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Analyses of infectious disease patterns and drivers largely lack insights from social epidemiology: contemporary patterns and future opportunities

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ABSTRACT

Background Infectious disease epidemiologists have long recognised the importance of social variables as drivers of epidemics and disease risk, yet few apply analytic approaches from social epidemiology. We quantified and evaluated the extent to which recent infectious disease research is employing the perspectives and methods of social epidemiology by replicating the methodology used by Cohen *et al* in a 2007 study.

Methods 2 search strategies were used to identify and review articles published from 1 January 2005 to 31 December 2013. First, we performed a keyword search of 'social epidemiology' in the title/abstract/text of published studies identified in PubMed, PsychInfo and ISI Web of Science, and classified each study as pertaining to infectious, non-infectious or other outcomes. A second PubMed search identified articles that were cross-referenced under non-infectious or infectious, and search terms relating to social variables. The abstracts of all articles were read, classified and examined to identify patterns over time.

Results Findings suggest that infectious disease research publications that explicitly or implicitly incorporate social epidemiological approaches have stagnated in recent years. While the number of publications that were explicitly self-classified as 'social epidemiology' has risen, the proportion that investigated infectious disease outcomes has declined. Furthermore, infectious diseases accounted for the smallest proportion of articles that were cross-referenced with Medical Subject Headings (MeSH) terms related to social factors, and most of these involved sexually transmitted diseases.

Conclusions The current landscape of infectious disease epidemiology could benefit from new approaches to understanding how the social and biophysical environment sustains transmission and exacerbates disparities. The framework of social epidemiology provides infectious disease researchers with such a perspective and research opportunity.

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INTRODUCTION

Infectious disease epidemiology aims to prevent microbial pathogen transmission using the classical paradigm that considers interactions among the human host, microbial agents and the environment.[1] In recent years, the methodology by which each of these factors is incorporated into research and practice has begun to change. Application of methods such as agent-based modelling,[2] multilevel analyses[3] and social network analyses[4 5] are being applied to infection transmission epidemiology. Many researchers in infectious disease epidemiology are realising that a simple, unidimensional delineation of risk factors, without considering systems and/or mechanisms by which these risk factors interact to augment risk, is of limited utility.[3 6]

The field of 'social epidemiology' has become an important component of modern epidemiology, advancing conceptual and analytical innovations for addressing some of the methodological challenges facing epidemiology, including how to best understand and conceptualise the social environment. One major strength of social epidemiological inquiry is the emphasis on the mechanisms and systems that produce social inequalities, and thereby put certain populations at higher risk for worse health outcomes.[7] However, despite the usefulness of a social epidemiological framework, few studies of diseases with microbial aetiologies have used such a perspective.[8]

Some infectious disease researchers unintentionally incorporate the principles and methods of social epidemiology in their studies. For example, historically, infectious disease epidemiologists have long recognised the importance of social variables, such as socioeconomic status, as drivers of epidemics and disease risk. Many studies of cholera and tuberculosis, for instance, from the 19th and 20th centuries, documented the tendencies for such diseases to thrive in areas of poverty and crowding,[9] targeting the most socially vulnerable.[10] Recently, the HIV/AIDS epidemic in the 1980s primarily affected socially marginalised populations.[11] However, few of these studies have prioritised the social environment as either essential to understanding or a rationale point of intervention in studies of infectious disease. Despite the obvious intersection of the two fields, few infectious disease epidemiologists would consider themselves doing the work of social epidemiology.

Moreover, the inadvertent employment of a social epidemiology perspective used to analyse various infectious disease patterns often goes unrecognised or unappreciated by those in social epidemiology. Specifically, studies that do not explicitly make use of social epidemiological methods are generally omitted from systematic assessments of the social epidemiology research landscape. Few social epidemiology research groups are primarily involved in studies of infectious diseases.

