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Original Research

Social network research hotspots and trends in public health: A bibliometric and visual analysis

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ABSTRACT

Objectives: To understand the research landscape and identify the research hotspots and trends of the application of social network theory and analysis to public health.
Study design: A bibliometric study of publications regarding application of social network theory and analysis to public health.
Methods: Choosing 1607 articles about the application of social network theory and analysis to public health from the core collection database of Web of Science published from 1991 to 2020 as the research sample. A bibliometric and visual analysis of publication quantity and content was performed to analyze time trends, spatial distribution, cooperation networks, influential references, and keyword co-occurrence, clusters, and emergence.
Results: There is an increasing trend in the use of social network theory and analysis in the public health field, with the United States taking the lead. Research focuses include on transmission of diseases or behavior through social networks and the influence of social networks on population health at different ages. Current research frontiers primarily include the role of social networks in tracking of emerging infectious diseases like COVID-19, preventing and controlling chronic diseases, and carrying out healthy behavioral interventions.
Conclusions: This study provides a comprehensive quantitative overview of the historic development of and latest topics in the application of social network theory and analysis method to public health. More attention should be paid to the important role of social networks in tracing the emergence of serious infectious diseases like COVID-19, as well as preventing and controlling chronic diseases and intervening in health behaviors, considering the increasing challenges and opportunities presented by online social networking.

1. Introduction

In recent decades, public health researchers have become aware that many of the topics we study are inherently relational, meaning that people's health is interdependent, and that health and health care can transcend the individual, for example in the case of disease transmission and peer influence on risky behavior [1,2]. These phenomena cannot be explained by traditional individual-level statistical methods. Social network theory and analysis (SNT/A), a method that originated in sociology and behavioral science [3,4], provides an appropriate and unique perspective for studying these problems, by enabling public health researchers to use theories and models expressed in terms of relational concepts or processes to study the health of a population, rather than regarding individuals as independent of or separated from the social context in which they live [1,5,6].

SNT/A has been increasingly widely applied to several research topics in the field of public health, primarily the associations between the structural and functional characteristics of social networks and health outcomes [7–11], transmission of diseases or health-related behaviors or information within a social network [1,12–14], and social network–based health interventions [15,16]. Recently, the development of network analysis techniques, technological innovations in communication, and changes in theoretical perspectives to include a focus on social and environmental behavioral influences have created opportunities for an even broader application of SNT/A to public health research [17]. The size of social networks and the strength of the links within these networks continue to increase, owing to advances in computing technology and the use of online or social networking media; thus, it is

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necessary to further discuss the impact of online social networks on health, given that these online social contacts now constitute a major part of people's social networks [17]. Public health researchers have also placed increasing emphasis on the influence that social context has on health, and especially on the development of chronic non-communicable diseases (NCDs), which are a major public health concern [18]. As such, more studies using SNT/A to guide interventions to prevent and control risk factors of NCDs are expected to be performed in the future.

Reviewing the past applications of a research method is an important reference for identifying research gaps and promoting the future development of the approach. Luke and Harris qualitatively reviewed the historical development, methods, and application of network analysis in the field of public health as early as 2007 [1]. Ten years later, Valente and Pitts reported on the challenges and opportunities of SNT/A as applied to public health [17]. However, to date, a comprehensive quantitative overview of the development of this interdisciplinary field, which can provide precise quantitative evidence to guide its development, has not been reported. In addition, as mentioned above, given the rapid development of online social networking and an increasing emphasis on social environment in recent years, especially with the emergence of COVID-19 as a hot public health topic in 2020, it is likely that there have been new applications of SNT/A to public health since Shelton's review was published. Thus, it is necessary to provide an update on the field that highlights new focuses and trends that have emerged since the previous review.

Bibliometrics, an emerging field of information science, is useful for gaining insights into a research activity to identify hotspots and academically significant and landmark publications [19]. Bibliometric analysis is a method that has been widely utilized in interdisciplinary research to identify hidden or emerging subjects [20], which can help researchers and funding agencies to focus more on valuable under-investigated topics in public health [21].

