

Social determinants of Health and Google Trends: a worldwide infodemiological report

E. DI SIMONE¹, N. PANATTONI², S. DIONISI³, N. GIANNETTA⁴, E. RENZI⁵,
A. MASSIMI⁵, M. DI MUZIO¹, F. FABBIAN⁶

¹Department of Clinical and Molecular Medicine, "Sapienza" University of Rome, Rome, Italy

²Nursing, Technical, Rehabilitation, Assistance and Research Direction – IRCCS Istituti Fisioterapici Ospitalieri – IFO, Rome, Italy

³Nursing, Technical and Rehabilitation Department, DaTeR Azienda Unità Sanitaria Locale di Bologna, Bologna, Italy

⁴UniCamillus – Saint Camillus International University of Health and Medical Sciences, Rome, Italy

⁵Department of Public Health and Infectious Diseases, "Sapienza" University of Rome, Rome, Italy

⁶Department of Medical Sciences, University of Ferrara, Ferrara, Italy

ABSTRACT. – OBJECTIVE: Several sociodemographic variables are essential to the complete comprehension of people's health conditions. Also, social determinants of health are decisive in influencing people's health and healthcare strategy outcomes. Nevertheless, the level of awareness of the general population about the social determinants of health still seems poorly investigated. In this scenario, using an infodemiological approach, Google Trends represents a handy tool for monitoring internet-related search activities concerning this specific topic. This study aimed to assess the general population's consciousness about social determinants of health, testing widespread knowledge of these items and evaluating the association of the results obtained through Google-specific search volumes.

MATERIALS AND METHODS: Data were collected using the Google Trends tool using several search terms related to food, social problems, and economic issues, which are useful for defining some social determinants of health variables. Descriptive data analysis was performed to show the worldwide Relative Search Volume variations from 1 September 2013 to 31 August 2023. Pearson's correlation analysis tested Relative Search Volumes and later logarithmic transformation. The K-Nearest Neighbors analysis was used to define and assess Relative Search Volumes (RSV) associations.

RESULTS: The results have shown that the general population was mainly interested in topics such as "social support" and "economic burden", showing frequent peaks during the 10 years of the study. According to Pearson's coefficients test, other specific interests and relative correlations emerged regarding social variables (i.e., social support and social problems), food,

and financial distress. Moreover, the K-Nearest Neighbors analysis showed that searching activities for "social support", "lack of food", and "social problems" were highly related; for "economic burden", "financial burden", and "out of pocket" suggested the existence of financial distress.

CONCLUSIONS: The results of this study underline that social determinants of health are significant barriers to health and well-being and that non-medical factors should be considered more. Healthcare professionals involved in public health should study and understand more about the social determinants of health in relation to health outcomes to provide patient-centered care. Finally, this research suggests that we should encourage and maintain a more comprehensive approach to addressing the health needs of patients and communities, also by an infodemiological assessment.

Key Words:

Social determinants of health, Google trends, Infodemiology, Global search activity.

Abbreviations

WHO - World Health Organization; SDoH - Social Determinants of Health; COVID-19 - COroNaVIrus Disease 19; RSVs - Relative search volumes; RECORD - REporting of studies Conducted using Observational Routinely; SPSS - Statistical Product and Service Solution; Ln - logarithmic transformation.

Introduction

Social conditions, including environmental or political countries, represent relevant variables

influencing health conditions. The World Health Organization (WHO) underlines that social determinants can be more important than health care or lifestyle choices in influencing people's health¹. Nowadays, there is increased awareness that more than medical care alone is needed for improving health overall or reducing health disparities without addressing where and how people live². Health differences exist based on ethnicity, age, sex or gender identity and sexual orientation, socioeconomic status, disability, geography, and primary language. All these factors could be considered Social Determinants of Health (SDoH) and frequently cluster together and are associated with other patient demographic characteristics³. The non-medical factors influencing health outcomes define the SDoH. These parameters include the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems influencing daily life. National economic policies and systems, development agendas, social laws, social policies and political systems are strictly related to SDoH¹. Health inequities are strongly related to the SDoH. Income and social protection, education, unemployment and job insecurity, working life conditions, food insecurity, housing, the environment, early childhood development, social inclusion and non-discrimination, structural conflict and access to affordable health services of decent quality act as compelling reasons for reducing health¹.