By explicitly incorporating the perspectives and methods of social epidemiology into studies of infectious disease, many opportunities arise. Although the primary goal of infectious disease epidemiology is to understand, control and eliminate

transmission, infectious disease investigations often focus on single risk factors that are proximal and recent, with limited consideration of contextual drivers. Less attention is typically paid to how multiple components of transmission interact to alter risk. Similarly, underlying contextual influences at various 'levels' beyond the individual (eg, family, community, social policies, regional ecologies, etc) are often not incorporated into analyses. While infectious disease epidemiologists have been studying social determinants of infectious disease risk for decades, such studies may benefit from a shift towards analyses that examine the mechanisms by which risk factors work in concert and disparities persist.

Given the potentially important contributions to infectious disease understanding that may arise from perspectives and methods of social epidemiology, we sought to quantify the extent to which such investigations are being published in recent scientific, peer-reviewed research reports. By using comparable methods, our analysis represents an update of a 2007 review that was published in this journal by Cohen *et al*.[8] Based on the findings of that report, we hypothesised that during the past decade there would be an increase in the absolute and proportional number of investigations that incorporated and applied social epidemiological methods to problems involving infectious disease.

METHODS

Two different search strategies were used to identify and review the published literature (summarised in figure 1). We first replicated the 'social epidemiology keyword search' used by Cohen *et al*.[8] From the PubMed results of this search, we also compiled a list of Medical Subject Headings (MeSH) terms that have been commonly used to identify social epidemiology publications. These MeSH terms represented an expansion of the terms used in the Cohen *et al* report (table 1). Thus, our second search was an update of the 'social determinants and disease outcomes' search from Cohen *et al*. We searched for studies using the combined list of socially relevant MeSH terms described above, and cross-referenced them with the specific disease categories defined in Cohen *et al* as non-infectious (including neuropsychiatric and chronic) and infectious (including sexually transmitted diseases (STDs) and non-STDs).

Cohen *et al* employed a third search strategy that focused on reviews of studies examining the social determinants of health. This search was not included, as we found that results were captured by one or both of the other two searches.

Search 1: social epidemiology keyword search (those studies explicitly classified as social epidemiology)

A keyword search of 'social epidemiology' in the title, abstract and/or keyword fields of PubMed, PsychInfo and ISI Web of Science was undertaken for studies published from 1 January 2005 to 31 December 2013. The exact search language is provided in online supplementary appendix 1. In addition to the 9-year time period (2005–2013), results were filtered to include only articles. Thus, other document types such as 'book chapter' or 'meeting abstract' were not considered. Results from the searches of all three databases were imported into the RefWorks citation management tool and checked for duplicate articles. Possible duplicates were examined (by JTK) and removed. The resulting list was imported into MS Excel 2013 where a line-by-line review of each citation's title, abstract and keywords was conducted (by JTK) to identify and remove any remaining duplicates or unwanted document types.

The title and abstract of all remaining articles were read and classified (by JTK) into three categories: infectious, non-infectious or other (generally involving concepts and/or methodologies of social epidemiology). Articles for which a clear classification could not immediately be determined were discussed (by JTK and GAN) until a consensus was reached regarding the classification.

