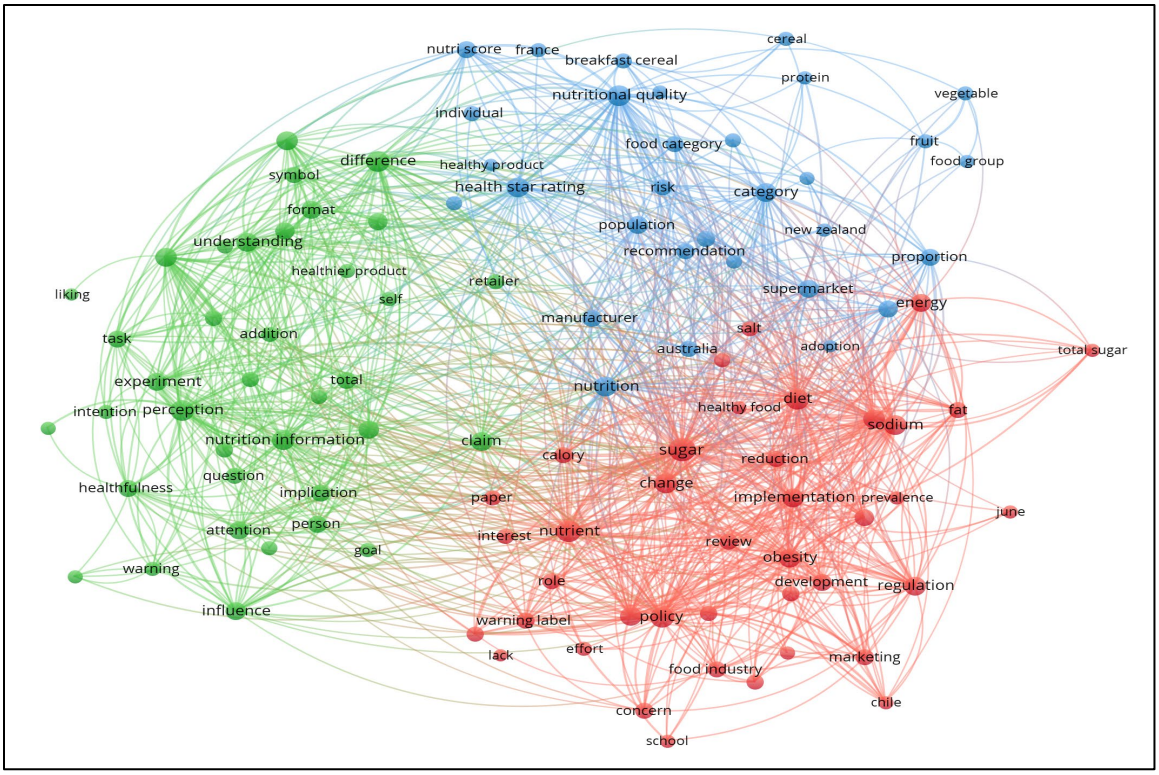


Figure 6A: Term Co-Occurrence Network Graph

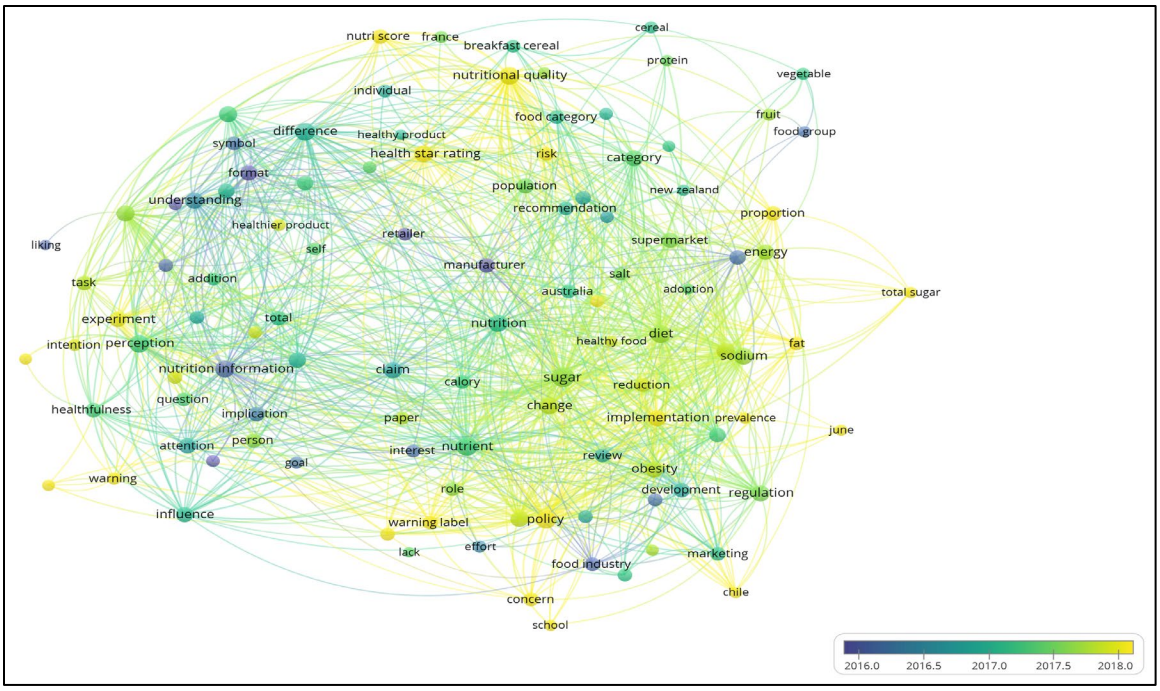


Figure 6B: Term Co-Occurrence Network Graph and Clusters

In the next part of the analysis, the co-occurrence of key terms was analyzed to explore the key research themes in FOPNL research. This analysis aimed to examine key themes, their emergence over the years, and their relationship across the domain (González-Serrano et al., 2020; Rashid et al.,

2019). The VOS Viewer software created a term co-occurrence network by connecting pairs of present terms in the title, abstract, and author keywords. We have used the selected 108 terms to create a co-occurrence map that was visually comprehendible yet presented most of the term co-occurrences. The term co-occurrence network was instrumental in identifying and understanding various research themes across the domain, which is an arduous task given the volume of data. The network's item size (term) reflects the number of term occurrences. The distance between the two items indicates how related the terms were, while the thickness of the edge reflected the link strength of the terms appearing together (Van Eck & Waltman, 2011). The network visualization (Refer to Figure 6A) shows various research themes, which are grouped into 3 clusters (Red, Green, and Blue) (Refer to Table 7). We have also created an overlay visualization using APY to understand the emergence of themes across the years (Refer to Figure 6B).

Cluster 1 (Red)

Effect of harmful nutrients on health and role of FOP nutrition in changing eating habits (Theme 1)

Policy and implementation of FOPNL regulations by the government (Theme 2):