Moreover, SDoH has been related to the development and increase of non-communicable conditions such as cardiovascular disease⁴, diabetes⁵, and kidney disease⁶. Indeed, kidney diseases have been associated with food insecurity in recent studies⁷ due to their relation of this condition with health outcomes. Healthcare professionals should understand the SDoH and their associations with health outcomes to provide patient-centered care. This is important, above all, for healthcare professional perspectives wholly oriented to the family and communities.

Despite that, the level of awareness of the general population about SDoH seems still poorly known⁸. A new way of investigating consciousness about specific items could be represented by evaluating access to internet data and its dissemination. The study of these data is called infodemiology or the science of distribution and determination of health information in an electronic medium. In 2002, Eysenbach⁹⁻¹¹ was the first in the world to define infodemiology, although it was used for the first time to identify misinforma-

tion. Google Trends is a handy tool for monitoring internet-related search activities concerning a particular topic.

Materials and Methods

This observational study follows the REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) guidelines¹².

This study aimed to assess the consciousness of the general population about SDoH by testing widespread knowledge on these items and to evaluate the association of the results obtained by Google Trends, a readily available and user-friendly tool to investigate health topics, being able to provide up-to-date and archived information on Google queries from 2004 onwards.

The relationship between health and healthy behavior could be unknown worldwide, especially if the educational level is low. A lower educational level was significantly associated with lower long-term health-related quality of life¹³. In order to study infodemiology, it is necessary to use internet data as an integral part of health informatics. Eysenbach^{10,11} defined this new science as "the science of distribution and determinants of information in an electronic medium, specifically the Internet, or in a population, with the ultimate aim to inform public health and public policy".

Health informatics research is based on internet data, which are increasingly integrated, and the most popular tool for examining online searches is Google Trends, an open tool providing information on trends and the variations of online interest in selected keywords and topics over time¹⁴.

Human behavior toward health topics and the prediction of disease occurrence and outbreaks appear to be associated with online search traffic data from Google. Google Trends allows information using appropriate keywords for specific interest areas or periods, and data express patterns and volumes of queries referring to one or more selected search terms¹⁴.

Relative search volumes (RSVs) represent percentages associated with a previously defined time frame and are numbers suggesting the search results but should not be interpreted as absolute search volumes. RSVs are, therefore, expressed in a data series on a normalized scale ranging from 0 to 100. When different search terms are analyzed, Google Trends permits comparisons of RSVs at a global level or sets other geographic

areas. Depending on different countries' populations, RSVs are standardized after adjusting the percentage for the population size of other countries using specific algorithms.

To detect the general population interest using search terms able to detect SDoH, we performed 2 consecutive analyses evaluating the search terms and comparing the RSVs worldwide.

In the first analysis, we used the search terms "medical expenses," "lack of food," "social problems," "cost of food," and "social support" to adapt our research to the primary language. In the second analysis, we explored the financial problems due to healthcare, exploring the search terms "economic burden," "out of pocket," "financial burden," "financial hardship," and "financial toxicity", the latter being a more technical concept. The period of time was set at 10 years, from 1st September 2013 to 31st August 2023.

Statistical Analysis

We performed a descriptive data analysis to show RSV variations during the study period. Mean values of RSVs associated with "medical expenses", "lack of food", "social problems", "cost of food", "social support", "economic burden", "out of pocket", "financial burden", "financial hardship" and "financial toxicity", were reported, as well as variations of RSVs. Moreover, associations between RSVs were tested by calculating Pearson's correlation after RSVs logarithmic transformation. The K-Nearest Neighbors analysis (with $K=3$) of the logarithmic transformation of RSVs was performed in order to classify cases based on their similarity to other cases. The K-Nearest Neighbors analysis (with $K=3$) was performed in order to determine whether the frequency with which something is observed spatially is comparable with other locations. It provides a numerical value for the 'clustering' of a geographical phenomenon, allowing this value to be compared more accurately with other places. The search terms used in this study expressed similar meanings; therefore, the K-Nearest Neighbor analysis was used to classify cases based on their similarity to other cases. The two groups of five search terms were analyzed in order to obtain a graph showing those search terms with the nearest RSVs. Data analysis was carried out using Microsoft Excel (Microsoft Corp., Albuquerque, NM, USA) and the Statistical Package for the Social Sciences (SPSS) 26.0 for Windows (IBM Corp., Armonk, NY, USA). A two-sided $p < 0.05$ was considered statistically significant¹⁵.

