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RESEARCH ARTICLE

A GLOBAL BIBLIOMETRIC ANALYSIS OF LONELINESS DURING THE COVID-19 PANDEMIC: FUTURE RESEARCH AND POLICY IMPLICATIONS

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ABSTRACT

INTRODUCTION

Under the profound impacts of the COVID-19 pandemic, loneliness has become a major public health concern worldwide. This study is conducted to systematically evaluate existing literature on loneliness during the pandemic to identify research trends and knowledge gaps for future studies and policy developments.

METHODS

Original articles and reviews related to COVID-19 loneliness, published from 2020 to 2023, were retrieved from the Web of Science database. Research collaboration and keyword co-occurrence analyses were performed using VOSviewer software. Latent Dirichlet Allocation algorithm from STATA was used to analyze common topics and research trends.

RESULTS

From 2020 to 2023, a total of 3,817 publications on COVID-19 loneliness were extracted. Regarding international collaboration, the United States and England produced the largest research output and had the most extensive network collaboration with other countries in the field. Main research topics included the risk factors for loneliness during the pandemic, its impacts on people's well-being, and social support interventions. However, there is a lack of research on adolescents, children, and behavioral changes such as increased smoking, unhealthy alcohol consumption, and substance use due to loneliness during the pandemic.

CONCLUSIONS

Our study highlights an increasing interest in research on loneliness during the pandemic and suggests the need for enhanced global cooperation between developed and developing countries. Moreover, researchers and policymakers should focus more on the long-term effects of COVID-19 loneliness on adolescents and children, behavioral lifestyle changes, as well as targeted social support programs using family-based interventions and communication technologies.

KEYWORDS

COVID-19, loneliness, bibliometric, mental health, adolescent, children, social support

INTRODUCTION

Loneliness during the COVID-19 pandemic is drawing significant public interest as a major health challenge and policy concern worldwide. Although loneliness was recognized as an emerging public health issue even prior to the pandemic [1,2], the stringent enactment of social distancing measures during the pandemic, such as quarantine, lockdown, and school closures, has severely compromised ongoing efforts against this health issue. Given the worsening levels of loneliness globally induced by the pandemic [3] and its attendant negative impacts on people's well-being [4–7], numerous relevant articles from various research fields such as psychology, geriatrics, healthcare sciences, and social sciences have been promptly published during the COVID-19 timeline (2020-2023) [8]. This requires a comprehensive and systematic summary of the heterogeneity of ongoing COVID-19 loneliness research from diverse sectors, for effective policy development and intervention updates. Therefore, in this study, we conducted a bibliometric analysis to quantitatively and qualitatively synthesize existing studies on loneliness during the pandemic, providing further insights into this critical area of research.

Although there are several systematic reviews of loneliness during the pandemic, our bibliometric study extends from the scope and methods of previous research by incorporating publications from multiple domains. Pai & Vella (2021) conducted one of the first reviews of the literature on COVID-19 loneliness, focusing on the adverse health impacts of loneliness on people's well-being during the pandemic [9]. Subsequently, Ernst et al. (2022) provided meta-analysis evidence on levels of loneliness before and during the pandemic, confirming an overall increase in loneliness since the onset of the health crisis [3]. Other review efforts have further examined varying degrees of loneliness among older adults [10], and adolescents and children [11]. Despite providing robust evidence and well-established summaries on how the COVID-19 crisis impacted loneliness, systematic reviews and meta-analyses typically focus on one single topic, such as vulnerable groups, risk factors, or interventions. It is imperative to reinforce the knowledge of loneliness during the pandemic from a multifactorial perspective, as the design of targeted public health interventions to mitigate loneliness requires collective efforts from multiple domains, ranging from psychology, medical sciences, to social sciences. Therefore, to address the scope limitation of previous systematic reviews, we utilized a bibliometric analysis – an advanced and reliable review method – combined with the Latent Dirichlet Allocation (LDA) technique, a cutting-edge topic modeling method, to comprehensively characterize the broader research landscape on loneliness during the pandemic.

Furthermore, unlike other previous bibliometric analyses on loneliness, this is the first scientometric study that specifically focused on loneliness during the pandemic. Bibliometric analysis has garnered greater attention in recent years as an advanced literature analysis tool. This scientometric method is commonly used in the scientific community to explore emerging trends in a particular research field, identifying collaboration patterns among countries, organizations, authors, and eliciting insightful directions for future research [12–14]. By rigorously combining data from academic databases such as the Web of Science (WoS) Core Collection, Scopus, and PubMed, bibliometric analysis enables scholars to map the progress of relevant articles within a specific time frame, providing an accurate overview of cumulative scientific data [15]. In terms of loneliness, this topic has been previously studied in several bibliometric studies. For example, Banerjee et al. (2023) reported the characteristics of the top 100 highly cited articles on loneliness in general [16], while Prasad et al. (2024) conducted a comprehensive bibliometric analysis on the relationship of internet pornography, loneliness, and social media addiction [17]. Another scientometric research by Marziali et al. (2024) investigated the literature on the use of voice assistants to reduce loneliness and social isolation of older adults [18]. However, none of these studies have assessed the unique development of research landscapes related to COVID-19 loneliness. The objective of this study is to thoroughly examine the increasing volume of scientific papers that investigated loneliness during the pandemic. We contribute to the existing literature in at least two ways: (1) assessing the bibliometric characteristics of pioneering works on loneliness during the pandemic, and (2) analyzing research patterns in this field using advanced topic modeling algorithms. This information will provide a better understanding of the dynamic changing patterns of research in the field, thus effectively guiding future research directions and policy recommendations for addressing loneliness in the post-pandemic era.