The purpose of this study was to perform a bibliometric analysis to understand the state of the research field based on publications and their relationships by identifying core authors, research institutions, countries, hotspots, evolution, and emerging trends. The primary aim of this study was to determine the research landscape of the application of SNT/A to the field of public health in terms of quantity and content through (1) time trend analysis of publication volume, (2) spatial distribution analysis of publication quantity and cooperation network analysis of countries/regions and institutions, (3) network analysis of co-cited references, (4) keyword co-occurrence analysis, and (5) keyword emergence analysis.

2. Methods

2.1. Data source

We retrieved data from the core collection database of Web of Science (WOS) from 1991 to 2020, limiting searches to the Science Citation Index (SCI), Social Science Citation Index (SSCI), Conference Proceedings Citation Index-Science (CPCI–S), and Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH).

2.1.1. Search strategy

The search rule was: TS=((“social network*” OR “social relationship*” OR “social *connect*” OR “social tie*” OR “social contact*”) AND (“public health” OR “disease* prevent*” OR “health* behav*”)). The language was limited to English, the literature type was limited to article, and the time span selected was from January 1970 to August 2020. The search was conducted on September 1, 2020.

2.2. Data analysis and visualization

Microsoft Excel 2016 was used to quantify publications on an annual basis. CiteSpace 5.7.R1, which is suitable for analyzing literature co-citations and keyword co-occurrence in large samples, was used to conduct knowledge graph analysis and visualization [22]. As for the CiteSpace parameter settings, the years slice was set as 1. We chose the term source in the text processing, including title, abstract, author keywords, with the data extraction object of Top 30. In addition, we selected pathfinder to prune the merged network because it can simplify the network and highlight the important structural features [23].

3. Results

3.1. Publication trends over time

To identify publication trends related to SNT/A and public health since 1991, we performed a keyword search of the WOS and quantified the number of the publications containing the search terms per year. After duplicates were removed, a total of 1607 articles remained. Fig. 1 shows the time distribution results for the 1607 publications related to the SNT/A applied in the field of public health in the WOS core collection, published from 1991 to 2020. Over this time period there was an overall upward trend with two distinct stages: exploratory development (1991–2007) and rapid development (2008–2020).

3.2. Spatial distribution of publications and their cooperation networks

To determine the spatial distribution of publications and their cooperation networks, we analyzed cooperation between institutions and countries/regions. Fig. 2a shows the network of cooperation between countries/regions. Fig. 2b shows the network of cooperation between institutions. The country with the most publications was the United States (786), followed by England (183) and Australia (133). England (centrality = 0.71), the Netherlands (centrality = 0.52), and France (centrality = 0.47) exhibited the most centrality, indicating that they collaborated directly or indirectly with many countries in the co-existing network. The United States had the most institutions with a large academic output in this field, and the main research institution from this country was Harvard University (58). For England, The University College of London (29) was the leading institution. The University of North Carolina (centrality = 0.29) and Johns Hopkins Bloomberg School of Public Health (centrality = 0.29) were the core institutions driving social network research in the field of public health.

At the national level, European countries had higher centrality than the United States, despite the United States having the highest volume of publications. At the institutional level, the institutions with the highest centrality were mostly from the United States. This suggests that there was more international collaboration among institutions from European countries, such as Britain, France, the Netherlands, Sweden, and Switzerland, and less collaboration with countries outside Europe. There was more domestic cooperation among institutions in the United States and less international cooperation outside the United States. Harvard University, the University College of London, the University of North Carolina, and Johns Hopkins Bloomberg School of Public Health were very active in the cooperation network.

3.3. Network analysis of co-cited references

To identify the core references in this field, we analyzed the co-citation networks. Fig. 3 shows the evolution of the co-citation network over time, as well as the key authors and references. These researchers and their research results are important foundations of the application of SNT/A to the field of public health. Among the top 11 most highly cited references are five papers published by N.A. Christakis's team, which demonstrates that Christakis's research results played an important role in the development of this field and helped establish the social contagion of chronic diseases and health behaviors as a research hotspot in this field.