Results

The mean RSVs and their logarithmic transformation (\ln) associated with "social support", "lack of food", "social problems", "medical expenses", "cost of food", and the representing global searching activity are reported in Table I. Moreover, variations in RSVs during each month of the study period are shown in Figure 1.

RSV for "social support" was the highest (59.2 ± 11.8), and RSVs for "medical expenses" and "cost of food" were the lowest (18.4 ± 3.4 and 18.3 ± 2.8 , respectively).

The mean RSVs and their logarithmic transformation associated with "economic burden", "financial burden", "out of pocket", "financial hardship", and "financial toxicity", representing global searching activity, are reported in Table II. Variations in RSV during each month of the study period are shown in Figure 2.

RSV for "economic burden" was the highest (63.5 ± 14.4) and RSV for "financial toxicity" was the lowest (4.8 ± 4.7).

Pearson's coefficients of the natural logarithm of the RSVs associated with "social support," "lack of food," "social problems," "medical expenses," and "cost of food" are shown in Table III. RSVs related to "social support" and "social problems" were highly correlated ($r=0.805$, $p < 0.0001$); besides, a good correlation was found between "social support", "lack of food" ($r=0.400$, $p < 0.0001$), "cost of food" ($r=0.558$, $p < 0.0001$), and "medical expenses" ($r=0.469$, $p < 0.0001$); "social problems" and "cost of food" ($r=0.512$, $p < 0.0001$); "medical expenses" and "cost of food" ($r=0.561$, $p < 0.0001$). A lower correlation was detected between "lack of food" and "social problems" (0.229 , $p=0.012$) and "cost of food" (0.339 , $p < 0.0001$); "social problems" and "medical expenses" (0.363 , $p < 0.0001$). No correlation was found between "lack of food" and "medical expenses".

Pearson's coefficients of the natural logarithm of the RSVs associated with "economic burden", "financial burden", "out of pocket", "financial hardship", and "financial toxicity" are shown in Table IV. Correlation between search terms was weak and was significant only between "economic burden" and "financial burden" (0.320 , $p < 0.0001$), "financial burden" and "out of pocket" (0.306 , $p=0.001$), "out of pocket" and "financial hardship" (0.267 , $p=0.006$).

The K-Nearest Neighbors analysis (with $K=3$) for the five search terms "social support", "lack of food", "social problems", "medical expenses",