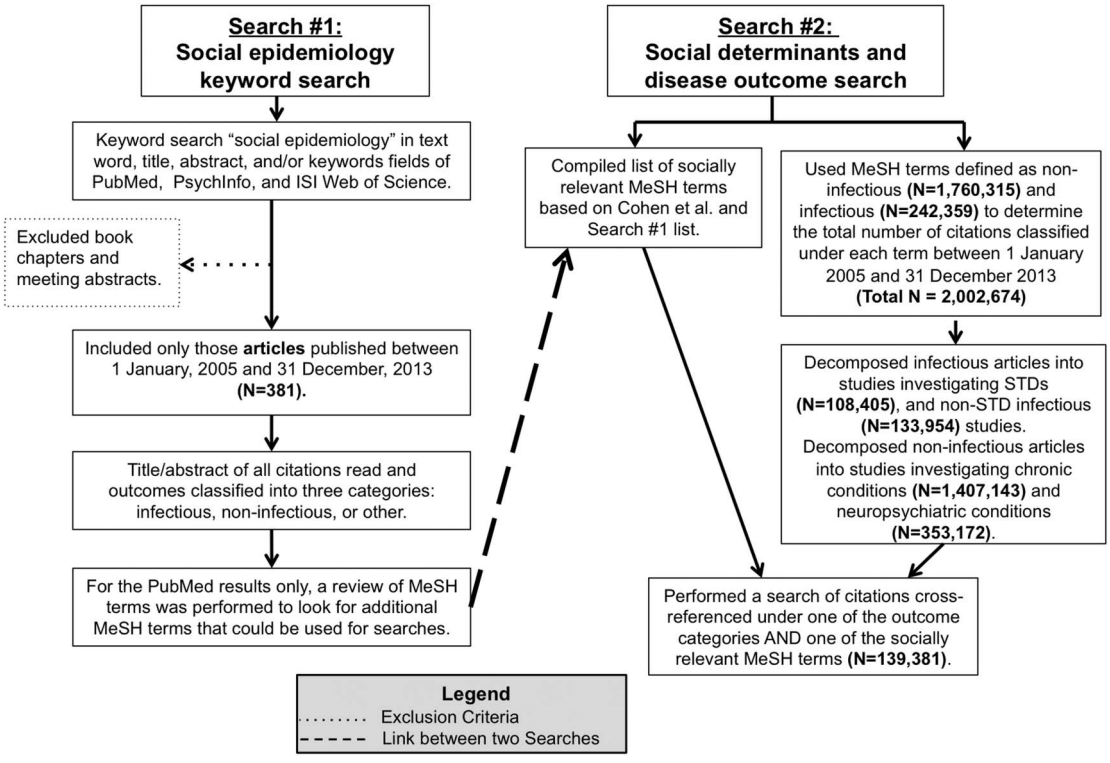

Figure 1 Schematic depicting search strategies 1 and 2.

Table 1 Medical Subject Headings (MeSH) terms used to investigate the number of articles referenced as dealing with social factors and/or outcome categories.

	MeSH terms by disease category			
	Non-infectious		Infectious	
Socially related MeSH terms	Neuropsychiatric	Chronic	Sexually transmitted	Non-sexually transmitted
Sociological Factors*	Mental disorders	Heart diseases	HIV infections	Respiratory tract infections
Sociology, Medical	Substance-related disorders	Neoplasms	Sexually transmitted diseases	Diarrhea
Residence Characteristics		Cerebrovascular disorders	Hepatitis B	Tuberculosis
Human Rights		Pulmonary disease, chronic obstructive		Malaria
Health Status		Digestive system diseases		Poliomyelitis
Healthcare Disparities				Measles
Urban Health				Diphtheria
Urban Health Services				Whooping Cough
Sexuality				Pertussis
Urban Population				Tetanus
Transients and Migrants				
Vulnerable Populations				
Ethnology				
Social Behavior				
Social Welfare				

*Encompasses other important MeSH terms including culture, family, social hierarchy, medicalization, minority groups, secularism, social capital, social change, social conditions, social environment, social isolation, social marginalization, social norms, socialization and socioeconomic factors.

Search 2: social determinants and disease outcomes search (those studies implicitly classified as social epidemiology)

For the second search, we used MeSH terms defined broadly as infectious and non-infectious to determine the total number of articles classified under each heading from 1 January 2005 to 31 December 2013. We then separated the infectious disease articles into those investigating STDs and the others investigating non-STDs. Non-infectious articles were divided into those investigating neuropsychiatric and those investigating chronic conditions.

Since 'social epidemiology' is not a MeSH term, we created a list of socially related MeSH terms that we considered to be representative of the field. This was based on the list of 'socially relevant subheadings' in the Cohen *et al* report, but also was expanded to include additional terms gleaned from search 1 described above. Changes to the list were made to ensure relevant MeSH terms which did not exist when the Cohen *et al* paper was published (eg, social determinants of health) were included. In some cases we also changed from a MeSH term used in the Cohen *et al* search to a broader term from the same MeSH hierarchy in an effort to be more conservative in our replication of the methods they used. This combination of MeSH terms served as our final list of socially relevant MeSH terms for the second search strategy (described in online Supplementary B). To complete this second search strategy, the list of socially relevant MeSH terms was combined with those of each of the more specific disease categories (infectious disease, STD, chronic disease, neuropsychiatric, etc). By compiling the searches in this way, we produced summary measures of the level of social epidemiology research being conducted in each specified area of study. The way in which both searches were developed and combined is summarised in figure 1.