The first theme in this cluster included prominent terms such as *sugar*, *sodium/salt*, and *fat*; and their effects on *diet* and other *non-communicable diseases* such as *obesity* specifically on children. The second theme revealed the emphasis researchers place on the *government* and *food industry*'s role in *policy* and *implementation* of *the regulation*. Niche terms included the recent *warning label* introduced in *Chile*. Analysis of the average publication year of various terms showed current research interest in the *warning labels* implemented in *Chile* in *June* 2016.

Cluster 2 (Green)

Attention, Perception, Understanding, and Influence of Multiple Traffic Light Scheme (Theme 3)

The second cluster focused on studies examining *attention*, *liking, perception*, *understanding*, and *purchase intention* of *healthier products/claim/food package,* and towards health label *format/symbol* such as *multiple traffic light*. Term average publication year analysis suggests that lately, there is less research interest in examining guideline daily amount (*GDA)* based labels. Moreover, interest in investigating purchase intention is emerging relative to other affect variables like *attention*, *perception*, *and attitude*.

Cluster 3 (Blue)

Health Star Rating, Nutri-Score, and Healthier Choice FOP nutrition labeling schemes (Theme 4)

The third cluster focused on studies examining *the nutritional quality* and covered topics such as *breakfast cereal, cereal, fruit, vegetable*, and their *proportion*. This theme specifically covered studies examining FOPNL conventions like *Nutri-Score* introduced in *France* and some parts of *Europe*, *the health star rating* introduced in *Australia and New Zealand,* and the *healthier choice* logo introduced in Singapore. The term frequency and average publication year analysis show that the Health Star rating has been examined more and is relatively older than the *Nutri-Score*. It parallels that *the Health Star rating* was introduced three years before the *Nutri-Score* labeling scheme.

