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Abstract: *The SARS-CoV-2 virus pandemic was also marked by research and the publication of scientific papers associated with the relationship between the pandemic event in the increase in food insecurity. The bibliometric tools were used to understand this scenario better. Two bibliometric strategies of co-words were used for research and data analysis, allowing the evaluation of scientific contributions related to the theme. The indicators showed the scope of food insecurity in different countries (detected by several research areas), and the adopted analysis strategies complemented each other. These indicators revealed that the studies were related to hunger, food security, food insecurity, and obesity. There is an association between the pandemic and all the items studied, with a strong probability of the pandemic interfering with food insecurity. Almost all research*

(papers) points to strategic actions to reduce the problems arising from the pandemic (loss prevention, mitigation and adaptation to climate change, international collaborative efforts, comprehensive health, and commitment to the SDGs) from a perspective to mitigate food insecurity. Also, most works argue that the pandemic interfered with the worsening of food insecurity, although this statement is made from a theoretical and empirical perspective.

Keywords: Food security; Hunger; SDG; WoS; KeyWords Plus; Multivariate analysis.

1 Introduction

Discussions involving the concept of food security began, more formally, in the 1970s, fueled by a global food crisis that gave rise to the World Food Conference in 1974. Later came to be considered a multidimensional issue due to the complexity of production, access, use, and stability of food production (FAO, 2003). As a result, access to adequate food has become a multidisciplinary issue at the global level. The research focused on in recent years has incorporated new and comprehensive challenges such as climate change, poverty, gender, nutrition, and diet structure (Xie *et al.*, 2021). The 17 sustainable development goals (SDGs) agenda embraces this theme (Department of Economic and Social Affairs of United Nations, 2022). Food security is directly related to the production, supply, and access to sufficient quantity and quality of healthy food. On the other hand, hunger, defined by the United Nations (UN) as the second challenge to be overcome in the set of SDGs presents itself as a risk to the dignified development of human beings.

The hunger map manifests itself markedly in regions with lower *per capita* income, in the outskirts of large cities, in rural areas, in families maintained by brown or black women, and in precarious places of access to water for both human consumption

and production of food (Andrade, 2020). Moreover, the pandemic caused by the SARS-CoV-2 virus, called the COVID-19 pandemic, intensified the global economic crisis and, in addition to the discontinuity of public policies to guarantee access to food, generated high levels of food insecurity in several countries.

A systematic review of the impacts of COVID-19 on food systems, food security, and nutritional status of low- and middle-income people was developed with a sample of 337 papers covering 62 countries. This study confirmed the magnitude and severity of a crisis that has spread worldwide and has mainly affected the low-income population who cannot access food (Béné *et al.*, 2021). However, the analysis showed, in particular, that the interruption in access to food was not just limited to the financial component as a result of job loss or reduced financial income. Furthermore, the results show that the food systems "withstood" the pandemic, and no severe shortages in food production were observed in 2020. Thus, the increased risk of food insecurity was mainly due to other aspects, such as the discontinuity of public policies and reduced access to food by the population most in need of financial resources.

In a global context, the pandemic period was marked by a high volume of publications covering different contexts of food insecurity. The increased data flow makes interpretation difficult, especially when dealing with qualitative variables. However, evaluation and understanding can be facilitated through bibliometric analyses. These tools make it possible to map cumulative scientific knowledge and its evolution, in addition to helping to identify new research trends in different areas of expertise (Moral-Muñoz *et al.*, 2020; Donthu *et al.*, 2021). Furthermore, bibliometric strategies can reveal the nuances of an extensive data set pod and results. For example, in co-word analysis, words present in papers are used as a focal point, where it is assumed that the frequency with which terms appear together (whether in keywords, titles, and abstracts) suggests

that there is a thematic relationship between them (Donthu *et al.*, 2021). This approach allows the evaluation of bibliographic coupling and possible research trends.

However, this analysis strategy can be influenced by misinterpretations due to the misuse of keywords, which are sometimes comprehensive, making it challenging to group a posteriori, making it necessary to track this type of publication to enable the understanding of the context in which it was published inserted (Chang, Huang and Lin, 2015). One way to mitigate or reduce the influence of this type of problem is to use a robust data set, as it can highlight relevant words and overlap meaningless words due to the low frequency in publications and/or even use different strategies, such as co-occurrence of authors' keywords and KeyWords Plus, to evaluate the conceptual structure of the set of selected publications.

Some literature reviews on food insecurity during the COVID-19 pandemic were developed under a bibliometric approach (Herrera-Calderon *et al.*, 2021; Xie *et al.*, 2021; Idamokoro and Hosu, 2022; Nilashi *et al.*, 2023) of great scientific relevance. However, there was a reduced number of studies of this nature and restricted to specific periods or countries. The lack of a broader analysis of this period may be one of the main obstacles to proposing and adopting public policies to combat hunger and food insecurity among populations.

In this context, it was decided to evaluate the scenario of food insecurity through bibliometric tools, using the co-occurrence of authors' keywords and KeyWords Plus as data analysis strategies, allowing the evaluation of scientific contributions related to food insecurity during the pandemic.

2 Methodology

2.1 Study design

The systematic bibliographic search for metadata recovery for the construction of bibliometric indicators was carried out through the academic database of Clarivate Analytics' ISI - Web of Science (WoS) on October 1, 2022, using a time frame of 6 years (2018 – 2023). WoS is referenced as one of the primary databases/results used by the scientific community, with broad multidisciplinarity and interdisciplinarity, including research at regional and international levels (Zhu and Liu, 2020; Pranckutė, 2021), and with a rigorous evaluation process for acceptance of papers (Singh *et al.*, 2021). For these reasons, this database was adopted for this study. In addition, the productions that had the characteristic of the primary source of results were considered a priority.

