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Research Article

Web-Based Map Application for Spatial and Temporal Analysis of Historical Demography and Health Inequality Studies

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Abstract: Demographics, mortality, and disease are among the key topics of interdisciplinary research. Examining these issues in the context of history and geography offers important insights into social structure and spatial variations. Especially in the wake of the COVID-19 pandemic, interest in the spatial distribution of diseases, social vulnerabilities, and past health patterns has increased significantly. However, the number of studies that systematically examine the geographical intersection of historical demography, health geography and health inequalities remains limited.

The aim of this study is to make research in the fields of historical demography, health geography, and health inequalities in Europe accessible through a Web-GIS-based interface, in accordance with the open science approach, and to systematically analyze this literature from spatial and temporal perspectives. To this end, a total of 210 publications identified through Google Scholar searches and deemed relevant to the scope of the research were evaluated. The boundaries of the study areas were defined, the geographic data linked to the bibliographic information and the resulting geographic data were transferred to ArcGIS Online and presented in the open access Web-GIS interface.

In the final stage of the research, the publications were analyzed in terms of spatial distribution and time density. The findings show that studies have increased especially in Western and Northern Europe after 2020. The dominant thematic areas were identified as infant and child mortality, socioeconomic mortality inequalities, nutrition, anthropometric history, and epidemics.

In this context, both research gaps and intensive research areas are highlighted. Furthermore, the developed Web-GIS interface contributes to an open science approach by presenting literature on historical demographic and health disparities in a more accessible, comparable format. The study is also expected to serve as a model for the development of similar digital mapping applications in other disciplines.

Keywords: Historical Demography, Health Inequalities, Spatio-Temporal Analysis, Web-GIS, Open Science

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1. Introduction

Historical demography is one of the various types of historical research that constitute quantitative history. It is a discipline situated at the intersection of history and statistics, examining the population structure of the past, the changes that occurred within that structure, and the causes of those changes (Mielke et al., 1982). It focuses on areas such as fertility, mortality rates, marriage patterns, and migration. It utilizes church and mosque records, archaeological data, and genealogical records as sources. Historical demography seeks to answer the question "What happened?" In doing so, it contributes to understanding population changes over time, patterns of birth and death, transformations in living conditions, and differences between societies.

Health inequalities are preventable disparities arising from social, economic, and environmental issues, excluding unalterable biological causes, among different groups in society (McCartney et al., 2019). Place of birth, income level, and education level directly influence how long an individual will live or how frequently they will fall ill. Health inequalities, on the other hand, focus on the question, "Why is this the case?" This helps in understanding the social, economic, and environmental determinants that

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shape health outcomes and in identifying the structural causes of inequalities.

Why is it important to address these two topics together? The greatest common ground between historical demography and health inequalities lies in illness and mortality. Illnesses and deaths can be interpreted not only as demographic outcomes but also as reflections of social and spatial disparities. This enables a more comprehensive understanding of the health structure of past societies.

In this context, the study is significant for its adoption of open data and open science principles. The open science approach advocates for the sharing of research data, methods, and outputs in a more transparent, accessible, and reusable manner. Open data, in turn, makes it possible for the information produced to reach not just a limited group of experts, but broader groups of researchers. The web-based GIS interface proposed in this research is conceived not merely as a system that integrates the literature on historical demography and health inequalities, but also as a digital platform that makes this information accessible, queryable, and comparable. In this regard, the study aims to contribute to the broader circulation of academic knowledge in line with the open science philosophy, moving beyond its confinement within closed texts.

The integration of research fields such as digital technologies, artificial intelligence and big data into the humanities can be traced back to the indexing of 11-million-word works in 1949. In Turkey, however, the examination of Ottoman archives by various disciplines began in the 2010s (Aladağ, 2020). The digitisation of manuscripts with the aid of artificial intelligence, and the application of methods used in contemporary studies—such as geographical analysis (Alkan Günay, 2025) and social network analysis (Abacı, 2013; Abacı et al., 2023)—to the historical geography context (Yakar & Yiğit, 2022) are also being explored. However, studies that address historical data in a systematic manner and in a comprehensive way using methods such as Web-GIS remain quite limited.