Table 7: Highlights of Co-Citations Network

Theme 1 (Cluster 1, Red): Effect of harmful nutrients on health and role of FOPNL nutrition in changing eating habits				
Title	**Author(s)**	**Journal**	**Year of Publication**	**Citations**
Consumer testing of the acceptability and effectiveness of FOP food label systems for the Australian grocery market	Kelly et al.	Health Promotion International	2009	207
The sweetening of the global diet, particularly beverages: Patterns, trends, and policy responses	Popkin and Hawkes	The Lancet Diabetes and Endocrinology	2016	343
An investigation into the nutritional composition and cost of gluten-free versus regular food products in the UK	Fry et al.	Journal of Human Nutrition and Dietetics	2018	64
Nutritional warnings and product substitution or abandonment: Policy implications derived from a repeated purchase simulation	Ares et al.	Food Quality and Preference	2018	41
Responses to the Chilean law of food label and advertising: Exploring knowledge, perceptions, and behaviors of mothers of young children	Correa et al.	International Journal of Behavioral Nutrition and Physical Activity	2019	51
How should sugar-sweetened beverage health warnings be designed? A randomized experiment	Grummon et al.	Preventive Medicine	2019	28
Consumer effects of FOP nutrition label: an interdisciplinary meta-analysis	Ikonen et al.	Journal of the Academy of Marketing Science	2020	53
fop food label: A narrative review	Temple N.J.	Appetite	2020	37
Experimental studies of FOP nutrient warning label on sugar-sweetened beverages and ultra-processed foods: A scoping review	Taillie et al.	Nutrients	2020	25
Changes in the number of nutrients in packaged foods and beverages after the initial implementation of the Chilean Law of Food Label and Advertising: A nonexperimental prospective study	Reyes et al.	PLoS Medicine	2020	24

Theme 2 (Cluster 1, Red): Policy and implementation of FOPNL nutrition labeling regulations by the government				
Title	**Author(s)**	**Journal**	**Year of Publication**	**Citations**
Structural responses to the obesity and non-communicable diseases epidemic: The Chilean Law of Food Label and Advertising	Corvalán et al.	Obesity Reviews	2013	130
Mexico attempts to tackle obesity: The process, results, push backs and future challenges.	Barquera et al.	Obesity Reviews	2013	122
Using behavioral economics to design more effective food policies to address obesity	Liu et al.	Applied Economic Perspectives and Policy	2014	88
Has a public-private partnership resulted in action on healthier diets in England? An analysis of the Public Health Responsibility Deal food pledges	Knai et al.	Food Policy	2015	71
Front-of-Pack nutrition label to promote healthier diets: Current practice and opportunities to strengthen regulation worldwide	Jones et al.	BMJ Global Health	2019	36
An evaluation of Chile's law of food label and advertising on sugar-sweetened beverage purchases from 2015 to 2017: A before-and-after study	Taillie et al.	PLoS Medicine	2020	77

Theme 3 (Cluster 2, Green): Attention, Perception, Understanding, and Influence of Multiple Traffic Light Scheme				
Title	**Author(s)**	**Journal**	**Year of Publication**	**Citations**
Impact of different food label formats on healthiness evaluation and food choice of consumers: A randomized-controlled study	Borgmeier and Westenhoefer	BMC Public Health	2009	204
Impact of FOP 'traffic-light' nutrition label on consumer food purchases in the UK	Sacks et al.	Health Promotion International	2009	200
Use and understanding of nutrition information on a food label in six European countries	Grunert et al.	Journal of Public Health	2010	231
FOP nutrition label. Their effect on attention and choices when consumers have varying goals and time constraints	van Herpen and van Trijp	Appetite	2011	203
Is simpler always better? Consumer evaluations of FOP nutrition symbols	Andrews et al.	Journal of Public Policy and Marketing	2011	127
Traffic-light nutrition label and junk-food tax: A modelled comparison of cost-effectiveness for obesity prevention	Sacks et al.	International Journal of Obesity	2011	147