2.2 Strategy used in locating and retrieving papers

The research theme was centered on "food security" and "hunger", and the terms used were determined with the aim of retrieving metadata at a global level (Figure 1a), showing the world hunger scenario, including information about the pandemic period. For the retrieval of papers within the theme under study, the Boolean operators "or" and "and", and quotation marks as special characters were used to ensure accuracy in the screening of papers related to the topic (Akintunde *et al.*, 2021).

The papers were from primary sources with robust experimental character (≈ 90%) and literature review (≈ 10%). Most reports are available in English (≈ 94%), totaling 7754 records. Then, using tools available in WoS, the papers were categorized by research areas and geographic distribution, retaining the 10 most prominent areas and 15 countries. Finally, these papers were exported from WoS and used to generate bibliometric indicators (Figure 1b).

2.3 Data analysis

2.3.1 Author Keywords Analysis

A bibliometric map of the co-occurrence of authors' keywords was prepared using the complete count method, adopting the minimum number of words to occur as 50, using the VOSviewer software (version 1.6.18) which is used to visualize similarities between article metadata (van Eck and Waltman, 2013) based on VOS mapping. This technique presents high precision, allowing to identify similarity through a low-dimensional Euclidean space, where the smallest distance between objects reflects a higher level of similarity, and these are positioned in the plane according to their ideal coordinate calculated in the software (Van Eck and Waltman, 2007). As an additional step, screening was carried out, by visual inspection, of the grouping of keywords selected to generate the bibliometric map, aiming to identify variations of the same term and even meaningless words about the research topic, these being disregarded, such as, for example, leptin and bariatric surgery.

2.3.2 KeyWords Plus analysis

Based on the generated bibliometric indicators, a correlation was identified between the number of papers published and the pandemic period (2020 to 2023). Then, the following terms were established to perform a new search: “food insecurity” and “covid-19 pandemic”. Finally, the results obtained (1070 publications) were used to identify the 10 most relevant journals, according to the number of publications in that period; the impact factor was consulted on the electronic address of the journals.

These results were filtered by document type (paper) and language (English), totaling 581 results. Then, these papers were ordered according to the number of citations, and the 500 most cited were selected for analysis. Finally, these were used for KeyWords

Plus extraction since they are mainly considered descriptive (Zhang *et al.*, 2016) through the bibliometrix package (Aria and Cuccurullo, 2017) in RStudio (versão 2022.07.1).

Afterward, the occurrence of words was evaluated, by frequency, of the 50 most cited to generate a WordCloud. Thematic evolution was studied using a minimum frequency of 200 words and 5 clusters. According to the results, the conceptual structure between the words was evaluated through Multiple Correspondence Analysis (MCA), using a count of 50 words, to identify clusters that express similar concepts.

3 Bibliometric indicators

3.1 Research areas and geographical distribution of scientific publications

Bibliometric studies on food insecurity were developed (Herrera-Calderon *et al.*, 2021; Xie *et al.*, 2021) in a short period of the pandemic and restricted to some countries and regions, highlighting the need for broader assessment information available in the scientific literature about the pandemic period. In the study by Pepetone et al. (2023), for example, the authors examined changes in the prevalence and severity of food insecurity among adults and youth before (2019) and during (2020) the Covid-19 pandemic in Australia, Canada, Chile, Mexico, United Kingdom United States, and the United States through multivariate regression models, considering the variables: age, gender, racial and ethnic identity and other sociodemographic characteristics associated with food insecurity. The results indicated that food insecurity has intensified in Mexico among adults and young people. However, only some changes in this scenario were observed in other countries. This behavior may be related to the short period of the study, with the need for broader investigations.

Therefore, scientific publications on the topic under study from 2018 to 2023 revealed that the research areas with the highest number of publications were (Figure 2a):

Nutrition Dietetics (15.65%), Public Environmental Occupational Health (11.00%), Environmental Sciences Ecology (6.92%), Science Technology Other Topics (6.60%), Agriculture (6.06%), Food Science Technology (5.84%), Psychology (5.29%) and others (< 12%).

In its February 2023 editorial, the newspaper that published the most on this topic (Nutrition Dietetics) highlighted the negative impacts of the pandemic on food security and also highlighted the necessary changes that can accelerate the achievement of SDG 2, “the responses to the pandemic educated the public about how epidemiological data can be applied to policy; we had demonstrations of how epidemiology can be communicated to the public, as unprecedented public health officials became media stars. As a result, we now have lived experience of public health interventions to an extent never before implemented at a population level” (Truby, 2023).

These publications, grouped according to the geographic location where the research was developed, are shown in Figure 2b, with the United States of America (34.88%) being the country with the highest number of publications, followed by Germany (10.51%), England (10.42%), Peoples R China (5.97%), Canada (5.53%), Australia (5.35%) and others (< 32%). Overall, between 2018 and 2023, the citation yield was 52,921 (without self-citations of papers), with an average per item of 7.47 and an H-index of 76. Between 2018 and 2021, the number of publications (Figure 2c) grew linearly, being that year (2021) with the highest level of scientific contribution (1970 publications), yielding a total of 19,187 citations. In 2022, there was a decrease in the number of publications (1,155), but there was an increase in the number of citations (24,037). This behavior can be explained by the pandemic marked by data profusion in different research areas.

3.2 Author Keywords Analysis

The bibliometric map of the co-occurrence of authors' keywords (Figure 3; Table 1 in supplementary material) was centered on hunger, with 482 occurrences in scientific papers. The blue cluster is related to hunger, food insecurity, nutrition, health, and the covid-19 pandemic, which are closely related to the pandemic period. The map's periphery can reveal new research trends, and access to food and food banks stands out in this cluster. According to Bublitz et al. (2021), the pandemic revealed systemic vulnerabilities in access to food, and according to the study by Drake et al. (2023), there was a tendency to intensify these effects in individuals experiencing food insecurity.. The three most cultivated Poaceae, wheat, rice, and maize, were responsible for more than 50% of the consumption of calories worldwide. Hence, a diet of low nutritional value reduces food insecurity, mainly among the poorest and vulnerable (Altieri and Nicholls, 2020).