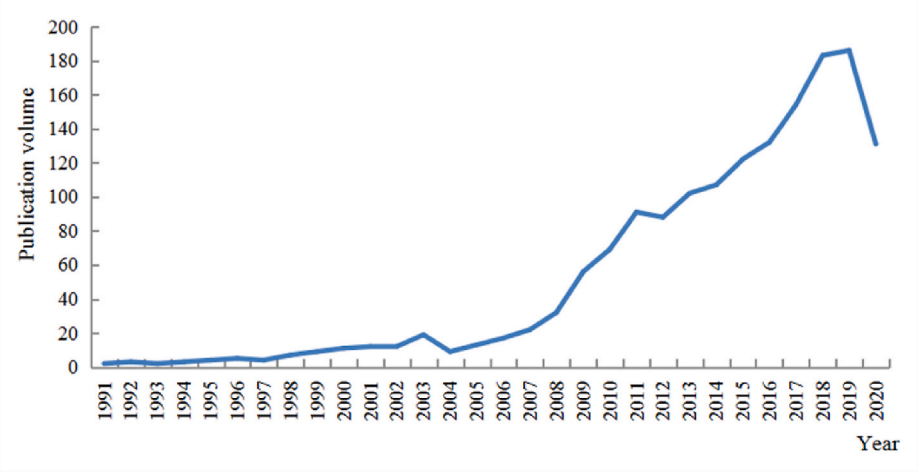


Fig. 1. - Time trends in publications related to the application of social network theory and analysis to public health from 1991 to 2020.

Keyword co-occurrence analysis; Keywords reflect the research focus of publications. Therefore, we analyzed the co-occurrence of keywords to explore research hotspots and frontiers in the field of social networks applied to public health. As Fig. 4 shows, the keywords were divided into ten significant clusters (Q = 7010, S = 0.8211), including age, transmission, children, sexually transmitted diseases, context, and COVID-19. Due to the similarity in content of some of the clusters, we then grouped the clusters into two broader, more comprehensive categories: people of different ages (Clusters #0 "age", #2 "children", and #8 "loneliness") and transmission (Clusters #1 "transmission", #3 "sexually transmitted disease", and #5 "COVID-19"), which represent the influence of social networks on population health at different ages and transmission of diseases or behavior through social networks, respectively.

Keyword emergence analysis; Keywords with strongest citation bursts refer to keywords whose frequency increases rapidly in a certain period of time, which can be used to predict new trends. Combined with emergence analysis and time view, emergent keywords can vividly show the evolution trend of the research topic over time. Fig. 5 shows 25 keywords related to the application of SNT/A to public health with strongest citation bursts over time, which shows the continuing evolution of research progress in this field. As for health outcomes, there was an obvious relationship between mortality and some specific diseases or health issues, such as heart disease, stress, HIV, influenza, overweight or obesity, and health equity. The main determinants related to social networks also shifted from social support to social contact and social capital. As for the data source, there was a clear transition from cohort data to online data. Thus, the transmission and dynamics of diseases or behaviors in social networks have become a single research focus.

4. Discussion

4.1. Time trends, space distribution and core academic groups

We found an increasing trend in the number of papers in the published literature that applied SNT/A to public health. This was consistent with the increasing focus on this research field in recent years and the wider application of social networks to many areas of public health research including mortality [24], quality of life [25], specific infections [26,27], chronic diseases [13], risky or healthy behavior [12,28,29], mental health [30], and health equity [31].