To the best of our knowledge, no studies have applied a mix of bibliometric and topic modeling methods to analyze the current literature on loneliness during the pandemic. This study represents the first bibliometric study conducted to systematically identify research growth and uncover latent research themes related to COVID-19 loneliness. By adopting a mixed analytical approach that combines both scientometric and topic modeling methods, we were able to characterize a large volume of relevant research in terms of research productivity, collaboration patterns, emerging topics, and knowledge gaps in various domains. Since the elevated prevalence of loneliness is not only confined to the COVID-19 pandemic but also continues to be significant beyond this period, our bibliometric results serve as a timely evidence-based reference to guide future research directions. This information is useful for researchers to navigate future studies and address research gaps in the existing literature. Furthermore, it helps healthcare providers and policymakers develop a nuanced understanding of emerging issues in COVID-19 loneliness, thereby improving interventions and public policies for people against loneliness.

METHODS

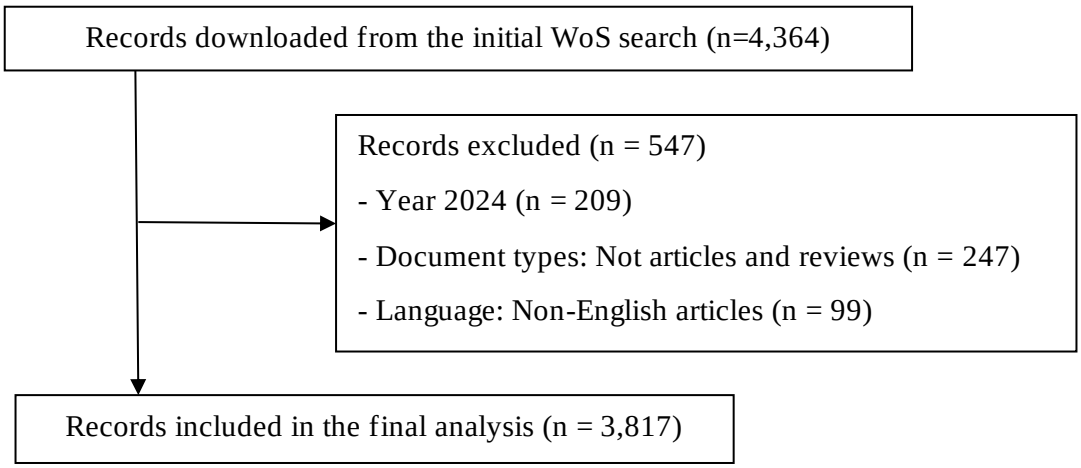
DATA SOURCE AND SEARCH STRATEGY

We performed a bibliometric analysis using the Web of Science (WoS) database. This is an optimal data source for scientometric studies, providing detailed information on high-quality articles and covering a comprehensive set of records since 1900.

The search process was divided into two steps. First, we applied a thematic search string using the "Topic search" function, combining keywords related to loneliness and the COVID-19 pandemic using Boolean logic AND/OR. The specific search string was TS= ("loneliness" OR "lonely" OR "loner") AND ("COVID-19" OR "coronavirus disease 2019" OR "2019-nCov" OR "2019 novel coronavirus" OR "SARS-CoV-2" OR "Severe acute respiratory syndrome coronavirus 2" OR "novel coronavirus disease 19" OR "novel coronavirus disease-19" OR "SARS2" OR "SARS-2" OR "COVID-2019" OR "COVID19"). Second, we applied several filtering processes to accurately extract records of loneliness during the pandemic. Only original articles and reviews, conducted in English, and published between 2020 and 2023 were included. Our final sample size is concluded with 3,817 papers.

Each paper's detailed information, including authors' names, paper titles, author keywords, institutions, citation counts, usage times, research areas, and abstracts, was manually downloaded from the WoS database. This data extraction step was independently conducted by two researchers and subsequently scrutinized by the study supervisor to ensure the consistency of the retrieved data. A flow chart of the search process is described in Figure 1.

FIGURE 1. PAPER SELECTION IN THE SEARCH PROCESS



DATA ANALYSIS

A summary of analytical techniques is presented in Table 1. Since the extracted data did not contain any information on human or animal objects, ethical considerations were not applicable in this study.

TABLE 1. ANALYTICAL METHODS AND RESULT PRESENTATION BY DATA TYPES

Type of data	Unit of analysis	Analytical methods	Result presentation
Countries, keywords	Words	Frequency of co-authorship and keyword co-occurrence	Cluster mapping by country, and keyword
Titles, Abstracts	Papers	Latent Dirichlet allocation	Classifications of 10 major research themes
Research areas	WoS classifications of research areas	Haberman distance	Dendrogram of research fields

To demonstrate the worldwide collaboration network of countries in COVID-19 loneliness research, we utilized the VOSviewer software (version 1.6.20, Center for Science and Technology, Leiden University, the Netherlands). This visualization tool has been widely used in various bibliometric studies, enabling the authors to create network graphs showing academic collaborations among different countries and organizations [16,18]. In this paper, it was also employed to identify the most frequent keywords appearing in Authors' keywords of each document.