The food access and food pantry were highlighted in this cluster, located in the map's peripheral region, suggesting that discussions about these two themes were fostered by the pandemic period. Government-imposed mobility restrictions, price increases, and reductions in food units to be purchased in supply chains such as markets have affected individuals' access to basic foodstuffs. In this context, the study by O'Meara et al. (2022) investigated consumption experiences of food environments and food procurement practices in 119 countries in Western Europe, North America, Latin America, Asia-Pacific, and Africa during the first months of the Covid-19 pandemic. Their findings highlighted several everyday negative experiences regarding food availability and accessibility among individuals from different countries, highlighting the need to implement practices aimed at more resilient food systems. Recent studies such as Karan

et al. (2023) and d'Errico et al. (2023) discuss this topic and reveal its complexity and scope.

Food security\insecurity (433 occurrences) in the green cluster was related to poverty, non-sustainability, agriculture, climate change, and Africa. In the peripheral region of the map, it was observed that there is a relationship between the SDGs, food waste, and with the second SDG, called zero hunger. This SDG aimed to eradicate hunger, establish food security, improve individuals' nutrition, and promote sustainable agriculture by 2030 (Al Nemer, 2022). To ensure the achievement of this rather daring and difficult-to-reach SDG, strategies to combat hunger must be articulated, encompassing legal instruments, social programs, and public policies to combat food and nutritional insecurity established in most countries (da Silva, 2019).

In contrast to the problem of hunger and food insecurity, obesity appears in the red cluster (361 occurrences), and its nuances related to children, adolescents, inadequate food intake, behavior, and eating disorders. The pandemic affected the eating behavior of children, adolescents, and young adults since, during this period, there was an increase in the intake of low-quality ultra-processed foods from a nutritional point of view and a decrease in physical activity. For example, the study by Loth et al. (2023) investigated the eating behavior of families with young children based on the food insecurity status of individuals recruited through "Kids EAT!" during the Covid-19 pandemic. The findings show coping strategies used, such as food storage, rationing, and additional resources, to overcome difficulties in accessing food.

This study indicates that the pandemic is an intervening component in the worsening of the problem (Stavridou *et al.*, 2021). According to Arora & Mishra (2022), the dangers that affected food safety directly affected the quality of the diet of individuals,

resulting in overweight and obesity, and this theme is repeated in 2023 as relevant in the newspaper that most published papers related to the subject under study.

The keywords present in the clusters in yellow (mental health, stress, depression, and anxiety) and purple (malnutrition, biofortification, and micronutrients) have low occurrence in the other clusters, indicating that they were underused in studies related to the theme of this research. In general, the cluster in yellow suggests a relationship between food security, the pandemic period, and the mental health of individuals. Kaner et al. (2022) evaluated the correlation between depression, anxiety, and stress with eating behaviors related to emotions established during the pandemic for 2,002 adults aged 18 or older. The results revealed that one in three participants reported moderate to severe levels of stress, anxiety, and depression, with a significant correlation with eating, with overeating appearing in response to negative emotional moods.

Another example is the study by Klatzkin et al. (2023), carried out with women (n = 44 and ages ranging from 18 to 50 years) on eating behaviors in response to acute stressors, revealing highly erratic behaviors that induce adverse effects on the diet of individuals when exposed to acute stress. Based on this study, the Covid-19 pandemic may have been a precursor to different agents that promote acute stress in individuals, impacting eating behaviors.

The purple cluster relates to malnutrition associated with non-biofortification and hidden hunger. The latter refers to the effects of reduced consumption of micronutrients in the human diet. The information in the different clusters is interrelated, demonstrating that a high volume of data was generated during the pandemic and suggesting that the progress in combating food insecurity is not following the SDG targets' aggravated by the period pandemic.

Therefore, agreeing with the discussions of Arora & Mishra (2022), who examined a report and stated that there is no progress in ensuring access to safe, nutritious, and adequate food for all, and eliminating malnutrition may be a distant reality. However, the editors of the European Journal of Development Research (Henson *et al.*, 2020), when conducting a strategic mapping in the first year of the pandemic for development studies with a particular focus on government actions and responses and their effects at the local, national, and global levels, highlighted that future studies need to consider how focal point marginalized groups, aiming to neutralize the short- and long-term impacts caused by the Covid-19 pandemic. In South Africa, for example, a study conducted by Arndt et al. (2020) showed that the Covid-19 pandemic severely affected the country's economy, food security, and income distribution factors, mainly affecting families with low levels of education and high dependence on income from work.

3.3 KeyWords Plus analysis

Based on the previously evaluated bibliometric indicators, it was identified that there is a correspondence between the number of published papers and the time frame from 2020 to 2023, where the most significant number of publications was in 2020 and 2021 (Figure 2c). Therefore, a different search strategy was adopted, based on KeyWords Plus, to evaluate the conceptual structure related to the theme of the present study. This algorithm improves bibliographic searches by identifying recurring terms (words or phrases) in the titles of papers organized in the reference list (Clarivate, 2022). In general, its use allows for retrieving a more significant number of papers containing a condensation of information on primary and secondary topics of interest.