Digital humanities is a field of scientific activity that integrates digital technologies with the humanities (Tarhan, 2026). This study contributes to this field in several ways. First, it transforms the literature on historical demography and health inequalities from merely written sources into spatial data. In other words, articles, book chapters, and other academic works are no longer just texts to be read but become data that can be displayed and compared on a map. Second, the study brings together different types of information on the same platform. Bringing together elements such as bibliographic information, historical periods, topics, and geographic scope within a Web-GIS interface aligns with a data integration approach. Third, the study does not merely store data; it enables new questions to be asked using the data. The ability to answer questions such as which regions have been extensively studied, which areas have remained invisible, and which themes have emerged through the map strengthens the analytical dimension of digital humanities. Fourth, by adopting the principles of open access and open science, the study contributes to the common ground of digital humanities.

In the post-COVID-19 era, the spatial distribution of diseases, regional inequalities, and the roots of health outcomes have regained significance. Historical demographic studies bring past records into the present, particularly to understand the origins of health inequalities. In this context, Mühlichen and Doblhammer (2025) in their analysis of German church records, demonstrated that demographic transitions reveal significant social differences in infant mortality rates based on inequalities.

Health inequalities are not limited to the moment of death; they also manifest as the reflection of early-life conditions throughout an individual's entire life. Cormack et al. (2024) highlighted this continuity by examining the effects of early-life conditions on individuals' lifelong well-being using the Swedish example (1905–2016). Where economic indicators intersect with demographic trends (Layfield et al., 2025), the historical rise in household-level income inequalities has been dissected. Another study presented the evolution of biological well-being in Spain from an anthropometric perspective. Studies using European data, in particular, have shown that increases in body size stem from improvements in food consumption and rises in income and earnings (Cañabate-Cabezuelos & Martínez-Carrión, 2016)

This research also forms part of the COST Action CA22116, titled "The GREAT LEAP, Multidisciplinary approaches to health inequalities, 1800–2022 (GREATLEAP)", which was carried out between 19 September 2023 and 18 September 2027 (COST, 2026).

Spatial analysis will open new avenues for researchers in the literature; however, a review of the existing literature reveals that such studies are generally limited to text and tables (Martínez-Carrión et al., 2016). The lack of sufficient spatial and temporal analysis of historical data, coupled with the

failure to adequately visualize it with analytical mapping tools, constitutes a significant gap in the literature. Presenting the available data solely as statistical results makes it difficult to understand the geographic distribution of health inequalities and their changes over time.

This study aims to address this gap by visualizing and analyzing data within the scope of a "Web-Based Mapping Application for the Spatial and Temporal Analysis of Historical Demography and Health Inequality Studies." Thus, the complex demographic data of the past will be made more accessible, comparable, and visually understandable through modern analytical methods. In pursuit of this objective, the research focuses on the following questions:

- RQ1: How does the literature on health inequalities and historical demography form temporal periods?
- RQ2: In which countries or regions is the literature on health inequalities and historical demography concentrated, or has it been insufficiently studied?
- RQ3: Which themes, diseases, and causes of death are more prominent or limited in this literature?
- RQ4: How does presenting the literature on historical demography and health inequalities via a web-based mapping application affect interdisciplinary visibility, and how can this application facilitate the discovery of the literature?

The Materials and Methods section of the study details the data sources used in this research, the analyses conducted, and the configuration of the Web-GIS interface. The findings section provides systematic answers to the research questions mentioned. In the discussion section, the research findings are synthesized and discussed.

2. Data and Methodology

To ensure scientific transparency, reproducibility, and methodological rigor, this study employs a systematic literature review (SLR) protocol combined with a workflow using Geographic Information Systems (GIS). The methodological framework consists of three sequential phases: systematic data acquisition, geospatial database design, and Web-GIS architecture deployment.

2.1. Systematic literature search and selection criteria

A systematic search was conducted using the Google Scholar database to capture interdisciplinary literature spanning historical demography, public health, and spatial humanities. To mitigate the limitations of restrictive search fields, an expanded Boolean search query was executed:

("historical demography" OR "historical population") AND ("health inequalities" OR "health inequality" OR "mortality disparities" OR "social differentials in mortality")

The total corpus retrieved and filtered through chronological cross-sections is detailed in Table 1. To refine the raw data into a clean analytical sample of 210 publications, strict inclusion and exclusion criteria were applied:

Inclusion Criteria (IC):

1. Peer-reviewed journal articles, academic book chapters, and doctoral dissertations published between 1800 and 2025.
2. Studies investigating past population dynamics (fertility, mortality, morbidity) in direct relation to socioeconomic, environmental, or spatial health inequalities.
3. Studies providing clear geographic reference points (country, region, or city-level data) within Europe and North America.