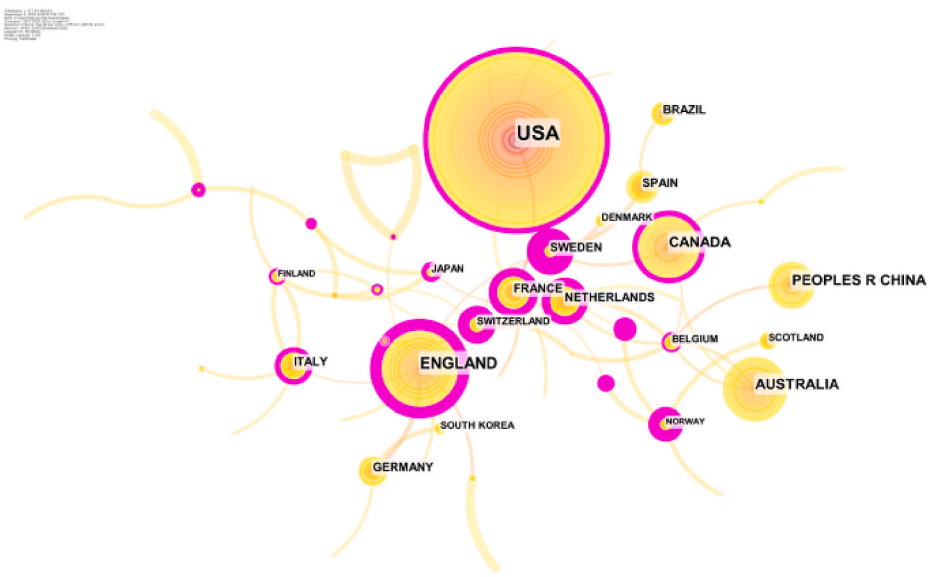
The rapid development of this research field beginning in 2008 is most likely related to several articles published in top medical journals by Christakis's team in 2007–2008 [12,13,32] that were also identified as core references in the field. Christakis et al. analyzed a large social network based on the Framingham Heart Study cohort data and concluded that obesity can be spread through social networks [13]. However, the article caused considerable controversy shortly after it was published. For example, Cohen-Cole and Fletcher [33] contended that failure to include contextual effects could lead to spurious inferences regarding "social network effects"; and indeed, when they attempted to replicate Christakis's results they found that point estimates of the "social network effect" were reduced and became statistically indistinguishable from zero once standard econometric techniques had been applied. Despite the controversy, more studies have explored the spread of poor fitness [34], adolescent weight gain [35], and fertility behavior [36] throughout social networks since then.

We identified close cooperation among some countries and institutes, with the United States taking the lead in this field of research, and two core academic groups forming within the United States and Europe. Harvard University, the University College of London, the University of North Carolina, and the Johns Hopkins Bloomberg School of Public Health were very active, so researchers can consider strengthening collaborative links and communications with these institutions to help them carry out research in the local social context.

4.2. Research hotspots, evolution, and frontiers

Distinct research focuses within the field of SNT/A in public health were clearly defined in terms of co-citation clusters, as the modularity of the network was relatively high (Q = 0.7010, mentioned as above) [22]. The two primary research focuses to date are the influence of social networks on population health at different ages and transmission of diseases or behaviors through social networks.

The first main research focus reflects the impact of social networks on population health at different ages, especially in children and the elderly. Peer influences on adolescent obesity and health behaviors, such as smoking [37–39], alcohol use [39–41], and physical activity [42], are major focuses in the field. As for elderly populations, researchers typically focus on the impact of social networks on mental health [30], quality of life [25], and health behaviors including engagement in physical activity, alcohol abuse, and use of complementary and alternative medicine [43]. For instance, Seeman et al. [30] evaluated whether social contacts, support, and social strain/conflict were related to executive function and memory abilities in middle-aged and older adults, and concluded that positive and negative aspects of social relationships were related to cognition throughout adulthood, and that social engagement could thus be an important factor to consider to promote optimal cognitive development and aging. The "loneliness" co-citation cluster in this category highlights the important role that