Using this search tool, it was possible to locate 1070 papers distributed among the 10 most relevant scientific journals (Figure 4). The Journal of Hunger & Environmental

Nutrition had the highest number of publications (336) in the period under study; however, among the 10 journals, this one has the lowest impact factor (IF) (1.770), followed by Nutrients and Appetite with 172 publications (FI of 6.706) and 170 publications (FI of 5.016), respectively. From an opposite perspective, it was observed that in this ranking, the journals with the lowest number of publications (≤ 41) had FI ranging from 4.996 (Scientific Reports) to 7.146 (Food Security), demonstrating the fact that despite the low level of publications in this period, these presented a reasonable citation count in the collection of WoS journals, considering the citations and publications of the two previous years that are used for the calculation of the IF.

The IF analysis indicates the quality and contribution of these publications to a field of study (Garfield, 1980). Therefore, we adopted the strategy of sorting these publications by number of citations in descending order and analyzing the 500 most cited papers through different approaches. The Word Cloud (Figure 5a) highlights hunger as the most frequent word in the title of scientific papers, followed by health and obesity. In general, the recurrent words identified by KeyWords Plus are interrelated with the co-occurrence map of authors' keywords (Figure 3), with both strategies having a reasonable level of information agreement. The thematic evolution analysis (Figure 5b) showed that between 2018 and 2020, the most recurrent words were hunger and obesity, also reflecting the type of food adopted by populations in the pre-pandemic period.

Studies carried out in different countries on consumption habits during the pandemic showed an increase in the consumption of snacks, bakery products, and alcoholic beverages; on the other hand, it seems that the consumption of fast foods differed in different countries (Chenarides *et al.*, 2021; Bakaloudi *et al.*, 2022; Souza *et al.*, 2022). For example, in Brazil (Souza et al., 2022), consumption has increased; in the US (Chenarides *et al.*, 2021), it has decreased.

Between 2021 and 2023, the term hunger was interconnected with health, suggesting that different studies relating to these terms were developed in this period. 2022 was the year with the highest number of confirmed cases of individuals with COVID-19 in two moments, on January 17 (23,390,619 cases) and December 19 (44,875,026 cases) (World Health Organization, 2023), a period that also presented a more excellent scientific production relating hunger and health. These two moments of a high number of individuals with COVID-19 are possibly related to local epidemics, as pointed out by Matteson et al. (2023) study with genomic, mobility, and epidemiology data, being driven by the dynamics of regional transmission and between international borders, due to the reduction of public health interventions.

The MCA (Figure 5c) separated the conceptual structure into two groups, and its dimensions (Dim 1 and Dim 2) showed a total explained variance of 70.90%. This indicates that the 500 papers used for these analyzes have a level of information alignment (> 70%). Words located far from the central region of the map have a higher level of contribution to generating the dimensions, and the location in a negative area indicates that the words are underused in the titles of scientific papers. The group with the largest number of words generally has more significant heterogeneity, and these are related to studies that addressed problems of the environment, agriculture, food security, and physical and mental health. In the smaller group, words are related to nutritional studies of individuals.

3.4 Future perspectives

The clusters shown in Figure 3 provide a diagnosis of the situation and, at the same time, allow a listing of the strategic challenges to mitigate the problems, which are concentrated in food insecurity, hunger, and inadequate nutrition, resulting in global

systemic problems, more impactful in some countries, notably from Africa, and from South and Central America. The solutions fit the intentions of the 17 SDGs, which have their structuring basis in local and global governance. There will only be success with this interlocution, given that the SDGs are interconnected and synergistic and depend on international cooperation. This was proven when the pandemic began in 2019/2020. It was not the physical blockade that brought the definitive solution to the problem, nor the competitive rhetoric. It was science and cooperation that, in 6 months, already offered efficient and effective vaccines.

Most countries recognized the SDGs as strategic and developed an action plan and goals at the international level. However, studies indicate that progress has been made, but far below what was planned. Some countries reached practically the full extent of actions, while others reached less than 30% of the proposed (Millennium Institute, 2023). The fact is that the macro problems persist and demand political and scientific-technological actions. Here, given the research results, we will propose some scientific-technological challenges.

In the induction of this research, the hypothesis was launched that food losses could guide a cluster. This was not detected. The most likely cause of this result must be related to the scientific profile of the journals considered in the research, which address aspects of nutrition, hunger, food safety, food safety and insecurity, health, food production, psychology, and economics. Even so, it was decided to propose the first strategic challenge, which is more pragmatic and perhaps more tangible. Around 20% of the food produced is lost, equivalent to 2x the total annual production generated in Brazil (one of the largest food producers). This loss includes disposal shortly after harvesting or collection, processing and post-processing, and final feed preparation. If we have the non-use of potential co-products, the losses go to something close to 30%. These losses are

severe because they occur when the input of inputs and other production components has already happened, vigorously attacking at least 10 SDGs. This situation is unacceptable since we have the knowledge and technologies to prevent these losses below 5%.

The second challenge is related to the evidence of climate change, which already demands the generation of technologies and inputs more suitable for food production in more adverse conditions than the current ones. Historically, actions in food production in unfavorable regions were guided by coping with overcoming the agent causing the problem: if there is water deficiency, irrigate; if there is salinity, desalinate; if there is excess radiation, shading, and so on. This logic will still be practiced for many decades, considering it solves the problem. However, a new path is being strengthened. We are talking about plants, animals, and microorganisms that are more tolerant to drastic variations in temperature, sun exposure, UV radiation, water restrictions, and salinity, among others. At the same time, there is a need to mitigate greenhouse gas emissions (GGE), mainly CO_2, CH_4, and NO. This reduction in generation and/or emissions needs to be agreed upon within the scope of agriculture, industry, and urban ecosystems. In the specific case of food production, significant progress has been generated based on knowledge of the primary sources of GGE and in developing intelligent agricultural and livestock production technology capable of reducing GGE emissions by 25 to 30%. This is the case of soil management with coverage in synergy with symbiotic microorganisms and N recyclers (even in non-Fabacea), microorganisms and biostimulators that generate defense induction in plants, plants, and signaling metabolites in plant-plant communication, plant-animal, plant-microorganism.