Exclusion Criteria (EC):

4. Contemporary epidemiological studies lacking historical context (post-2000 data without historical baselines).
5. Non-English or non-Turkish publications lacking verifiable translations.
6. Gray literature, conference abstracts, and non-peer-reviewed blog posts.

In line with the objective of this study, a methodological approach combining a literature review with geographic information systems was adopted. The research was conducted in three phases. ArcGIS Pro 3.5 was used as desktop GIS software, and MS Excel 2016 was used to save the records of the publications. In the first phase, a search was conducted in the Google Scholar database. Only two sets of keywords were used during the search process. These were the phrases the search terms and logical operators. The publications identified through these searches were reviewed individually, and studies directly related to the intersection point were selected. Subsequently, information such as author name, publication year, title, subject, city, and geographic scope was extracted for each publication.

In the second phase, this information was converted into spatial data. The country, region, city, or local area covered by each selected study was identified and defined in a desktop GIS environment. Thus, each publication was treated not merely as a bibliographic record but also as data corresponding to a specific geographic area. These data layers were created, enabling the research areas of the studies to be visualized on a map. A word cloud was created on the worldcloud.online site from the dominant words in the study.

First, the geographic locations extracted from the 210 publications were digitized and structured within a spatial geodatabase as vector features. Second, a density-based symbology was applied to these features to represent the concentration of academic output. In the third phase, an interactive web map interface was created using the data prepared in the desktop GIS environment. To visually delineate the geographic intensity and spatial gaps within the examined literature, a heat map visualization was generated using ArcGIS Pro 3.5.

With this structure in place, users can now search for publications by specific bibliographic information, view the location of the relevant study on a map, and access its basic details. Thus, the literature has become more accessible both spatially and thematically.

Geographic Information System (GIS) methods were employed during the data analysis. Bibliographic data and geographic information were evaluated together, and their spatial distribution was examined. The finalised research data was entered into a spatial database and published as interactive map services via ArcGIS Online. Subsequently, the end-user interface and queries (such as searches by keyword, year, author and title) were configured using the Experience Builder tool within ArcGIS Online, and the Web-GIS application was finalised (Ocak & Şirin, 2024). As a result of this process, a database suitable for tracking publications in the fields of historical demography and health inequalities in a digital environment has been created. Furthermore, a basic data refresh infrastructure has been designed to ensure the system can be updated in the future. Consequently, the Web-GIS interface created has evolved from a static structure merely displaying existing data into a research environment capable of being developed over time.

3. Findings

The sources examined and the results of the literature review in this study indicate that the literature on historical demography and health inequalities has grown significantly, particularly since 2000. While early studies were more limited and often proceeded within a theoretical framework, they gained a stronger empirical foundation after 2010. Following 2020, there has been a more intensive output centered on local case analyses, lifetime health outcomes, social disparities, and historical causes of death.

Geographically, the literature is concentrated primarily in Western and Northern Europe. The United Kingdom, the Netherlands, Sweden, Spain, Italy, and Switzerland are prominent areas of study. In contrast, Southeastern Europe, the Balkans, and parts of Eastern Europe are underrepresented. This indicates a clear geographical imbalance in the literature.

Thematically, the dominant areas are infant and child mortality, socio-economic mortality inequalities, nutritional and anthropometric history, and the social context of epidemics. In contrast, the regional distribution of health infrastructure, historical access to health services, and the direct bibliometric-spatial mapping of the literature appear to be more limited.

The Web-GIS based mapping application, however, brings this fragmented literature together into a single digital environment, making both spatial concentrations and research gaps visible. In this regard, it serves not only as a presentation tool but also as an analytical platform that enables comparative analysis.