Theme 3 (Cluster 2, Green): Attention, Perception, Understanding, and Influence of Multiple Traffic Light Scheme				
Title	**Author(s)**	**Journal**	**Year of Publication**	**Citations**
The Growing Role of FOP Nutrition Profile label: A Consumer Perspective on Key Issues and Controversies	Kleef and Dagevos	Critical Reviews in Food Science and Nutrition	2015	120
Impact of the different FOP nutrition labels on consumer purchasing intentions: A randomized controlled trial	Ducrot et al.	American Journal of Preventive Medicine	2016	79
Impact of FOP nutrition information and label design on children's choice of two snack foods: Comparison of warnings and the traffic-light system	Arrúa, Curutchet, et al.	Appetite	2017	84
Warnings as a directive FOP nutrition label scheme: Comparison with the Guideline Daily Amount and traffic-light systems	Arrúa, Machín, et al.	Public Health Nutrition	2017	81
Are FOP warning labels more effective at communicating nutrition information than traffic-light label? A randomized controlled experiment in a Brazilian sample	Khandpur et al.	Nutrients	2018	67
Does FOP nutrition information improve consumers' ability to make healthful choices? Performance of warnings and the traffic light system in a simulated shopping experiment	Machín et al.	Appetite	2018	52
Taxes and fop label improve the healthiness of beverage and snack purchases: A randomized experimental marketplace.	A et al.	International Journal of Behavioral Nutrition and Physical Activity	2019	37
How do different warning signs compare with the guideline daily amount and traffic-light system?	Deliza et al.	Food Quality and Preference	2020	12

Theme 4 (Cluster 3, Blue): Health Star Rating, Nutri-Score, and Healthier Choice FOPNL nutrition labeling schemes				
Title	**Author(s)**	**Journal**	**Year of Publication**	**Citations**
FOP nutrition label: Testing effectiveness of different nutrition label formats FOP in four European countries	Feunekes et al.	Appetite	2008	294
FOP nutrition label stimulates healthier product development: A quantitative analysis	Vyth et al.	International Journal of Behavioral Nutrition and Physical Activity	2010	152

Theme 4 (Cluster 3, Blue): Health Star Rating, Nutri-Score, and Healthier Choice FOPNL nutrition labeling schemes				
Title	**Author(s)**	**Journal**	**Year of Publication**	**Citations**
FoodSwitch: A mobile phone app to enable consumers to make healthier food choices and crowdsourcing of national food composition data	Dunford et al.	JMIR mHealth and uHealth	2014	115
Effects of a voluntary FOP nutrition label system on packaged food reformulation: The health star rating system in New Zealand	Ni Mhurchu et al.	Nutrients	2017	65
Objective understanding of FOP nutrition label: An international comparative experimental study across 12 countries	Egnell, Ducrot et al.	Nutrients	2018	82
Comparative performance of three interpretative FOP nutrition label schemes: Insights for policy-making	Ares et al.	Food Quality and Preference	2018	58
The impact of price and nutrition label on sugary drink purchases: Results from an experimental marketplace study	Acton and Hammond	Appetite	2018	46
Do nutrient-based FOP label schemes support or undermine food-based dietary guideline recommendations? Lessons from the Australian health star rating system	Lawrence et al.	Nutrients	2018	38
Consumers' perceptions of five FOP nutrition label: An experimental study across 12 countries	Talati et al.	Nutrients	2019	26
Performance of the FOP nutrition label Nutri-score to discriminate the nutritional quality of foods products: A comparative study across 8 European countries	Dréano-Trécant et al.	Nutrients	2020	17
Influence of FOP label and regulated nutrition claims on consumers' perceptions of product healthfulness and purchase intentions: A randomized controlled trial	Franco-Arellano et al.	Appetite	2020	13
Effects of FOP label on the nutritional quality of supermarket food purchases: evidence from a large-scale randomized controlled trial	Dubois et al.	Journal of the Academy of Marketing Science	2021	21

SUMMARY, CONCLUSION, AND FUTURE RESEARCH DIRECTION

FOPNLs aim to inform consumers about the nutritional content of packaged foods and drinks. It is observed that regulators, manufacturers, and the public increasingly understand the importance of FOPNLs in informing consumers and their potential to change habits. The exhaustive bibliometric analysis research points to many exciting insights and developments in the area. First, the analysis shows researchers' rapidly growing interest in this area's inquiry. Interestingly, though over the years, most of the articles in this area were published in the United States, Australia, United Kingdom, France, and Canada, five of the initial 10 publications in this field were published in the Netherlands.