With population growth and advances in SDGs, particularly SD1, the perspective is of a growing demand for food. Here lies the third challenge. There is a need to produce more in the same area and sustainably. Assisted by innovative technologies, classic

genetic improvement is decisive in this advance. Decision-making will come from prospecting for new species, germplasm banks, selection of varieties, generation of mutants, and gene editing. All these options are based on tangible knowledge generated by omic strategies. Searches will be directed towards varieties and cultivars that are more adapted, remedial, with a high productivity ceiling, greater tolerance to biotic and abiotic stressors, and biofortified in minerals and/or vitamins limiting human nutrition. Thanks to the advances generated by omics and bioinformatics instruments, which make it possible to start from complex matrices and reach the detail of the genetic, epigenetic, and functional map of organisms, building integrative biology, the generation of cultivars adapted to stressful conditions are already materialized and, by at the same time, with high productivity and high concentration of bioactive compounds.

The cluster analysis generated in this research (Figure 3) also points to the unstable situation when seeking comprehensive health (humans x animals x plants x water x air x microbiota). Here lies the fourth challenge. Notably, two nodes stand out in this theme: food safety and quality, the latter from the perspective of adequate nutrition. For example, obesity is a frequent focus (with exceptions) in studies based on populations with food insecurity. But, returning to the issue of food security (food security, nutrition, health, agriculture, poverty, sustainability), the priority is to emphasize the appreciation and respect for local cultural values with the safe production of food. When talking about safe production, emphasis is placed on preventing chemical, biological, and physical hazards.

There is an interconnection between the diet of individuals and physical and mental health. Studies show that the intestinal microbiota of individuals in a healthy mental health state differs from the microbiota found in individuals with depression, with the types of microorganism present being influenced by diet. The act of eating is part of

the system or way of life adopted in different countries around the world, where the habit of a more natural diet, made with foods with reduced input of chemical additives, rich in beneficial nutrients, results in the promotion of a healthy state healthier physical and mental health, reducing the risk of mental disorders. This is due to the stimulation of brain neurotransmitters that release satiety and happiness hormones and perform regulatory functions such as insulin that controls blood glucose. This “harmonious” state is far from the reality of food-insecure individuals with a mental disorder, a fact that increased substantially during the pandemic due to restrictions and limited access to healthy foods. Future guidelines should enable public policies for access to more nutritious foods in times of crisis and interventions for the negative impacts on mental health.

Finally, these perspectives presented will consolidate themselves as relevant or not in a concise future, considering that we will have, in a maximum of two years, the production of scientific knowledge about the financial, educational, behavioral, food, as well as physical, and health impacts mental health in people's lives in several countries.

4 Conclusions

Using bibliometric tools, using the co-occurrence of authors' keywords and KeyWords Plus as data analysis strategies, making it possible to assess the association relationships and putative interference that the pandemic had with food insecurity. Scientific works are unanimous in associating/linking the pandemic with food insecurity and its intrinsic events, such as hunger, obesity, nutrition, food safety, and agriculture. Likewise, virtually all research (papers) points to strategic actions to reduce the problems arising from the pandemic (loss prevention, mitigation and adaptation to climate change, international collaborative efforts, comprehensive health, and commitment to the SDGs) from a perspective to mitigate food insecurity. Finally, most works argue that the

pandemic interfered with the worsening of food insecurity, although this statement is made from a theoretical and empirical perspective. The research studies that started at the end of the pandemic, now declared under control at the international level (Briefing, 2023), will test this hypothesis. The results will likely be released by 2024, as is the case with the Epicovid studies, which are being carried out on virtually all continents, seeking to understand the dimension of the impact of the pandemic by Sars-Cov-2 and mutants on people's lives.

Declaration of Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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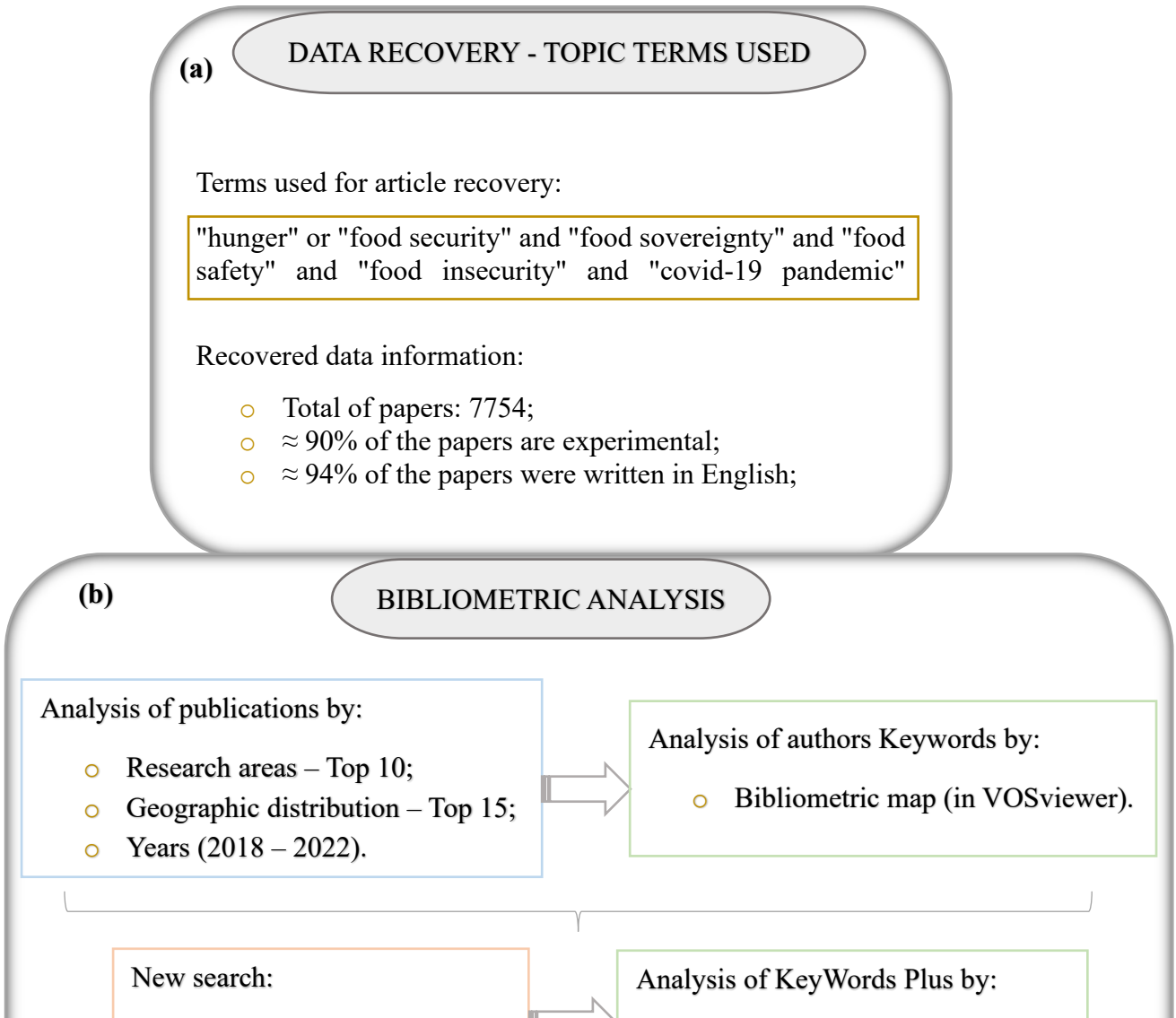
Figure 1 – (a) Steps for mining and (b) analyzing data extracted from scientific papers related to food security and hunger.