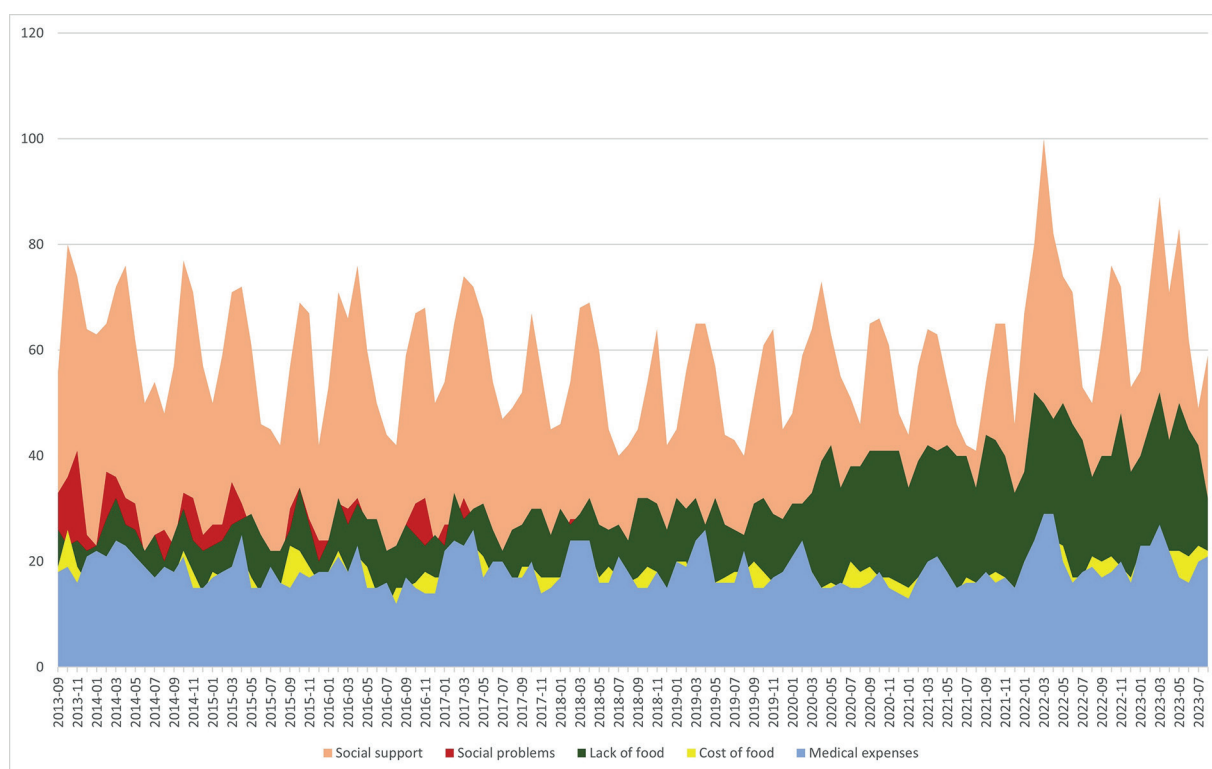


Figure 1. Monthly RSVs variation.

and “cost of food” is shown in Figure 3. Searching activities for “social support”, “lack of food”, and “social problems” were highly related. The K-Nearest Neighbors analysis (with K=3) for the five search terms “economic burden”, “financial burden”, “out of pocket”, “financial hardship”, and “financial toxicity” is shown in Figure 4. Searching activity for “economic burden”, “financial burden”, and “out of pocket” suggested the existence of financial distress.

Discussion

To the best of our knowledge, this seems to be the first study evaluating the infodemiology of SDoH. As the first step, it was challenging to select search terms commonly used in the health field to obtain information on difficulties related to decreased well-being. We set five search terms that could suggest seeking social help, such as “social support”, “lack of food”, “social problems”, “medical expenses”, and “cost of food”. Moreover, we selected five search terms that could suggest financial difficulties in the field of health, such as “economic burden”, “financial burden”,

“out of pocket”, “financial hardship”, and “financial toxicity”.

Our results have shown that the general population was mainly seeking social support and economic burden, both showing frequent peaks during the 10 years of the study. Apparently, there was an increasing search for financial obligations during the last period of the study. Seeking activities for “social support”, “social problems”, and “lack of food” were correlated, and these results were confirmed by K-Nearest Neighbors analysis, suggesting that the three search terms could identify a real problem in the general population.

Correlation between search terms that could identify economic problems was weaker than seeking activity for social help. Indeed, the correlation coefficient between economic and financial burden, financial burden and out-of-pocket, out-of-pocket, and financial hardship was below 0.400, although statistically significant. However, the K-Nearest Neighbors analysis revealed that financial distress could be identified by the search terms “economic burden”, “financial burden”, and “out of pocket”.