Furthermore, we utilized STATA 18.0 to examine the hierarchical relationship of research areas and emerging research trends in loneliness during the pandemic. Specifically, for the hierarchical clustering of major research disciplines, a dendrogram was used to visualize the intricate association of various research areas categorized by the WoS database. For research trend assessment, we first utilized the Latent Dirichlet Allocation (LDA) technique to model 10 latent topics from the included papers and then labeled research themes for these topics.

The LDA technique, a Bayesian probabilistic algorithm, is commonly used in scientometric analysis for topic modeling [19]. It is considered a state-of-the-art analytical method for topic clustering, by grouping words with relevant meanings into specific topics [20,21]. The LDA's text mining principle is depicted in Figure 2 [22,23].

FIGURE 2. DIAGRAM OF LDA'S GENERATIVE PROCESS

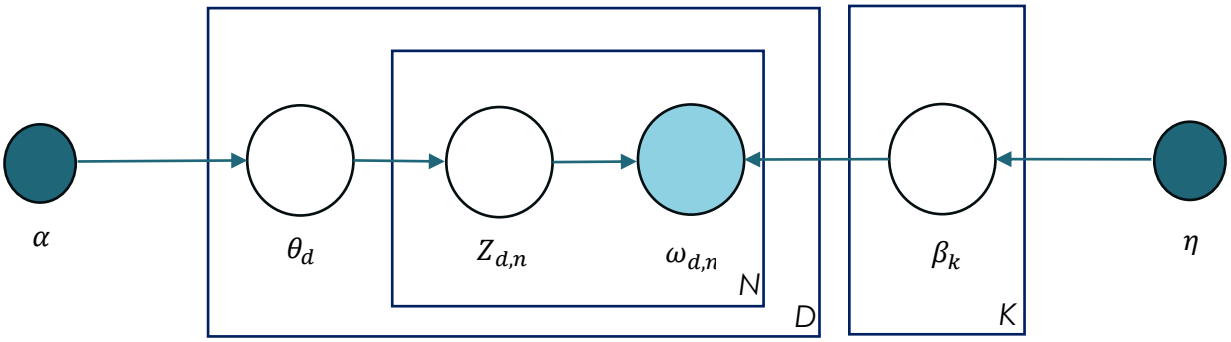


Figure 2. Diagram of LDA's generative process, where *K*: number of topics; *D*: number of documents; *N*: number of words; θ_d: the probability of topic *k* for document d; β_k: the probability of word *n* created for topic *k*; α: the prior distribution of topic *k* by document; η: the prior distribution of word *n* by document; $Z_{d,n}$: the topic for the *n*th word in the *d*th document; $\omega_{d,n}$: the *n*th word in the *d*th document

To identify major research trends, first, we applied STATA's LDA command to determine 10 latent topics using words from the titles and abstract of each publication [24]. Second, after exporting the resulting output of the LDA model into an Excel file, we labelled the latent topics. Topic labeling was conducted by (1) analyzing the top 20 words with the highest

probability within each topic, and (2) intensively reviewing titles/abstracts of the highly cited publications within each topic. Furthermore, we assessed the growth of identified research topics by estimating the number of publications by topic and changes in topic shares by year. In essence, the LDA's topic modeling facilitates defining the 10 common topics about pandemic-related loneliness and helps characterize the development of research landscapes from 2020 to 2023.

RESULTS

ANALYSIS OF DESCRIPTIVE INFORMATION FROM SELECTED PUBLICATIONS

Table 2 shows the descriptive statistics of selected papers on loneliness during the pandemic. The number of studies in this field experienced an overall upward trend, increasing dramatically from 367 publications in 2020 to 1,273 publications in 2022, before slightly decreasing to 978 in 2023. Publications in the year 2020 were cited the most, with a total of 29,684 citations and an average citation of 20.22 per year. On the other hand, articles published in 2021 received the highest total usage (29,588 downloads) over the 4-year period, while publications in 2023 achieved the highest downloading times over the past 6 months.

TABLE 2. GENERAL CHARACTERISTICS OF THE INCLUDED PAPERS

Year	Total Papers	Total Citations	Mean Cite Rate Per Year	Total Usage Last 6 months	Mean Use Rate Last 6 months	Total Usage Last 4 years	Mean Use Rate Last 4 years
2020	367	29,684	20.22	1,442	3.93	16,128	10.99
2021	1,199	27,078	7.53	3,109	2.59	29,588	6.17
2022	1,273	7,197	2.83	3,677	2.89	19,675	3.86
2023	978	649	0.66	3,686	3.77	7,137	1.82

ANALYSIS OF INTERNATIONAL COLLABORATIONS

Figure 3 illustrates the collaboration network of 69 countries with at least five co-authorships, among a total of 117 countries producing research on COVID-19 loneliness. There were 7 major clusters formed based on the volume of their collaborations, with respective regional representatives including Germany, China, Spain, the Netherlands, Canada, England, and the USA. The USA and England were the largest contributors to the overall research landscape, with the strongest collaboration networks.