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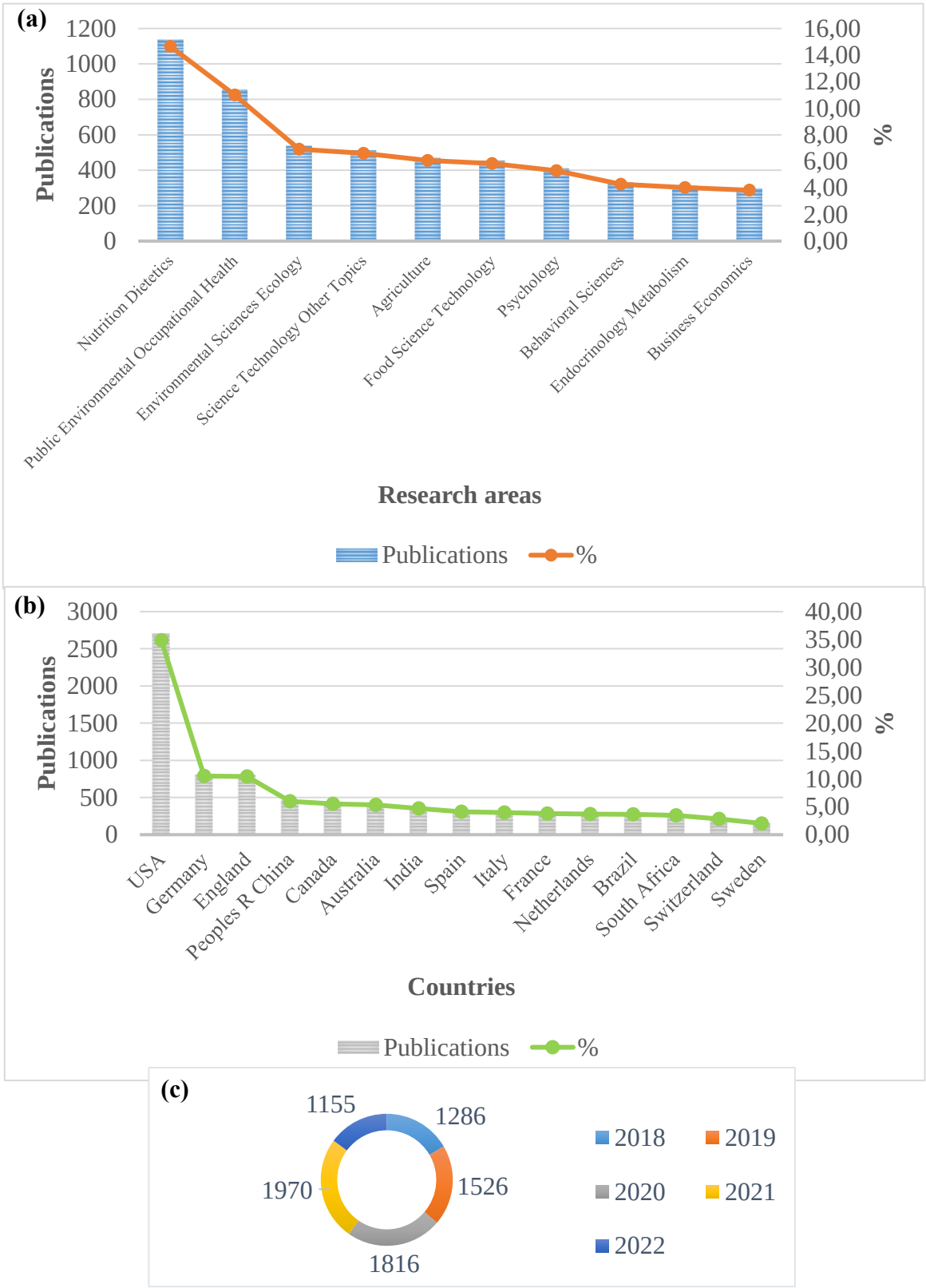
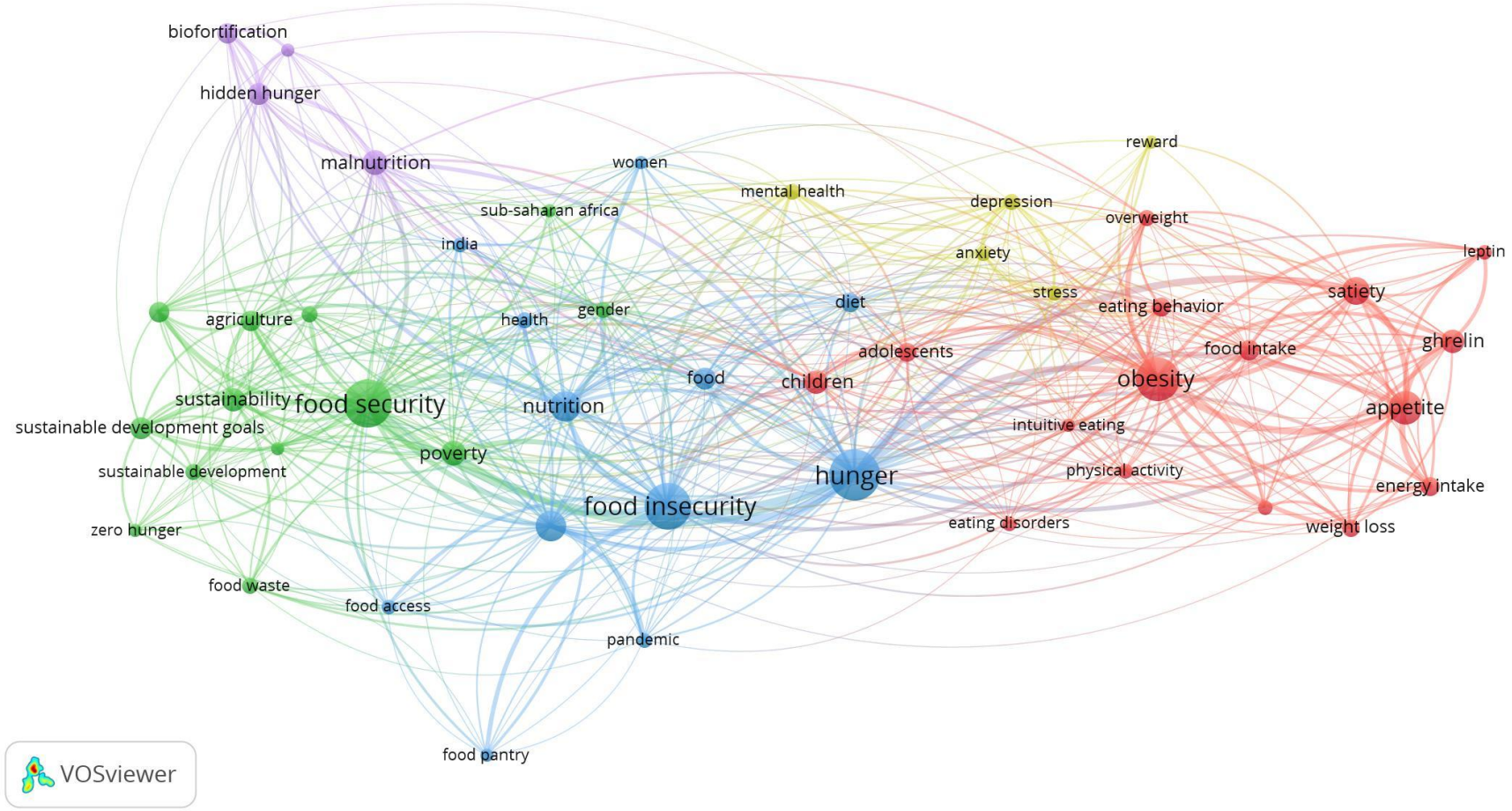
630 Figure 2 - Indicators of publications by (a) research areas (Top 10), (b) geographic
631 distribution (Top 15) and (c) total publications per year related to food security and
632 hunger.