An analysis of the word cloud generated from the keywords used in 210 studies revealed that the most frequently occurring terms were ‘inequality’ and ‘demographics’. Furthermore, terms such as ‘racial’ and ‘segregation’, which imply discrimination and exclusion, were also frequently used (Figure 1).

Figure 1

Word Cloud of Keywords in the 210 Studies

The data reveals that during the nineteenth and most of the twentieth centuries (1800–1999), the concept of 'health inequalities' developed within its own independent track, showing a steady but modest baseline frequency. Throughout this long span, interdisciplinary synthesis between historical demography and health inequalities was virtually nonexistent, as evidenced by a near-zero co-occurrence count (Figure 2).

However, a dramatic paradigm shift occurred during the 2000–2019 period, where publications focusing solely on health inequalities experienced an exponential surge, reaching a peak frequency of 451. Concurrently, interdisciplinary studies bridging the two fields emerged strongly, recording 202 publications. In the most recent period (2020–2025), a compelling structural stabilization is observed: while standalone health inequality queries adjusted to 58, joint interdisciplinary research maintained a dominant momentum with 93 publications. This shifting ratio indicates that the intersection of historical demography and health inequalities has successfully transitioned from an emerging, novel crossover into a mature, consolidated, and institutionalized field of academic inquiry.

This surge, observed in the literature after 2000 and reaching its peak between 2020 and 2025, can be attributed not only to the digitization of archival data and the development of spatial analysis tools such as GIS, but also to the academic interest sparked by global health crises like COVID-19 in the historical epidemiology and social inequalities underlying such crises (Figure 2.) and (Table 1.).

Figure 2

Temporal Trends and Interdisciplinary Intersection of "Health Inequalities" and "Historical Demography" Literature Across Distinct Historical Periods (1800-2025)

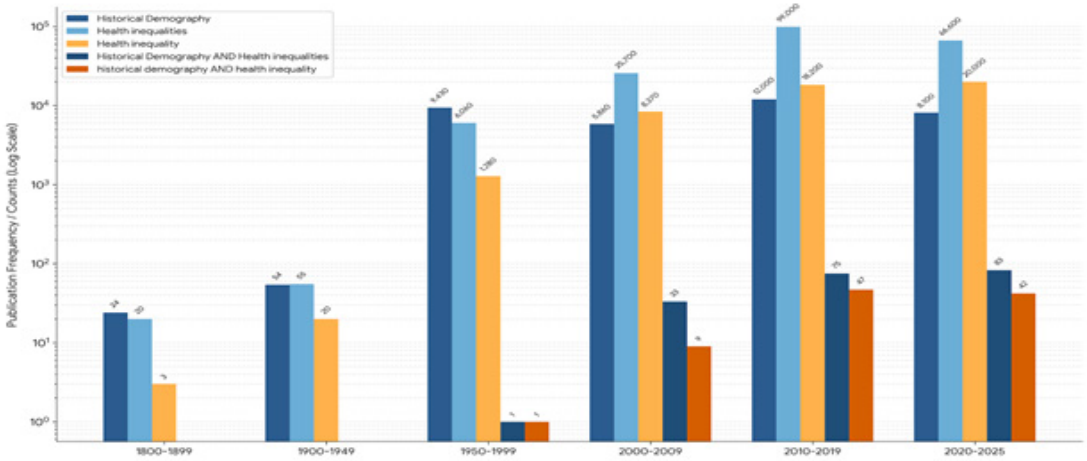


Table 1

Distribution of Search Terms According to Google Scholar Results

Search word	1800-1899	1900-1949	1950-1999	2000-2009	2010-2019	2020-2025
Historical Demography	24	54	9,430	5,860	12,000	8,100
Health inequalities	20	55	6,060	25,700	99,000	66,600
Health inequality	3	20	1,280	8,370	18,200	20,000
Historical Demography AND Health inequalities	0	0	1	33	75	83
Historical demography AND health inequality	0	0	1	9	47	42

While the concepts searched alone indicate a very large literature, the number of results decreases significantly in the scans where the two concepts are used together. This shows that the literature at the intersection of historical demographics and health inequalities is narrower but has grown rapidly, especially since 2000 (Table 2).