FIGURE 3. MAP OF COLLABORATION NETWORK BY COUNTRY/REGION

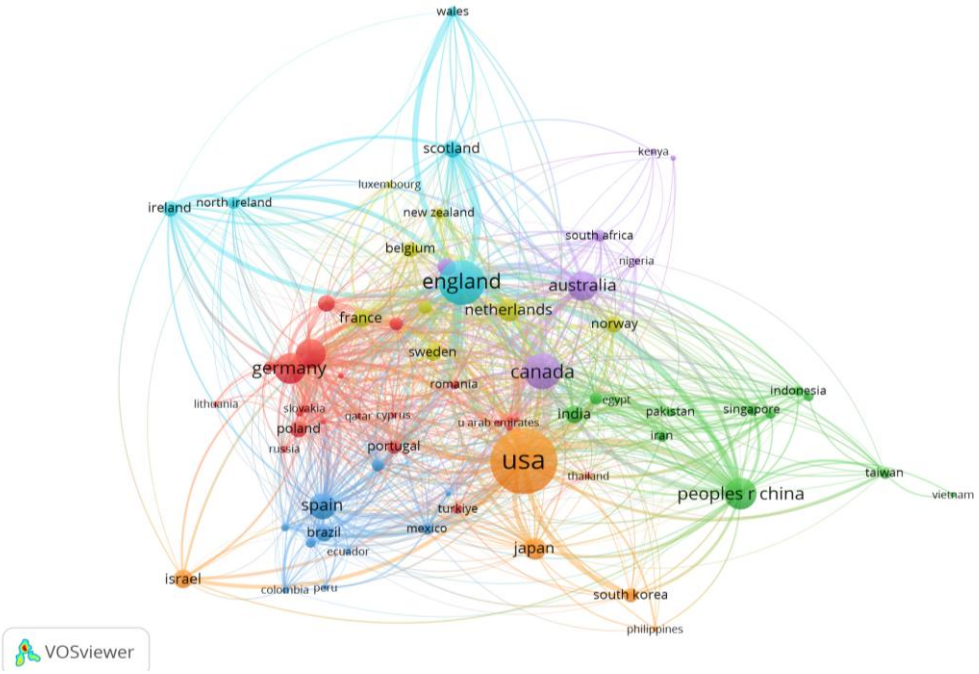


Figure 3. Map of collaboration network by country/region regarding loneliness during the pandemic from 2020 to 2023 (Red cluster: Germany, Portugal, and Eastern European countries; green cluster: China, India, and Southeast Asian countries; blue cluster: Spain, Central and South American countries; yellow cluster: New Zealand, Northern and Western European countries; purple cluster: Australia, Canada, and African countries; bright blue cluster: the United Kingdom; orange cluster: the USA and East Asian countries)

ANALYSIS OF KEYWORD CO-OCCURRENCE

Figure 4 shows the co-occurrence analysis of the terms extracted from the authors' keywords of selected papers, demonstrating the most frequent keywords used in publications related to COVID-19 loneliness. Of the 6,067 keywords, 77 met the minimum threshold of 20 occurrences. The most frequently appearing keywords were grouped into four major clusters, including (1) "older people", "technology", "long-term care", "nursing home" (red), (2) "adolescents", "emotions", "depressive symptoms", "perceived stress" (green), (3) "risk factors", "suicide", "telehealth" (dark blue), and (4) "children", "psychological impact" (yellow).

FIGURE 4. MAP OF CO-OCCURRENCE OF AUTHORS' KEYWORDS

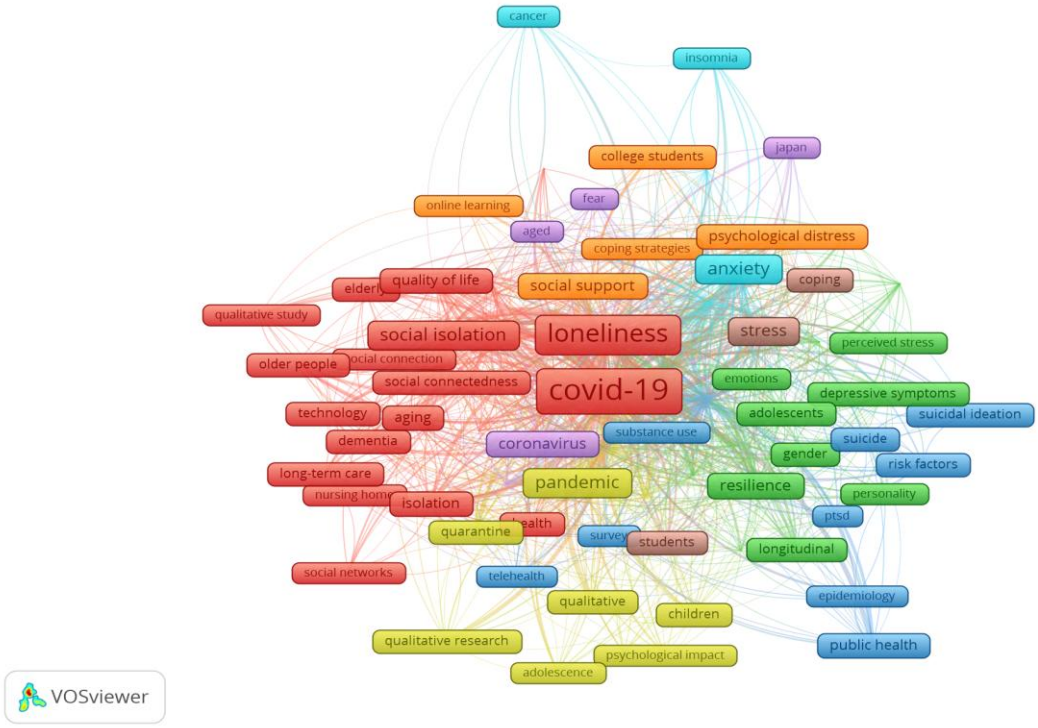


Figure 4. Map of co-occurrence of Authors' keywords (The size of the term represents its weight. The color indicates the cluster. The line between two terms indicates their relatedness. Red cluster: loneliness of the elderly, green cluster: loneliness of adolescents, blue cluster: risk factors of loneliness and relevant behavioral changes, yellow cluster: loneliness of children, purple cluster: fear of aged people in Japan, bright blue cluster: psychological impacts of loneliness, orange cluster: social support to deal with COVID-19 loneliness, and brown cluster: loneliness-coping strategies among students)