633 Figure 3 – Bibliometric map of co-occurrence of keywords by authors related to food security and hunger.



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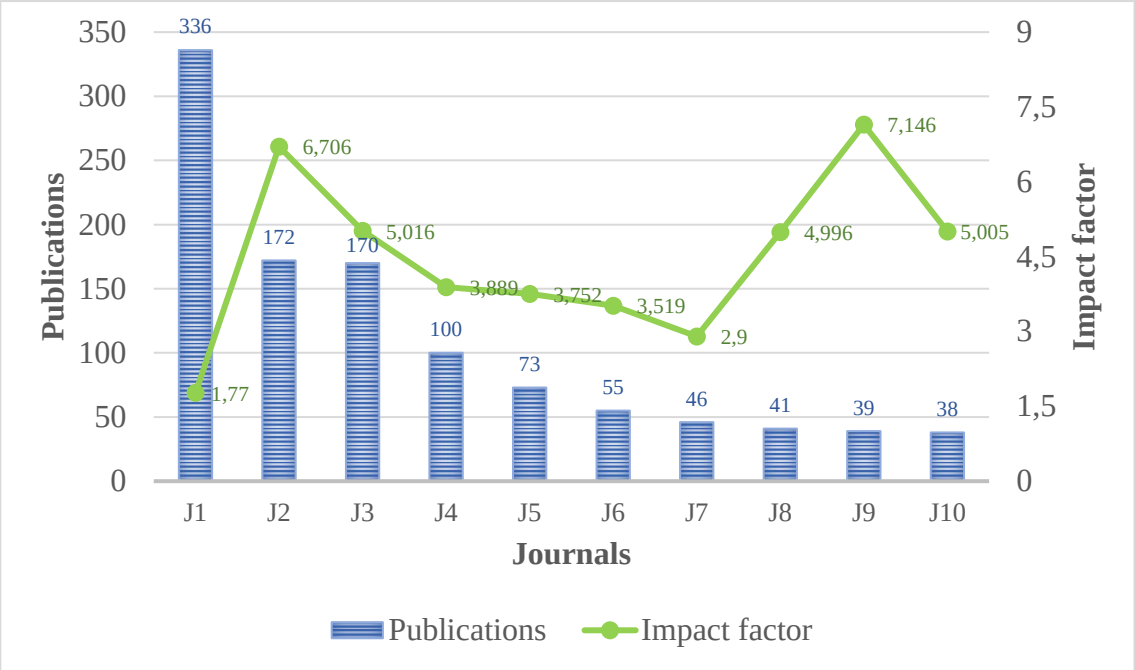
635 Figure 4 - Impact of scientific productivity related to food insecurity and the COVID-19
636 pandemic from 2020 to 2023.