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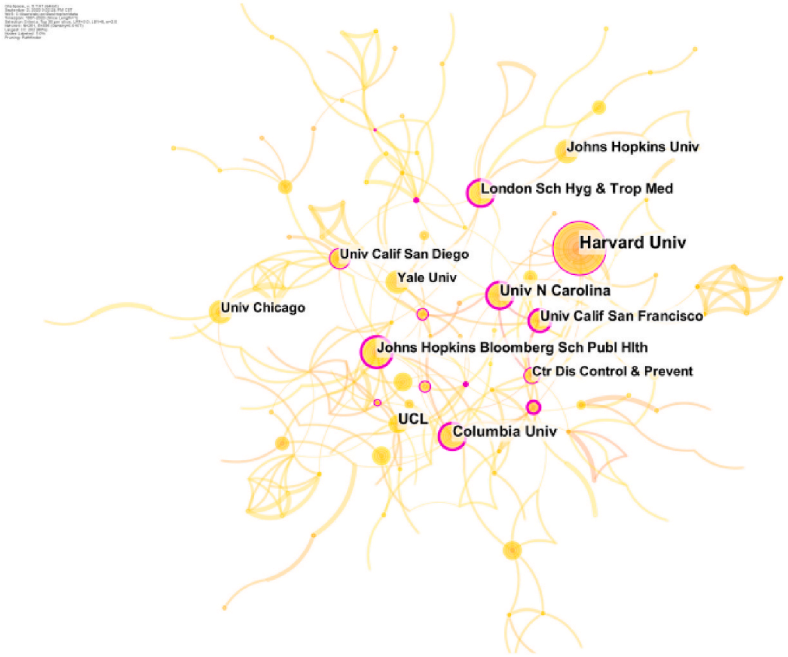

（b）

Fig. 2. - Cooperation network graph of country/region (a) and institution (b)[a].

[a] The size of each ring represents the number of publications (the larger the ring, the greater the number), and the thickness of the outer purple ring indicates centrality (the thicker the purple ring, the greater the centrality). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

social isolation and loneliness play as risk factors for morbidity and mortality in the elderly [24].

The second of the two focuses mentioned above, namely transmission of infectious diseases, chronic diseases, or health behaviors within social networks, demonstrates one of the most valuable contributions of SNT/A to public health research. Early researches regarding SNT/A in public health classically focused on the transmission of infectious diseases especially HIV/AIDS [17]. Watts et al. pointed out that infectious diseases spread more easily in small-world networks rather than in regular lattices [44]. Researches regarding SNT/A in public health subsequently transitioned from a focus on infectious diseases to chronic diseases. Christakis's team initiated a wave of research into the transmission of chronic diseases and health behaviors within social networks, as described above [12,13,32]. The "sexually transmitted disease" cluster within this category was consistent with the large number of studies on the spread of sexually transmitted diseases within social networks. Most of these studies are related to HIV and risky behaviors associated with transmission of this virus, such as sexual behaviors and injection drug use [45–48]. A "COVID-19" cluster was also apparent in this category, reflecting the application of social network