In our opinion, these results underline a certain degree of consciousness about SDoH of the gen-

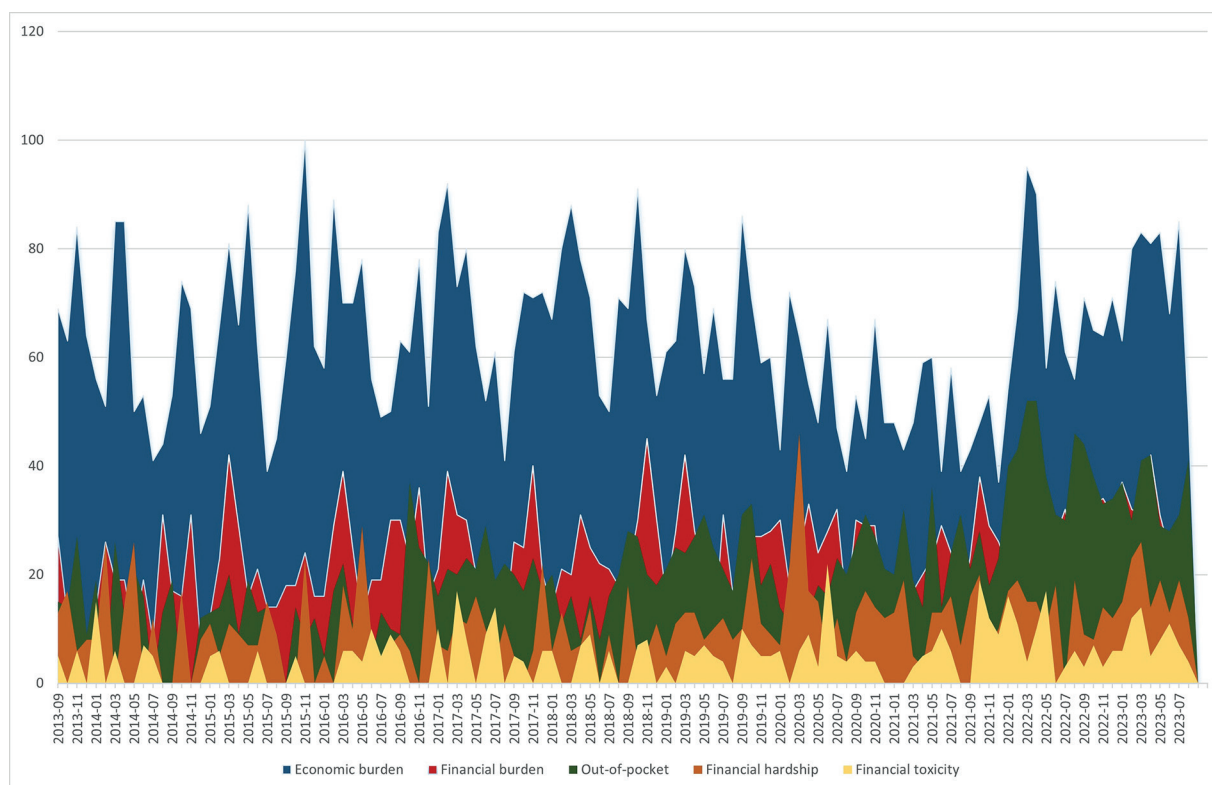
Table I. Global searching activity by mean RSVs and their logarithmic transformation.

	Relative Search Volume (RSV)	Ln (RSV)
Social support	59.2±11.8	4±0.2
Lack of food	32.1±8	3.4±0.2
Social problems	25.7±6	3.2±0.2
Medical expenses	18.4±3.4	2.9±0.2
Cost of food	18.3±2.8	2.8±0.1

Ln - logarithmic transformation.

eral population; however, it is essential to specify that using different search terms could give different RSVs. We agree that amelioration of public health is not uniquely related to access to high-quality, affordable health care. Our results underline that non-medical factors should be taken into account. SDoH are significant barriers to health and well-being. A more comprehensive approach to address the health drivers of patients and communities should be encouraged and sustained after an infodemiological assessment. Monitoring World Wide Web activity can provide valuable insights by analyzing user search behavior. SDoH

could cause stress because of the inability to pay bills, lack of money for buying food, lack of money for eating healthy and balanced meals, and, ultimately, making ends meet. Financial problems due to the high cost of healthcare are a well-known phenomenon in people with cancer¹⁶⁻²². More recently, chronic conditions, polypathology and comorbidities have been considered causes of financial distress among affected individuals²³⁻²⁹. Due to the high costs of chronic disease management, financial stress negatively influences the well-being of individuals and their families³⁰⁻³². Adherence to treatment in people suffering financial