637 J1: Journal of Hunger & Environmental Nutrition; J2: Nutrients; J3: Appetite; J4: Sustainability; J5: Plos
638 One; J6: International Journal of Environmental Research; J7: Physiology & Behavior; J8: Scientific
639 Reports; J9: Food Security; J10: Frontiers in Sustainable Food Systems.

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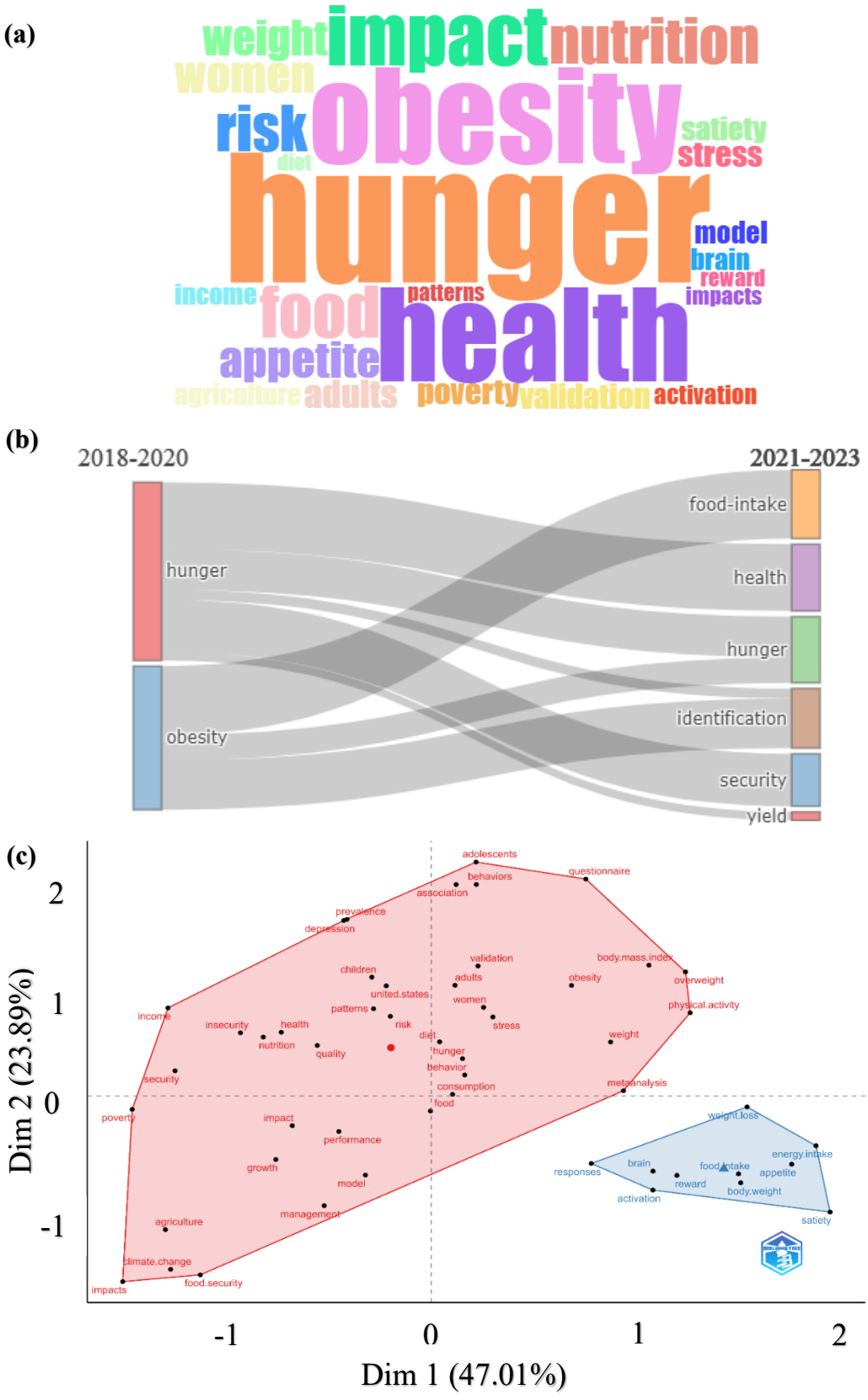
652 Figure 5 - Conceptual structure analysis by (a) WorldCloud, (b) thematic evolution and

653 (c) MCA of words related to food insecurity and the COVID-19 pandem



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Autor 1: pesquisa bibliométrica e escrita do artigo

Autor 2: Elaboração dos gráficos e escrita do artigo

Autor 3: Orientação geral do trabalho

Autor 4: Pesquisa e escrita

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