We had hoped to include 2014 and 2015 in our analysis; however, on reviewing the output of search 2 it became clear the lag time in assignment of a MeSH term had biased the results for these years. We performed a sensitivity analysis by rerunning search 2 in March 2016, 3 months after our initial search looking for any significant change in the number of articles in a given year. A substantial number of articles published in 2014 and 2015 had been assigned relevant MeSH terms in the intervening period. This confirmed that the results we observed were not an accurate representation of these 2 years and the decision was made not to include them in our analysis.

RESULTS

Social epidemiology key word search

A total of 381 unique articles with 'social epidemiology' in the title/abstract/text were identified in PubMed, PsychInfo and ISI Web of Science during 2005–2013 (average of 42/year; figure 2). The annual number of articles generally increased over the period (figure 2A). The number of articles with 'social epidemiology' in the title/abstract/text classified as non-infectious and infectious stayed relatively stable over the time period, while the number of articles classified as 'other' increased (figure 2B). Of 381 published articles, 62% were classified as 'other' (generally focused on concepts and/or methods), 25% involved non-infectious diseases and 13% addressed infectious. Most of the increase during the period was in publications classified as 'other'.

Studies examining social determinants of health and disease outcomes

Non-infectious articles were divided into those investigating chronic conditions and those investigating neuropsychiatric conditions. The total number of non-infectious articles increased from 2005 to 2013, comprised primarily of articles addressing chronic conditions (figure 3A). Infectious disease articles were divided into those investigating STDs and those investigating non-STDs. The total number of infectious articles also increased from 2005 to 2013 (figure 3A). The number of infectious disease articles published in 2013 (31 116) represents ~37% increase compared with 2005 (21 959).

Non-infectious disease publications accounted for 88% of all articles of any sort during the study period (figure 3B); moreover, 80% of those non-infectious articles were classified as pertaining to a chronic condition rather than a neuropsychiatric condition (data not shown). Articles involving infectious diseases accounted for 12% of all articles of any sort during the study period (figure 3B). Among these infectious disease articles, about half (45%) investigated STDs (data not shown).

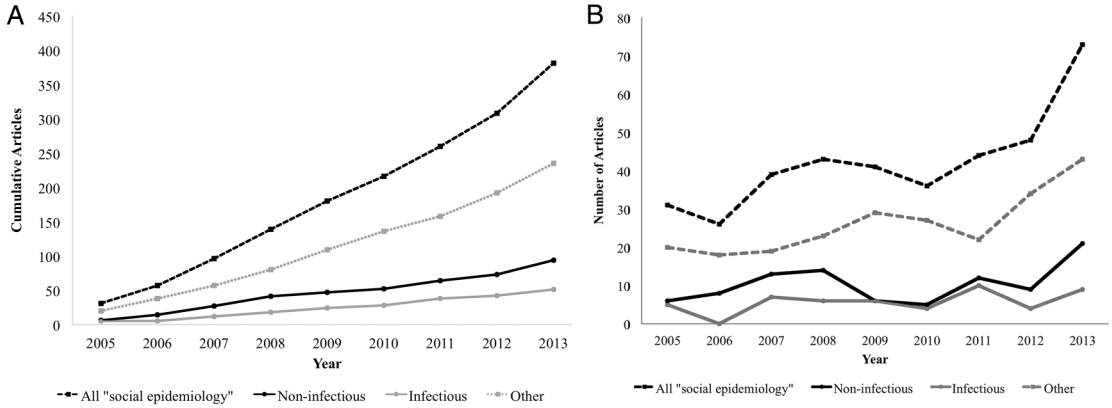

Figure 2 The cumulative number (A) of articles containing 'social epidemiology' in the title, abstract or text from 2005 to 2013. The number (B) of articles containing 'social epidemiology' in the title, abstract or text from 2005 to 2013 and for both figures, 'all social epidemiology' is the summation of the categories of non-infectious, infectious and other.