ANALYSIS OF RESEARCH DOMAINS

Table 3 shows the 10 latent research topics identified using the LDA topic modeling technique. To label these research themes, we conducted an intensive review of the titles and abstracts of the most impactful publications in each category, as well as the most commonly appearing words extracted from the LDA word analysis. After careful reviews, each topic was thematically identified, except for topics 3 and 4, which were combined into one new topic (topic 3) based on similar shared themes. During the pandemic, the topic of socioeconomic and clinical risk factors for loneliness (topic 9) achieved the highest research output, accounting for 24.65% of total publications. The next most popular research topics focused on the impacts of pandemic control measures on loneliness and its impacts on people's overall well-being (topic 3), as

well as social support issues (topic 10), constituting 23.4% and 11.47%, respectively. The least popular research topic was loneliness and psychosocial problems experienced by vulnerable groups of adolescents and children.

TABLE 3. TEN RESEARCH TOPICS IDENTIFIED BY LDA

Topic	Research themes	N	%
Topic 1	Technology use during the pandemic	185	4.85
Topic 2	Loneliness and psychological pressures of patients and healthcare workers	141	3.69
Topic 3	Impacts of COVID-19 loneliness on physical, mental, and social well-being	336	23.40
Topic 4	Impacts of COVID-19 loneliness on physical, mental, and social well-being	557	-
Topic 5	Impacts of COVID-19 loneliness on behavioral changes	300	7.86
Topic 6	Loneliness of older adults and their coping strategies	265	6.94
Topic 7	Loneliness of younger adults and their coping strategies	199	5.21
Topic 8	Loneliness of adolescents, children and their coping strategies	68	1.78
Topic 9	Socioeconomic and clinical risk factors for loneliness during the pandemic	941	24.65
Topic 10	Social support challenges and social services interventions	438	11.47

Figure 5 visualizes trends of the 10 most common topics from 2020 to 2023. All topics saw substantial increases in the number of publications at the beginning of the period (2020-2021), reflecting an immediate surge in research interest in the field of COVID-19 loneliness. Throughout the next 3 years, publication shares in topics 3, 9, and 10 remained much larger than those of other topics and followed an overall upward trend, highlighting the significant and growing interest from academic researchers in these three topics. By contrast, topic 5 on behavioral changes driven by COVID-19 loneliness received less scholarly interest, with a relatively downward trend in the volume of publications.