**Figure 2.** Monthly RSVs variation.

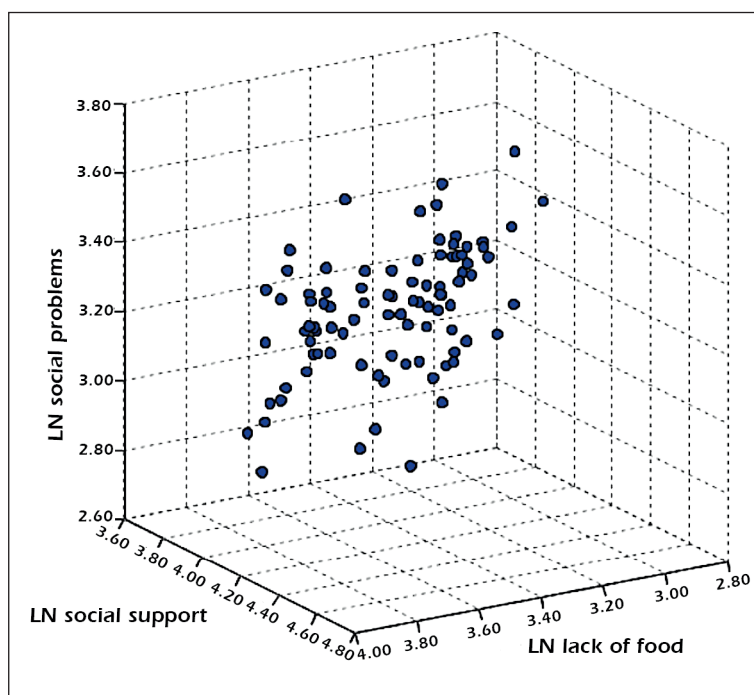


Figure 3. K-Nearest Neighbour analysis (K=3) graph.

distress is scarce³¹, resulting in worse survival³³. Out-of-pocket expenses, medical debt and loss of work are the significant consequences of managing chronic conditions in low-income people³⁴⁻³⁸. The coexistence of multiple pathologic conditions is more frequently encountered in low-income people³⁹. On the other hand, low socioeconomic status is associated with an early onset of multimorbidity⁴⁰. People living in socioeconomically deprived areas develop multimorbidity 10 to 15 years earlier than those from wealthier places⁴⁰. Both healthcare systems and individual patients need to pay for multimorbidity; therefore, referrals to financial assistance programs and community resources could be helpful. Drivers that

include poverty, racism, housing, food security, social isolation, discrimination, environmental exposures, and limited educational and economic opportunities are causes of financial distress, especially in the case of chronic disease development. Different and more integrated health systems should be able to consider and address the SDoH. In order to obtain such a target, an organizational commitment to address health-related challenging social conditions and health disparities is necessary. It would be appropriate to screen patients for social needs and provide personalized assistance in accessing services to address those real needs detected. Healthcare professionals, particularly nurses, should collaborate with part-

Table II. Global searching activity by mean RSVs and their logarithmic transformation.

	Relative Search Volume (RSV)	Ln (RSV)
Economic burden	63.5±14.4	4.1±0.2
Financial burden	24.2±8.7	3.1±0.4
Out of pocket	21.6±10.9	3±0.5
Financial hardship	11.1±7.4	2.4±0.5
Financial toxicity	4.8±4.7	1.9±0.4

Ln - logarithmic transformation.

Table III. Pearson’s coefficients of RSVs and Ln.