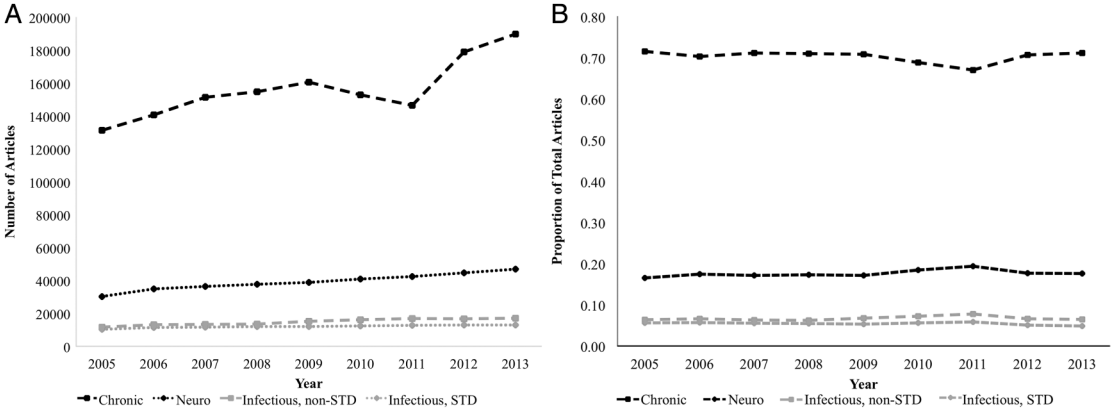

Figure 3 The number (A) and proportion (B) of articles per year indexed from PubMed from 2005 to 2013 under headings of non-infectious (chronic and neuropsychiatric) diseases and infectious (non-STD and STD) diseases. STD, sexually transmitted disease.

From the expanded list of socially relevant MeSH terms, we determined the number of articles with a social epidemiological link for the period of 2005–2013 (see online supplementary figure A) in order to classify the infectious and non-infectious articles as defined above (table 1, figure 4A). The number of non-infectious disease articles (comprising both chronic and neuropsychiatric conditions) that were cross-referenced with socially relevant MeSH terms increased from 2005 to 2013 (figure 4A). However, the proportion of articles with a social epidemiological link that were classified as non-infectious remained relatively stable at around 80% over the time period (figure 4B). Further, despite there being 3.5 times more chronic publications than neuropsychiatric overall (figure 3A), the proportion of neuropsychiatric articles with a social epidemiology link was nearly double that of chronic articles (figure 4B).

There was little change in the number of infectious disease articles that were cross-referenced with socially relevant search terms from 2005 to 2013 (figure 4A). From 2005 to 2013, infectious disease publications accounted for only one-fifth (~20%) of all articles with a social epidemiological link (figure 4B). Within these infectious disease publications, those addressing STDs accounted for the largest proportion (figure 4A).

DISCUSSION

We employed two systematic literature search strategies to characterise recent trends in published scientific studies operating at the intersection of social epidemiology and infectious disease epidemiology. While the number of publications explicitly self-classifying as 'social epidemiology' has been increasing, the proportion of these articles that investigated infectious disease outcomes has declined. Furthermore, infectious diseases accounted for the smallest proportion of articles that were cross-referenced with MeSH terms related to social factors and most of them were studies investigating STDs, suggesting that researchers have more readily incorporated social epidemiological methods into studies investigating STD outcomes.

Our two separate search strategies were designed to determine trends in scientific publication from two different vantage points. While the first approach, which identified 'social epidemiology' in the title/abstract/text, had low sensitivity the high specificity gave us confidence that articles identified in the search had truly employed social epidemiological methods. The second approach, involving articles that were cross-referenced with both socially relevant search terms and major disease categories, had very high sensitivity that captured all articles using applied social epidemiological methods. However, this 'test' could not distinguish those studies that simply included terms such as 'race' and 'poverty', for example, from others that considered the systems in which these factors operated, arguably a key tenet of social epidemiological inquiry. Thus, in conjunction with one another, these two search strategies were able to shed light on larger trends in recent scientific inquiry.