FIGURE 5. RESEARCH TRENDS GROUPED BY 10 MAJOR THEMES IN COVID-19-RELATED LONELINESS

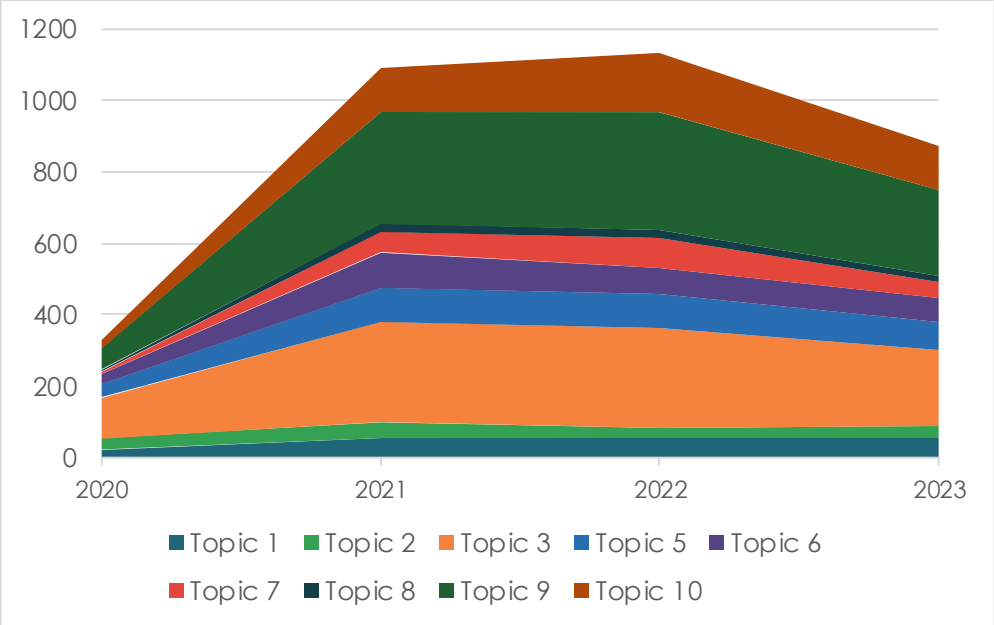
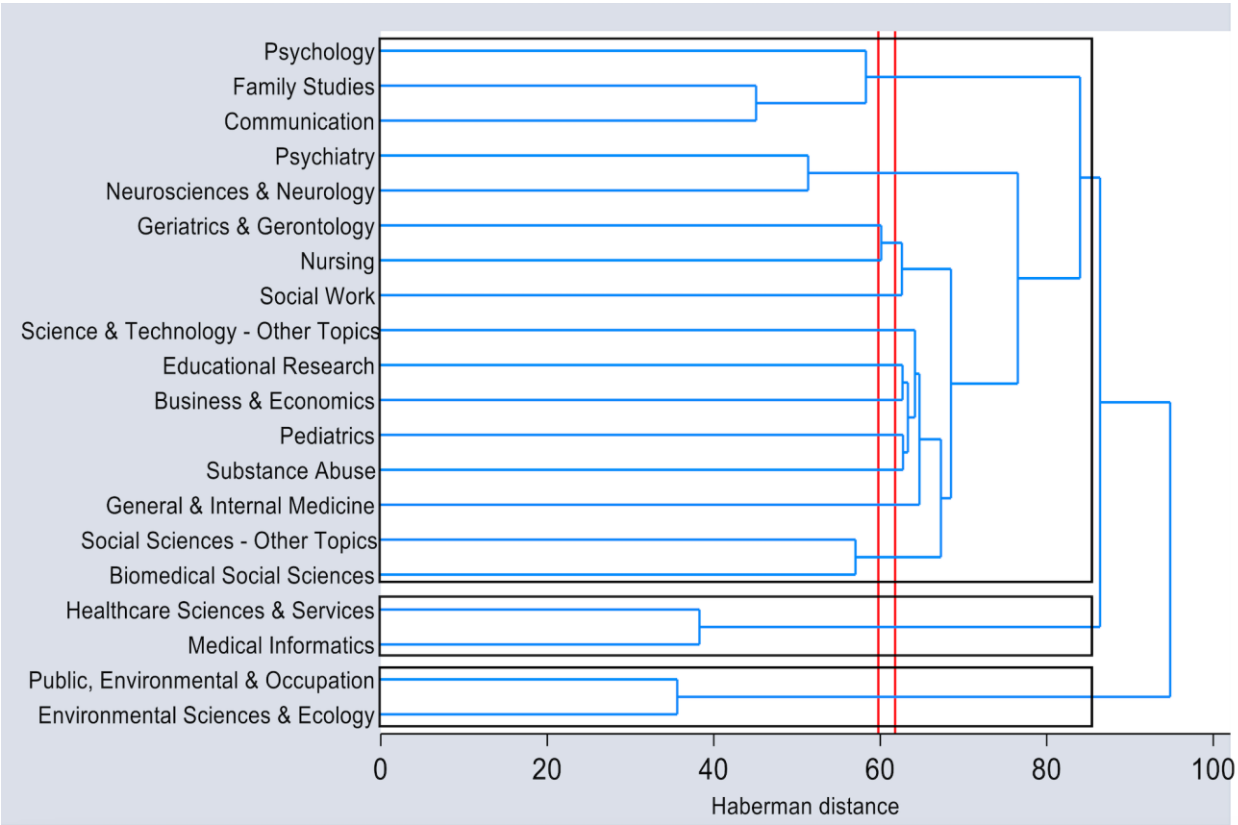


Figure 6 presents the hierarchical clustering of research areas related to the COVID-19 loneliness field. Research disciplines such as Psychology, Psychiatry, Geriatrics & Gerontology, and Social Sciences garnered considerable traction from researchers. In contrast, Healthcare Sciences & Services, and Medical Informatics received comparatively less attention. It is also noted that the cluster of Family Studies and Communication substantially diverges from the cluster of Pediatrics and Substance Abuse, suggesting a lack of social support interventional studies for young individuals who experienced loneliness and substance use issues during the pandemic.

FIGURE 6. DENDROGRAM OF HIERARCHICAL GROUPING OF RESEARCH AREAS



DISCUSSION

This study presents the first attempt to summarize the existing literature on loneliness during the COVID-19 pandemic from 2020 to 2023. The review is conducted to analyze the bibliometric characteristics of each study and to evaluate content developments in the field. Based on the aggregated volume of selected scientific papers, we found a steady increase in research productivity on COVID-19 loneliness over time, highlighting growing interest in this field from both academia and policy making. Furthermore, by analyzing changes in research contents, we discovered that the most common research topics included investigations into how COVID-19 mitigation measures affect loneliness, its impacts on people's well-being, associated risk factors, and social support interventions. Our results provide valuable insights into the advancement of research on COVID-19 loneliness, helping to identify knowledge gaps and inform future impactful research proposals.

Our bibliometric analysis revealed that developed countries, such as the USA, England, and Canada, play an important role in contributing to the rapidly expanding research landscapes on COVID-19 loneliness. The dominance of research output from educational institutions in these countries is consistent with findings from a previous paper that reviewed the top 100 studies on loneliness from 1989 to 2021 [25]. This trend is not surprising, given the high research capacity in these nations, characterized by abundant research resources and efficient management systems. Moreover, we found that inter-country collaborations predominantly occurred within the same region, likely attributed to geographic proximity that facilitates the expansion of research networks. Given the cultural differences in how loneliness is conceptualized across different countries [26], more research is needed to better understand COVID-19-related loneliness in developing countries.