Table 2

Key Features of the Periods

Time Period	General Feature	Featured content
1800-1949	Early theoretical period	Epidemiological thought, theoretical discussions with demographic data
1950-1999	Expansion period	Social inequalities, mortality, life expectancy, nutrition, class differences
2000-2025	Period of condensation and synthesis	Local case studies, infant mortality, lifelong health, pandemic and historical inequalities

In northern and western European countries such as the United Kingdom and Sweden, the focus has been on industrial class distinctions and life-course analyses, utilising long-term records. In contrast, in southern European countries such as Italy and Spain, where the Mediterranean climate prevails, climate-related deaths and anthropometric studies based on military records have come to the fore (Table 3). It has emerged that, compared to these countries, relatively less research has been conducted in regions such as the Balkans, South-Eastern Europe and Türkiye.

Table 3

Prominent Research Topics by Country

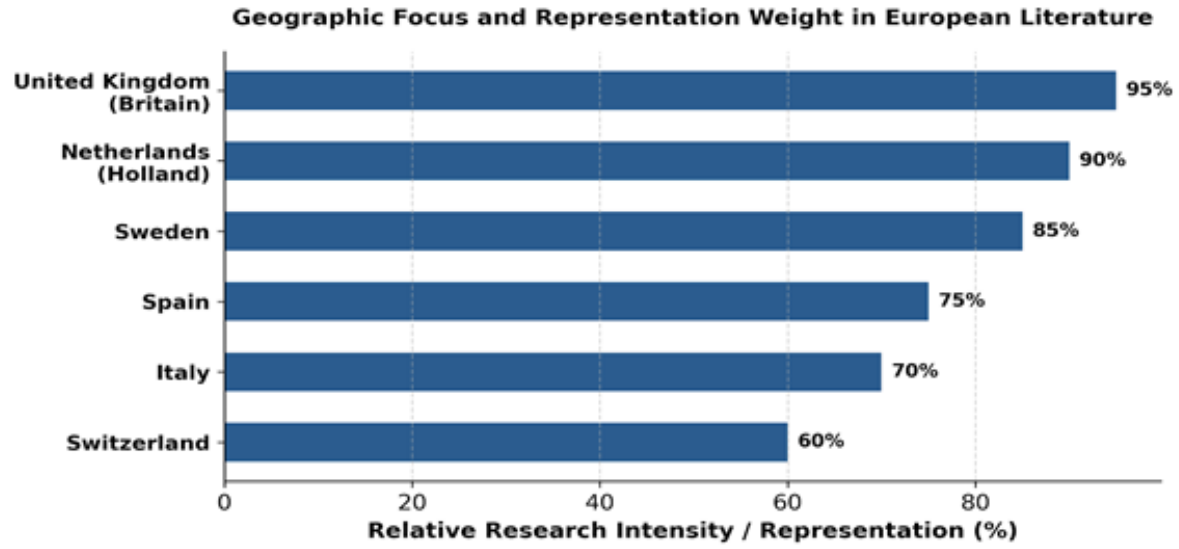
Heavily studied areas	Feature
Britain	Child mortality, social environment, inequality
Netherlands	Amsterdam-focused causes of death, smallpox epidemic, class differences
Sweden	Lifetime health, adult mortality, early life effects
Spain	Anthropometric history, poverty, height, rural inequality
Italy	Plague, seasonal mortality, spatial inequality
Switzerland	Old age poverty, social stratification

The empirical data reveal a highly uneven spatial distribution of academic focus across the continent (Figure 3). Countries characterized by early industrialization and institutionalized archival traditions, such as the United Kingdom (95%) and the Netherlands (90%), form the dominant 'core' of the existing literature. Sweden (85%), Spain (75%), and Italy (70%) act as substantial sub-cores, reflecting localized archival strengths in specific areas such as longitudinal health registers, anthropometric metrics, and historical plague tracking.

Conversely, Central European nations like Switzerland (60%) demonstrate a comparatively lower relative representation weight within this specific interdisciplinary domain. When evaluated alongside the broader literature, this spatial hierarchy highlights clear geographic asymmetries, pointing out significant analytical blind spots in regions such as Eastern Europe and the Balkans. Consequently, these underrepresented areas offer fertile, highly promising ground for future comparative geographic and demographic inquiries.