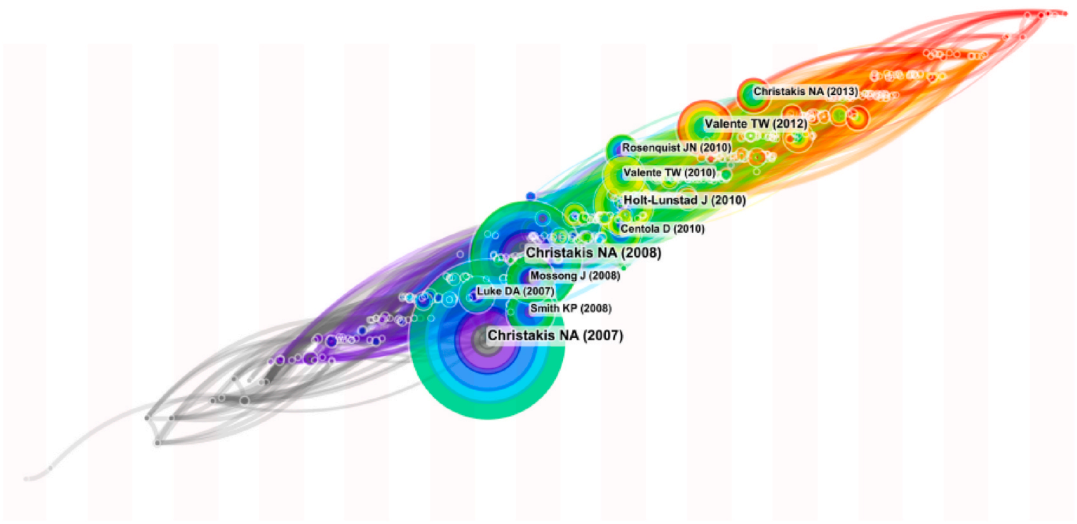

Fig. 3. - Co-citation network of publications over time.

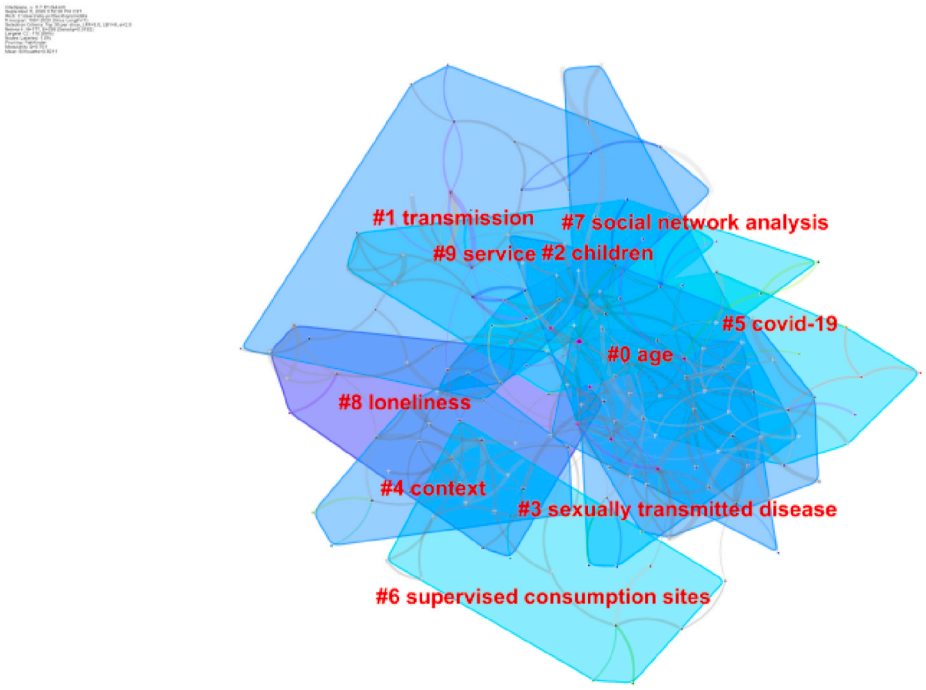

Fig. 4. - Clustering graph of keyword co-occurrence.

theory to the study of the spread of COVID-19. Similar to many other respiratory infectious diseases, COVID-19 is transmitted by droplets, and thus spreads easily to social contacts [49]. Many researchers have focused on tracking the social contacts of COVID-19 patients to trace possible transmission paths, and advocate reducing social contacts to a minimum to control the COVID-19 pandemic [50,51]. As the SNT/A method could provide important insight into the study of emerging infectious diseases such as COVID-19, more applied studies relevant to this topic are expected to be published in the future.

We identified four main topics that have trended in the field over the past 30 years, namely: the impact of social support on health, the impact of social capital on health inequity, the dynamics of disease or health behavior transmission, and health research based on online social networks. Social support and social capital were the most important functional characteristics of social networks and using network analysis to understand how social support and social capital influence health has been one of the largest areas of social network research in public health [1,11,52]. The development of the Internet has strengthened social contacts, and health is likely to be influenced by online social networking [53,54]. This has presented challenges in terms of researching disease, behavior, and information transmission networks, but also opportunities in the form of empirical studies [54] and intervention studies [55] performed based on online social networks.