In addition, our keyword co-occurrence analysis provides a glance at the most frequent keywords in the literature. This information is useful to effectively capture research hotspots in the field of COVID-19 loneliness. To illustrate the co-occurrence map, the VOSviewer software categorizes different clusters by analyzing the links and weights (cited frequency) between items. The bigger the cluster is, the more extensively the topic is investigated is in the field. Our co-occurrence map of author keywords divided COVID-19 loneliness into 8 distinct clusters. The first cluster (red) is centered on research of the elderly during the pandemic, which includes keywords such as aging, long-term care, dementia, older people, technology, social networks, and nursing home. Loneliness among younger adults dominates the second cluster (green) with keywords such as adolescents, emotions, perceived stress, and depressive symptoms. The third cluster (blue) describes topics related to compounding factors of COVID-19 loneliness and its related health outcomes, which consists of keyworks like risk factors, suicide, substance use, epidemiology, and post-traumatic stress disorder (ptsd). The fourth cluster (yellow) highlights psychological impacts of pandemic-induced loneliness on children and adolescents, while the fifth cluster (purple) focuses on aged populations and feelings of fear, particularly in the Japanese context. The sixth cluster (bright blue) depicts people's poor health conditions, such as anxiety, insomnia, and the exacerbated effects of COVID-19 loneliness on cancer patients' health outcomes. The seventh cluster (orange) relates to social support, college students' coping strategies, and online learning. Finally, the eighth cluster (brown) shows psychological problems like stress among students during the pandemic. This visual keyword co-occurrence allows us to identify research topics with heigtened citation activity, where most studies investigate elderly populations and emerging topics of COVID-19 loneliness focus on university students, children, and adolescents.

Based on the keyword cooccurrence map and the research topic table, this study provides confirming evidence on the most significant topics related to loneliness during the pandemic, including the impacts of COVID-19 public measures and the resulting loneliness on people's well-being, associated risk factors, and social support interventions. In particular, the onset of the pandemic (2020) saw a sudden increase in publications on the influences of social distancing policies on loneliness and its effects on people's physical and mental health. Since loneliness was a topic of concern even before the pandemic, with its relevance to deteriorating health outcomes, it is evident that most researchers sought out to comprehensively examine the changing levels of loneliness during the early stages of the pandemic. In the following years, emerging research topics began to focus more on the factors that contribute to loneliness and the role of social support services during the health crisis. There is ample evidence on the effects of socioeconomic determinants on COVID-

19 loneliness, such as living alone and lower income due to the pandemic [27,28], as well as clinical risk factors like prior mental symptomatology [29,30]. Similarly, the preventive role of social support in mitigating loneliness has received increasing attention from scholars. The disruption of social interconnectedness due to anti-pandemic measures posed significant challenges to social support services, especially for individuals with preexisting psychological issues [31,32] and elderly residents in nursing homes [33]. Research topics related to social support during the pandemic have been widely studied, regarding how to improve the quality of social relationships and how to increase the accessibility of social support services [3,34]. Examples include intergenerational communication programs within the community [35], widespread applications of digital technologies (e.g., video calls and social media) [36], and visiting schedule arrangements in healthcare settings [37].

On the other hand, our topic modeling analysis highlights a lack of publications that explored loneliness among adolescents and children. Adolescence is recognized as a crucial developmental stage in human life, marked by significant physical and emotional changes [38]. During this developmental phase, it is vital for young people to form relationships, engage in peer groups, and develop mentality. However, children and adolescents became one of the most affected populations during the crisis, facing severe restrictions due to mass quarantine measures, including studying from home and the cessation of in-person extracurricular activities with their friends. These restrictions indirectly exposed this age group to increased risks of physical, social, and mental health problems. Extant literature from various countries, such as the USA, Canada, and China, reported that children experienced increased physical inactivity and sedentary behavior during the pandemic [39–41]. On top of that, these younger adults were severely prone to heightened social isolation, worsened mental health, and increased depressive symptoms. In addition to external factors, like school disconnection, children and adolescents were also heavily affected by internal factors, like family conflicts driven by social and economic changes during the pandemic [42]. Such combination of these internal and external factors made the youth even more susceptible to fear, uncertainty, and diminished psychosocial functioning during the health crisis. Moreover, children and adolescents have been empirically evidenced to be at higher risks of developing mental health issues than young adults, if getting exposed to the same health threats [11,43]. Therefore, given the potential for adverse health outcomes to be exacerbated by the pandemic among this demographic [44], further research is needed to explore how COVID-19 loneliness, which has been shown to persist beyond the pandemic, affects the well-being of children and adolescents in the long run.