Figure 3

Geographic Distribution of Research Focus and Relative Representation Weights of European Countries in Historical Demography And Health Geography Literature



Areas with highly clustered research footprints—such as the United Kingdom and the Netherlands—are rendered as high-intensity hotspots (in red). Conversely, regions with sparse or nonexistent research footprints are visualized as low-intensity cold spots.

A global review (Figure 4) reveals a significant geographical imbalance in the literature. The main center of research is concentrated in Western Europe, which forms the most intense hotspot on the map. A second, smaller hotspot appears in North America, particularly within the United States. In contrast, large areas in the Southern Hemisphere, including parts of South America, Africa, and South Asia, contain little to no research traces. These regions appear mostly as cold spots, despite remaining within the defined data collection boundaries. This highlights the predominantly Western focus of the existing literature.

A closer look at Europe (Figure 4) provides a more detailed regional overview. The highest hotspots, with the strongest research density, are tightly clustered over the UK and the Netherlands. These red hotspots indicate areas with a well-established institutional research tradition and high historical data availability.

Medium-Intensity Hotspots: Moving outward from the core region, smaller, medium-intensity hotspots emerge in central France and Spain. This suggests that research in these countries is largely concentrated in capital regions rather than evenly distributed across the country.

Peripheral Regions: Cold Spots: Areas such as Ireland, Northern Germany, and the Alpine region show only a slight, low-intensity trace. Meanwhile, Eastern European countries such as Poland and the Czech Republic, although within the study's boundaries, remain almost entirely blank on the map, indicating a lack of clustered research.

Figure 4

Overview of The Heat Map and Study Area Boundaries Created Within the Scope of the Research

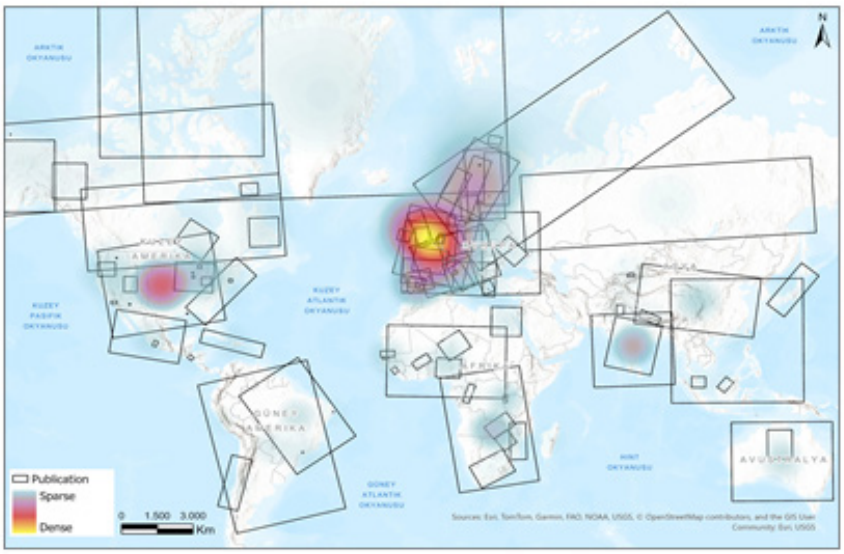


Figure 5

The Heat Map was Created Within the Scope of the Research and the European View of the Study Area Boundaries