4.3. *Strengths and limitations*

Unlike previous qualitative reviews, this is the first study to quantitatively and intuitively describe the application of SNT/A to the field of public health, and as such will serve as a valuable reference for researchers in this field. However, there were some limitations. The article language was limited to English, so non–English-language articles published in local journals were not included. In addition, the search

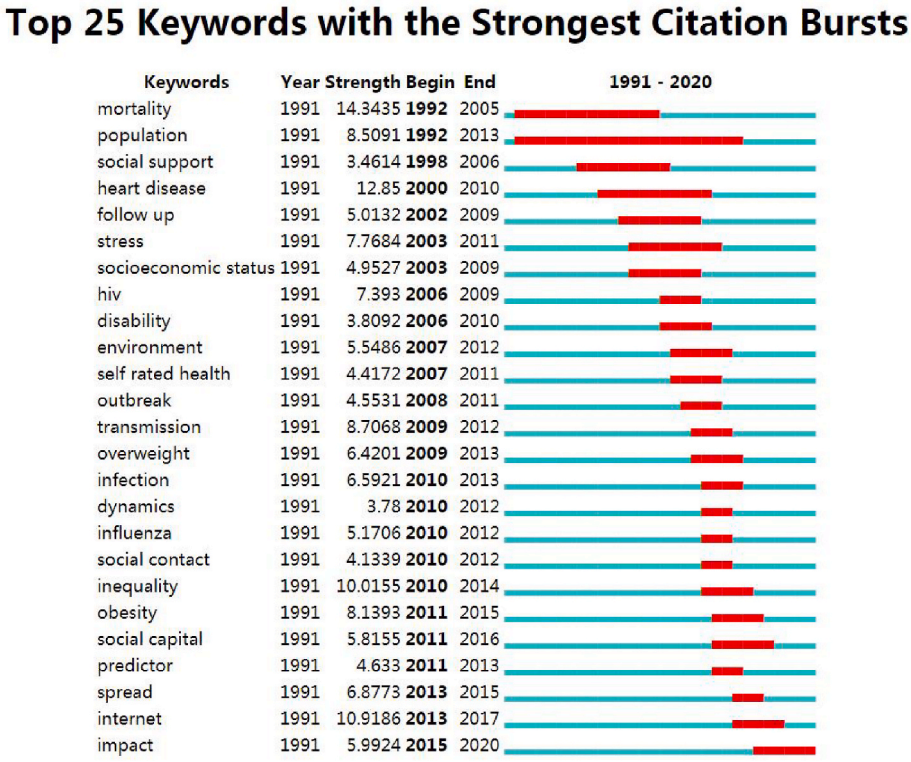

Fig. 5. - Keywords with the strongest citation bursts[a,b,c].
[a] Year means the earliest year of all publications being analyzed. [b] Strength is an indicator related to the frequency of the keyword in a short time (the higher the strength, the higher the frequency). [c] Begin and end refers to the year of beginning and ending of the emergence of keywords, respectively.

strategy most likely did not cover all topics in the field of public health, as some disease-specific studies may not have been identified by the search terms that we used.

5. Conclusions

This study provides a comprehensive quantitative overview of the historic development of and latest topics in the application of social network theory and analysis method to the field of public health. The results from this study will help researchers quickly identify important references, scholars or academic groups that should be collaborated with, and new research directions in this field. There are many sub-fields that are worthy of further attention, such as social contagion, social capital, and social support, and further bibliometric analysis is needed to provide a more systematic and in-depth understanding of these aspects of the field. More attention should be paid to the important role of social networks in tracing the emergence of serious infectious diseases like COVID-19, as well as preventing and controlling chronic diseases and intervening in health behaviors, considering the increasing challenges and opportunities presented by online social networking.

Ethics approval

None sought. This study was a secondary analysis of publicly available data, therefore ethical review and consent were not required.

Conflict of interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in the manuscript.

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