Furthermore, we found that there is limited research on how loneliness affects lifestyle behaviors, such as smoking, alcohol consumption, physical inactivity, and substance abuse. Loneliness is well-established as a major contributor to adverse health outcomes and negative health behaviors, such as smoking and substance misuse. While it has been widely documented that the COVID-19 pandemic has intensified feelings of loneliness and poorer health status, empirical evidence on how increased loneliness during this period impacts behavioral changes remains limited. Proposed by Cacioppo et al. (2013), the Evolutionary Theory of Loneliness posits that loneliness is an adaptive evolutionary tool that encourages individuals to reengage socially and repair or replace relationships, resulting in a series of behavioral, neural, and hormonal adjustments [45]. This framework lays the foundation for researchers to investigate the potential effects of loneliness – as an exposure leading to health risk behaviors, like smoking and alcohol misuse, as maladaptive strategies to cope with social isolation. Empirically, scientific evidence has supported the underlying mechanisms that explain the effects of loneliness on negative health behaviors, derived from physiological changes channeled via the stress response [46,47]. Allen et al. (2022) highlighted the potential for long-lasting negative health consequences linked to the pandemic, with a 37% and 29% increase in the likelihood of higher alcohol consumption and weight gain, respectively, among people who often or always felt lonely [48]. Similarly, a cross-sectional analysis by Vanderbruggen et al. (2020) found that loneliness was positively associated with higher alcohol consumption and cigarette smoking than pre-pandemic levels [49]. A heightened risk of non-cannabis drug use was also reported among individuals with constant daily increases in loneliness above the baseline levels during COVID-19 [50]. However, most pandemic-related behavioral research has revolved around samples of the general population, rather than specific vulnerable groups. Hence, more attention should be paid to conducting research on behavioral changes in relation to COVID-19 loneliness, with the aim of identifying distinctive groups of populations who are at risk of increased substance use and developing long-term adaptive interventions.

This study has several important implications for research and policy. First, our results suggest that future research agenda should investigate the effects of COVID-19 loneliness on health-related behavior during and after the pandemic, as well as the prevalence of loneliness among children and adolescents to predict its impacts in their long-term mental health developments. Second, we recommend prioritizing research on adolescents' loneliness using multidisciplinary approaches, such as family support, communication strategies, technology use, and behavioral changes (e.g., substance abuse). Furthermore, it is imperative to encourage research on effective use of information and communication technologies to improve the quality of social support, both in healthcare settings and everyday life aspects. Finally, strengthened collaboration between developed and developing countries could provide a comprehensive understanding of global patterns of COVID-19 loneliness, offering insights into this health issue from a diversity of cultural perspectives.

Some limitations should be considered when interpreting our findings. First, our selected literature was exclusively derived from a single database. By relying solely on the WoS database, our results may not fully encompass all relevant publications and research areas in relation to COVID-19 loneliness. Nonetheless, despite some criticisms on the relative lack of coverage of social sciences studies compared to natural sciences, WoS remains a highly credible database for the broad inclusion of high-quality indexed journals and multi-functional citation analysis [51]. Second, focusing only on English-language documents may limit the comprehensiveness of our review in a global context. This is because in countries such as China and Japan, many studies are conducted and published in local languages. Finally, our topic modeling method to identify latent research themes over time was based on data extraction from the titles and abstracts of each publication, rather than from the full texts.

CONCLUSIONS

This bibliometric analysis is the first review study conducted to characterize research productivity of existing literature on loneliness during the pandemic from 2020 to 2023, as well as exploring recent research trends in the field. Based on the findings, it is recommended to expand research networks between developed and developing countries to explore the long-term effects of loneliness after the pandemic. The most common research topic is the investigation of risk factors associated with COVID-19 loneliness. Furthermore, while the impacts of loneliness on people's well-being and social support interventions have been extensively studied, inadequate attention has been paid to COVID-19 loneliness among children and adolescents, as well as its effects on behavioral changes. Future studies on pandemic-related loneliness should focus on these topics and adopt a cross-disciplinary approach, incorporating family-based interventions, communication technologies, and behavioral analysis.

Family plays a crucial role in providing consistent emotional support to children and adolescents. Social support from family members helps young people overcome feelings of disconnection from friends and community due to COVID's protective measures, and maintain positive daily routines, which are essential to prevent them from unhealthy lifestyle habits and depressive symptoms. For instance, a study in Germany found that adolescents with stable family environments reported reduced mental strain during the pandemic [42]. Likewise, a study in Indonesia presented the significant influence of family relationships on adolescents' loneliness, highlighting the need for family-centered interventions to improve mental health of this demographic [52]. Furthermore, family support serves as a critical protective factor against the risk of harmful online relationships and negative behaviors among children and adolescents. On the one hand, although social media use can help adolescents foster a sense of peer connections during the pandemic, whether these tools can build genuine friendships to deal with loneliness remains a public concern. On the other hand, loneliness is suggested as a compounding factor for increasing incidence of smoking, alcohol consumption, and substance abuse among young people. Such evidence presents an intricate network of loneliness, its protective and risk factors, and its health consequences, especially concerning the context of vulnerable populations.

Based on the latent research topics identified and the hierarchical dendrogram of various research areas related to COVID-19 loneliness, our bibliometric study highlighted the need to promote cross-disciplinary research that explores the

impacts of family roles, combined with technology use, in mitigating loneliness among children and adolescents. The implications of this study's findings are crucial for guiding future research and policies aimed at addressing adolescent loneliness in the post-pandemic era. For future research, it is imperative to investigate the mediating role of loneliness in the effects of family support on quality online relationships formed during the pandemic and behavioral health changes in young people. Families should provide persistent support to strengthen adolescents' emotional health and create healthy living environments, while giving guidance to promote quality online friendships. Although the WHO declared the end of the COVID-19 pandemic as a global health emergency in May 2023, the risk of new pandemics cannot be overlooked, given the emergence of numerous COVID-19 variants. As a result, multidisciplinary implications targeted at vulnerable groups of COVID-19 loneliness and urgent measures to promote positive health behaviors should be prioritized in future public health policy.

DECLARATIONS

CONFLICTS OF INTEREST

The authors have declared that no competing interests exist.

DATA AVAILABILITY STATEMENT

Data is available upon reasonable request from the first author.

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