Figure 6

Overview of the Prepared Web-GIS Interface

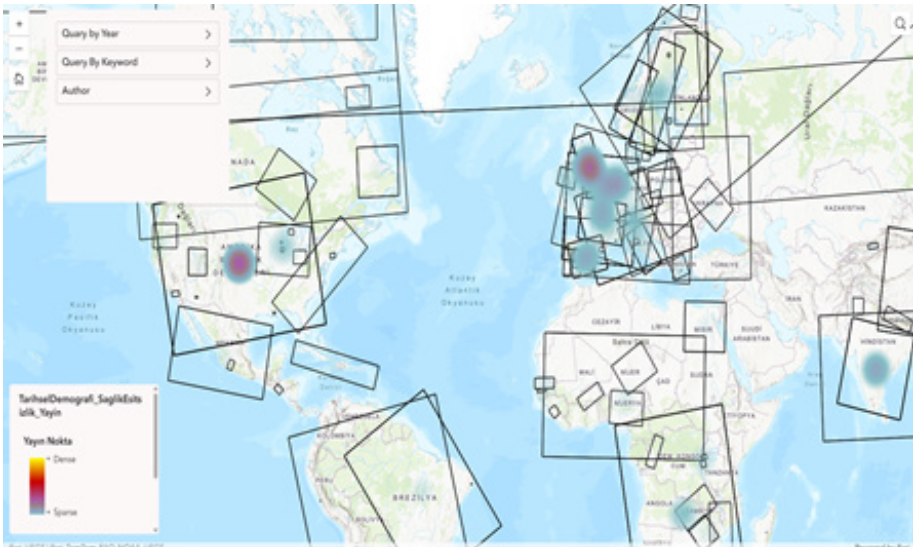


Figure 7

The Plotted Area of The Researched Study and the Appearance of the Main İnformation of the Study

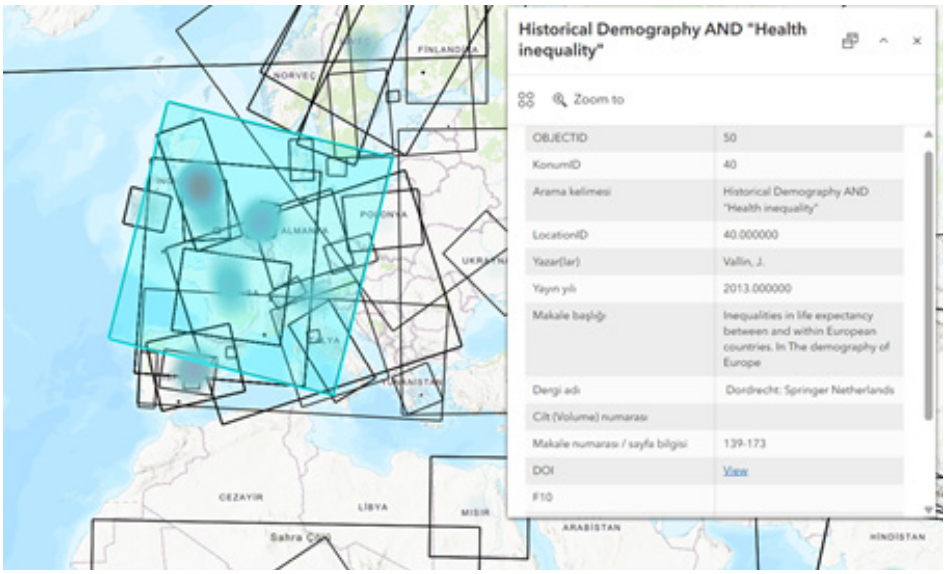
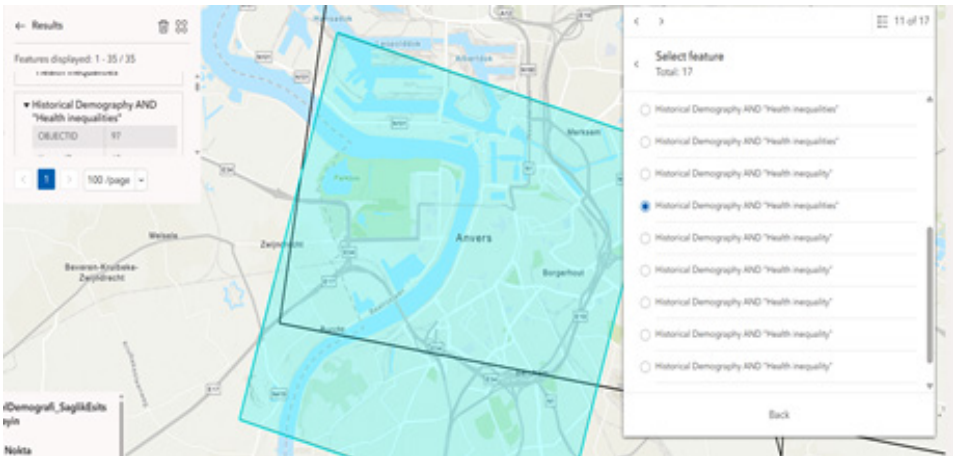


Figure 8

A close-Up Image Showing the Nearby Work Site Where the Work Clicked From the Search Box is Zoomed to



With the prepared interface, the user will be able to search with certain parameters such as keyword, author and year from the search box, and when he clicks on the studies, he will be able to easily access the geographically marked study area. Since this application is open to development afterwards, different categories can be added and updated. This open-access application also supports understanding of open science, thanks to these features, and can serve as an idea for new studies.