Moreover, four of these articles were authored by researchers affiliated with Unilever Food and Health Research Institute, Netherlands (Feunekes et al., 2008). These studies were part of Unilever's Nutrition Enhancement Programme, which was started in 2003 to assess foods with nutrients of concern, such as sugar, salt, and saturated and trans fats. Thus, the presumption that the industry is reluctant to change food composition or introduce FOPNL may not be entirely correct.

The bibliometric analysis shows that though there is an increasing interest in this area, the area is influenced by a limited number of researchers. With a sizable number of authors who co-authored research in this area, the overall research output is dominated by a few authors. Illustratively, the top 10 authors co-authored more than fifty percent of the total publications. Moreover, the FOPNL research is still limited to Western countries. There is little research in this field from countries such as China, India, Indonesia, Pakistan, Brazil, Nigeria, etc., which is home to approximately 50 percent of the world population. Although it is mandatory to mention energy value and the amount of fat, carbohydrates, sugars, and proteins on the back of the pack label across most countries, front-of-pack labeling is optional across major countries. It is important to note that terms such as poor, poverty, below the poverty line, and bottom of the pyramid were under-represented in the title, abstract, author, and index keywords. It suggests that existing research on how FOPNL can influence the dietary habits of the population from various socioeconomic strata is limited. One such study (Gustafson & Prate, 2019) focused on the effectiveness of tailored labels for the local people compared to generic FOPNLs. The study sample consisted of rural American Indian reservation supermarket shoppers. Another study (Jáuregui et al., 2020) examined the impact of various FOPNL formats on low- and middle-income Mexican adults. Nevertheless, more research is needed to make FOPNLs effective across consumer segments.

Few recent studies examined and compared the impact of the relatively new 5-color nutrition label 'Nutri-Score.' Studies comparing the effectiveness of Nutri-Score with other FOPNL formats have contradicting results, with some suggestive they fared better (e.g., Egnell, Ducrot et al., 2018; Egnell, Kesse-Guyot et al., 2018), while others found Nutri-Score less effective (e.g., Ares et al., 2018). However, Nutri-Score has become one of the significant FOPNL formats alongside other formats such as the traffic light system and warning labels. Though the Nutri-Score was first implemented in France voluntarily, a few other European countries (e.g., Belgium, Switzerland, Germany, Luxemburg, etc.) have also given formal approval for its voluntary use.

The analysis showed the recent interest of marketing scholars in publishing research on FOPNLs. However, only a small proportion of articles in this area are currently published in marketing journals.

We analyzed if there was a significant difference in the research themes across the literature published in medicine and health *vs.* marketing journals. Though the author and index keywords had terms such as purchase intention, consumer evaluation, marketing, policy, etc., in a more significant proportion of the articles published in marketing journals compared to health and medicine journals, these differences were insignificant. As our analysis was limited to keywords already provided in the SCOPUS database, it is suggested that future research can uncover how research published across different disciplines differs. Furthermore, despite WHO's emphasis on adapting to a single FOPNL

system (WHO, 2019), we did not find literature trying to examine such possibilities or nuances related to such interventions.

The bibliometric study does have its share of limitations. First, the papers reviewed in this study were limited to the papers indexed in SCOPUS database. Although, SCOPUS is one of the most widely indexed databases, some of the pertinent studies appearing outside this database may have been excluded. Second, the paper includes studies on FOPNL published up to the second week of October 2021; relevant studies (e.g., Mazzù et al., 2023; Schruff-Lim et al., 2023; Shrestha et al., 2023; etc.) published after this date could not be included. Third, literature review studies in general and bibliometric studies in specific use various approaches to identify underlying research themes, gaps, and insights. Though the authors used the most relevant and recent bibliometric techniques to examine this area, other bibliometric approaches may potentially uncover more insights into this area.

The development, implementation, monitoring, and evaluation of FOPNL have become increasingly important (Croker et al., 2020; Ikonen et al., 2020; Storcksdieck Genannt Bonsmann et al., 2020). The domain would benefit from increased research and participation across geographies and disciplines. It would be interesting to see if academic inquiry and analysis can help in the accelerated and uniform adoption and implementation of FOPNLs.

Conflict of Interest: The authors declare that they have no conflict of interest.

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