	Social support	Lack of food	Social problems	Medical expenses	Cost of food
Social support	1	0.400 <i>p</i> <0.0001	0.805 <i>p</i> <0.0001	0.469 <i>p</i> <0.0001	0.558 <i>p</i> <0.0001
Lack of food	0.400 <i>p</i> <0.0001	1	0.229 <i>p</i> =0.012	0.149 <i>p</i> =0.102	0.339 <i>p</i> <0.0001
Social problems	0.805 <i>p</i> <0.0001	0.229 <i>p</i> =0.012	1	0.363 <i>p</i> <0.0001	0.512 <i>p</i> <0.0001
Medical expenses	0.469 <i>p</i> <0.0001	0.149 <i>p</i> =0.102	0.363 <i>p</i> <0.0001	1	0.561 <i>p</i> <0.0001
Cost of food	0.558 <i>p</i> <0.0001	0.339 <i>p</i> <0.0001	0.512 <i>p</i> <0.0001	0.561 <i>p</i> <0.0001	1

Ln - logarithmic transformation; RSVs - Relative search volumes.

ners belonging to different sectors to improve healthcare, including public health and social services, and ask for support and the strengthening of these systems, which are often underfunded, poorly linked (or even isolated) by other services, and under-resourced.

For example, referring to the difficulty in accessing a healthy and balanced diet, a person is defined as food insecure when “he/she lacks regular access to enough safe and nutritious food for normal growth and development and active and healthy life. This may be due to unavailability of food and/or lack of resources to obtain food.

Food insecurity can be experienced at different levels of severity⁴¹. We decided to avoid the use of the search term “food insecurity” because we are not sure that the general population knows its meaning. We used more understandable search terms such as “lack of food” and “cost of food”. In 2022, Sigalo et al⁴² developed a predictive model for identifying food deserts in the United States using the linguistic constructs found in food-related tweets. However, our design was completely different; we investigated Google Trends, and it is not a social environment. One of the main problems of the study, which was designed on the

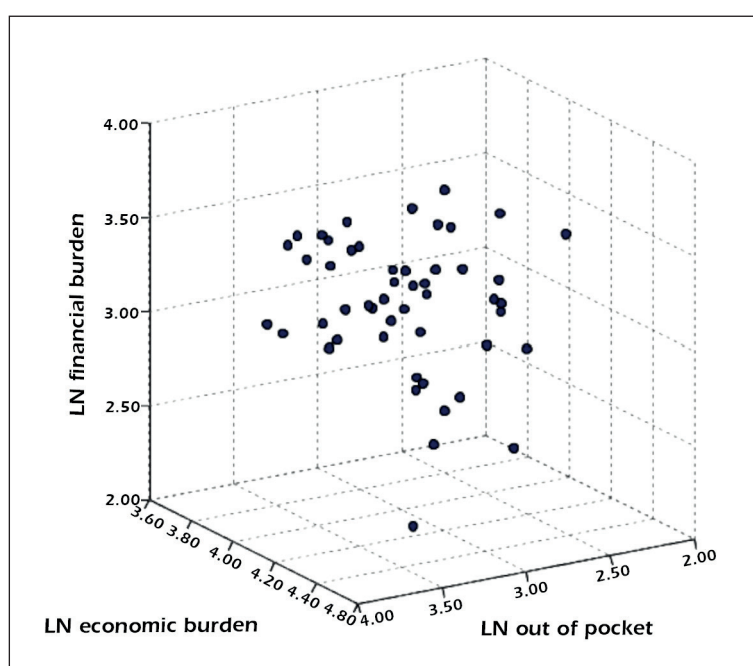


Figure 4. K-Nearest Neighbour analysis (K=3) graph.

Table IV. Pearson’s coefficients of RSVs and Ln.

	Economic burden	Financial burden	Out of pocket	Financial hardship	Financial toxicity
Economic burden	1	0.320 <i>p</i> <0.0001	0.115 <i>p</i> =0.220	0.065 <i>p</i> =0.508	0.096 <i>p</i> =0.339
Financial burden	0.320 <i>p</i> <0.0001	1	0.306 <i>p</i> =0.001	0.091 <i>p</i> =0.354	0.100 <i>p</i> =0.379
Out of pocket	0.115 <i>p</i> =0.220	0.306 <i>p</i> =0.001	1	0.267 <i>p</i> =0.006	-0.031 <i>p</i> =0.788
Financial hardship	0.065 <i>p</i> =0.508	0.091 <i>p</i> =0.354	0.267 <i>p</i> =0.006	1	0.046 <i>p</i> =0.702
Financial toxicity	0.096 <i>p</i> =0.399	0.100 <i>p</i> =0.379	-0.031 <i>p</i> =0.788	0.046 <i>p</i> =0.702	1

Ln - logarithmic transformation; RSVs - Relative search volumes.

use of Google Trends, is to think about words that the general population associates with conditions defined by healthcare professionals because the specialist language could be very different from the colloquial one. According to our assessment, “lack of food” and “cost of food” are very colloquial terms many people use.