The Web-GIS interface can be accessed via the following URL:

https://experience.arcgis.com/experience/45f98374ce084c4dbe79f21681f166f1

4. Discussion

The significant increase in the number of publications in the 2020-2025 period can be explained by evaluating several factors together. First, the relationship between historical demographics, health inequalities, pandemic studies, and digital humanities has become more visible in recent years. Especially in the post-COVID-19 period, the spatial distribution of diseases, social vulnerabilities, and past pandemic experiences has once again created a strong research agenda (Perry et al., 2021). Secondly, COST Action CA22116 The Great Leap, which is carried out on a European scale. Multidisciplinary approaches to health inequalities, the 1800-2022 (GREATLEAP) actions, and similar international networks bringing researchers together around common themes may have accelerated scientific production in this field. Health In order to contribute to achieving greater equality in outcomes, a new Joint Action, JAHEE (Joint Action Health Equality Europe), was funded by the third EU Health Programme in 2018. The primary objective of this action is to strengthen cooperation among

participating countries and implement concrete actions to reduce health disparities (Bucciardini et al. 2023). Such collaborations facilitate both data sharing and comparative research, contributing to the creation of specific research centers and thematic hotspots in Europe. Therefore, the concentration observed during the 2020-2025 period can be considered not only a quantitative increase but also a result of research activities funded across Europe and developed within the network structure.

It is thought that there are several reasons why the 210 studies are concentrated in Europe, and within Europe particularly in the western and northern regions such as England and Sweden. The first of these is due to historical records being kept more systematically than in South-Eastern Europe. In particular, church and parish records, along with Sweden's Tabellverket (also known as TABVERK), form the database for what is considered the world's first modern census. This census, conducted in 1749, led to the establishment of Tabellverket. During this process, all priests in the country regularly reported demographic changes in their regions to the central government (Statistics Sweden, 2026). In England, regular data recording began with the establishment of the General Register Office (GRO) in 1837. As in Sweden, it is thought that research has intensified in England due to the availability and quality of the data. In addition to this, it is thought that such research has intensified in certain regions due to factors such as the budget allocated to research from the general budget and digitisation capacity.

5. Conclusion

This study aims to reveal how publications in the field of historical demography and health inequalities in Europe are distributed across time, subject, and place. The findings show that this literature has increased significantly, especially after 2000. After 2020, a stronger increase in the number of publications drew attention. This shows that the relationship between historical demographics and health inequalities has gained more attention in recent years.

The study also found that these publications were not evenly distributed across Europe. There is a greater accumulation of research in countries such as Britain, the Netherlands, Sweden, Spain, Italy, and Switzerland. In contrast, parts of Southeastern Europe, the Balkans, and Eastern Europe appear to be less studied. This shows that research is intensifying in some regions, while there are open gaps in others.

The methodological approach employed in this study can also be applied to other systematic reviews. In this way, by integrating a geographical perspective with research tools commonly used in the digital humanities, it is possible to answer questions such as who is conducting research, with whom, when, on what topic, and where, across different disciplines. In this context, the research may guide future work in the field of digital humanities.

The most prominent topics in terms of topics are infant and child mortality, social differences, nutrition, height, and epidemics. On the other hand, issues such as access to health services, regional distribution of health infrastructure, and direct mapping of this literature are less studied. This situation also points to which new studies can be carried out in the future.

One of the most important contributions of this study is bringing together scattered publications into a Web-GIS-based map system. Thus, publications can be seen not only as bibliographic information but also as studies of specific geographical areas. This approach shows more clearly which areas are being researched intensively and which areas are more in the background.

As a result, this study has made the current state of the literature on historical demographics and health inequalities in Europe more visible. It also provided a framework that helped to recognise new areas of research. The Web-GIS-based structure created makes this literature more accessible and comparable, creating a useful basis for future studies.

Article Information Form

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