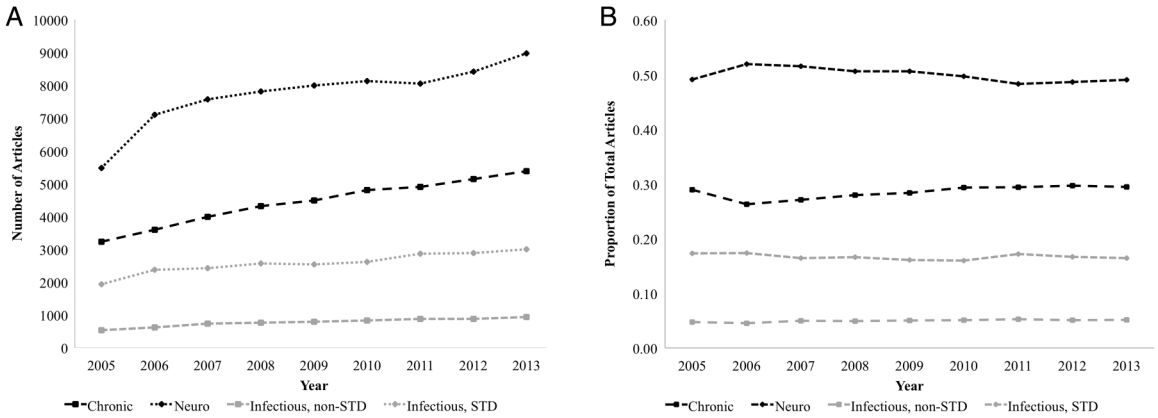

Figure 4 The number (A) and proportion (B) of articles indexed under important headings of non-infectious (chronic and neuropsychiatric) and infectious (non-STD and STD) and cross-referenced with socially relevant subheadings from 2005 to 2013. STD, sexually transmitted disease.

Our study represents a sequel to an earlier report by Cohen *et al*,[8] which examined these same trends during 1966–2005. That review found 137 articles with explicit mention of social epidemiology, of which only 11% focused on infectious diseases, a proportion that is comparable to our recent finding of 12%. While the total number of studies classified as 'social epidemiology' has continued to increase since 2005, the number of those studies investigating infectious disease has stagnated. Additionally, similar to the Cohen *et al* review, we also found that the lowest number of articles cross-referenced under socially relevant MeSH terms were those belonging to infectious, non-STD articles.[8]

The main conclusion that has emerged from our analysis of recent publication patterns is that social epidemiological methods are largely absent from infectious disease epidemiology studies, both explicitly and implicitly. This finding is particularly pronounced for published studies of infectious diseases other than STDs. Roughly a decade ago, Cohen *et al* suggested that infectious disease epidemiologists should begin to embrace and apply social epidemiological methods in order to advance understanding of multiple pathways and contextual determinants of infectious disease dynamics. Our review indicates that there has been little research progress in applying such an approach.

While conducting this review, we encountered several methodological challenges that may help explain the paucity of social epidemiological studies of infectious diseases, but also structural barriers that restrict progress in this approach. One persistent issue that kept resurfacing involved the very definition of 'social epidemiology'. What makes a study a social epidemiology study, for example, and how then do we evaluate the extent and impact of such studies in the landscape of contemporary scientific literature? We returned to some of the seminal studies in social epidemiology for perspective. It is clear that simply controlling for 'social factors' such as poverty, race/ethnicity, sex/gender is insufficient to be defined as social epidemiological inquiry. The foundational scholars in this field often reference the importance of the systems in which these factors operate,[12] or the 'upstream' influences that lead to multiple outcomes.[13] From theories of neighbourhood environments[14 15] to how economic and political systems influence disease outcomes,[16] research contributions to this field must analyse how social factors operate within a larger system. However, despite these hallmark features of such study paradigms, a clear and consistent definition of social epidemiology was not found. This is problematic for two reasons: it discourages researchers from employing such perspectives and principles, thereby aligning themselves with the field, and it prevents the consistent identification comparison and evaluation of such studies.