Financial hardship experienced by the patients/families was defined in different ways, such as financial toxicity⁴³, economic/financial burden of disease¹⁶, cost-related nonadherence⁴⁴, cost-related prescription delay⁴⁵, medical financial hardship⁴⁶, and financial stress/strain/distress⁴⁷. These terms describe people’s feelings and experiences about financial resources and suggest behavior due to economic circumstances⁴⁸. Financial distress secondary to financial obligations and debt and the erosion of wealth may consume people’s ability to cope effectively with a disease, its physical symptoms, and its treatment, adversely affecting health outcomes and potentially creating a vicious cycle of mounting expense. Families often have to change their financial behavior, adjusting their budget and costs, especially if cancer is diagnosed, due to the negative impact of the disease on household income⁴⁹.

Limitations

We are aware of the several limitations of this study. First, the study design does not help provide information about the prevalence of SDoH but is productive in gaining knowledge of the conditions in the general population. Google Trends simply describes RSVs for English search terms, and the results obtained were merely shown. Second, we did not focus on specific countries but described the global situation. We limited to the

most colloquial English terms and did not perform specific searches in the other languages of different countries. This attitude probably excluded all people from the poorest areas of the world.

Moreover, to collect data with this type of infodemiological study, people must be familiar with information technology and know how to search for information on Google. Third, we could not understand the profiles of the search populations since the association between individuals and queries in the Google database is unknown. Google Trends does not record information about any user’s identity, internet protocol address or specific physical location. Finally, the technology used in this study is Web 1.0, then the social media data were not considered.

Conclusions

The right to an adequate standard of living is one of the universal human rights⁵⁰. Although SDoH has been defined, the effect of mounting financial obligations and debt and the erosion of wealth still reduce the patient’s ability to cope effectively with several diseases, increasing physical symptoms, adversely affecting health outcomes, and potentially creating a vicious cycle. These, particularly the specific strategies to reduce them, are poorly frequently discussed and studied in the literature.

Actual knowledge about effective interventions that can improve medical financial hardship is scarce. A scoping review⁵¹ of behavioral interventions addressing medical financial hardship published in 2021 could not demonstrate a significant reduction in out-of-pocket expenses, perceptions of financial burden/toxicity, or health status. Hamel et al⁵² reported how behavioral science, which leads

the development and evaluation of apps to support patients with cancer, could help them cope with the disease. By the use of infodemiology in the field of SDoH, it could be possible to monitor people's interest in viable strategies and solutions to improve their quality of life. Finally, artificial intelligence is increasingly used in medical fields such as cardiology⁵³, and it could be the appropriate means to weigh the impact of SDoH on well-being.

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethics Approval

Ethical review and approval were waived due to the design of the study.

Informed Consent

Not applicable due to the design of the study.

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Authors' Contributions

EDS and FF designed the study. MDM and FF conducted data collection. NP, SD, NG and ER analyzed the data and interpreted the results. EDS, NP, and AM wrote the paper. EDS, NP and FF reviewed and validated the themes. FF, MDM and AM provided critical scientific input, review, and revisions. All authors contributed to revising the manuscript and gave substantive feedback. All authors read and agreed to the published version of the manuscript.

ORCID ID

Emanuele Di Simone: 0000-0002-6373-8163
Nicolò Panattoni: 0000-0002-4162-937X
Sara Dionisi: 0000-0001-7933-8490
Noemi Giannetta: 0000-0003-4575-1898
Erika Renzi: 0000-0001-9760-0245
Azzurra Massimi: 0000-0001-6612-2949
Marco Di Muzio: 0000-0003-2641-4044
Fabio Fabbian: 0000-0001-5189-3695

Data Availability

The datasets generated and/or analyzed during the current study are publicly available in Google Trends and are available from the corresponding author upon reasonable request.

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