We also encountered challenges with the databases themselves, particularly PubMed, calling into question the systems used to classify scientific literature. One such hurdle involved how manuscripts are catalogued and classified by MeSH terms in PubMed. Our study team consulted with several library science experts in PubMed's MeSH system, and discovered considerable ambiguity in how and why publications are classified with a specific MeSH terms. This is less of an issue when authors self-identify their manuscript as belonging to a certain category, either through their keywords or title. However, in the absence of such an explicit classification, assigning categories is left to an outsider arbiter. This again highlights the need for a clear and consistent definition of social epidemiology that will help inform decisions about the category of investigations.

Our review was initially planned to analyse articles published from 2005 to 2015; however, the time lag in MeSH term assignment made it necessary for us to restrict comparison to no later than 2013. Through consultations with library scientists and PubMed officials, our suspicions were confirmed that there is a non-systematic, months-to-years lag between publication date and PubMed classification that prevents near-current analysis. This is another challenge that is exacerbated by the lack of a well-established definition for what constitutes social epidemiology.

Additionally, because we sought to replicate the methodology of Cohen *et al* the MeSH terms used in search 2 left out several important vector-borne diseases such as yellow fever or dengue. However, such research would have been captured in search 1. Importantly, the two searches did not show publication patterns that were different in important ways suggesting the omission of such vector-borne diseases did not substantially bias the results.

Despite these challenges, our findings suggest a persistent paucity of research during the past decade that applies social epidemiology perspectives and methods to infectious disease research. Cohen *et al*[8] hypothesised that this may be due to the time period when social epidemiology came to prominence. The rise of social epidemiology largely began in the 1950s and continued to gain popularity into the 1970s[7]—a time when infectious disease epidemiology research was declining. Thus, when theories and principles of social epidemiology were being formulated, the disease outcomes most relevant were those of a

non-infectious nature. Perhaps the medical perspective that many infectious diseases are considered easily treatable (antibiotics) or prevented (vaccines) has limited social epidemiological analyses. Similarly, the relatively short time from exposure to disease might discourage interest in understanding 'upstream' or 'life-course' drivers of risk. Nevertheless, infectious diseases remain as important causes of morbidity and mortality, with, for example, nearly 10 million people being diagnosed with tuberculosis disease in 2014[17] and 37 million people living with HIV.[18]

The current landscape of infectious disease epidemiology requires new approaches and analytical tools for understanding how multiple factors interact in complex systems to affect risk, and how the social and biophysical environment sustain transmission and exacerbate disparities. The framework of social epidemiology provides infectious disease researchers with such a perspective. It encourages expanding analyses from biomedical studies of microbial aetiologies to those encompassing historically and contextually complex interactions between different types of human hosts and our microbial agents, interacting in sociocultural and economic environments that can better explain disease risk.

What is already known on this subject

- The current landscape of infectious disease epidemiology requires new approaches and analytical tools for understanding how multiple factors interact in complex systems to affect risk, and how the social and biophysical environment sustain transmission and exacerbate disparities. The framework of social epidemiology provides infectious disease researchers with such a perspective. Yet, previous research has shown a persistent paucity of research that applies social epidemiology perspectives and methods to infectious disease research. We sought to examine whether this trend has changed in the past decade, hypothesising that we would observe an increase in the number of infectious disease studies incorporating social epidemiological methods.

What this study adds

- Based on our findings, the proportion of infectious disease articles that explicitly self-classify as 'social epidemiology' has decreased over the study period despite increases in the number of publications explicitly self-classifying as 'social epidemiology'. The current landscape of infectious disease epidemiology could benefit from new approaches to understanding how the social and biophysical environment sustains transmission and exacerbates disparities. However, this study suggests that such applications of social epidemiology are largely lacking in studies of infectious disease.

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Contributors GAN contributed to study design, helped access, extract and assemble the data, and drafted and revised the manuscript. JTK designed the search strategy, accessed and summarised the data, and revised the manuscript. MLW contributed to study design and data searching, and revised the manuscript.

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Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Technical appendices provide detailed instructions on how the search was undertaken. A list of the articles used in the analysis is available from the authors.

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