

BIBLIOMETRIC ANALYSIS ON COVID-19 IN THE CONTEXT OF MIGRATION HEALTH

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ABSTRACT

Introduction: Human mobility has been pivotal to the spread of COVID-19 through travel and migration. To mitigate the spread, most countries have imposed strict travel restrictions that have severely affected both the wellbeing and livelihoods of many migrant and mobile populations (both internally and internationally), particularly those from impoverished communities, affected by humanitarian crises, displaced and/or living in camps and camp-like settings. The need to include migrants (both regular and those irregular “undocumented”) in the national strategic response plans in disease prevention and control has been increasingly recognized. Better understanding of the existing scientific evidence in migration health to effectively respond is crucial. This study aimed to provide valuable information to support evidence mapping and assessment of research activities on COVID-19 and migration health, including the identification of important research gaps.

Methods: A bibliometric analysis of scientific publications on COVID-19 and migration health published from 1 January 2020 to 4 May 2020 was implemented using Elsevier’s Scopus abstract and citation database.

Results: A total of 276 publications were retrieved on COVID-19 and migration health. The mean number of authors per document was 8.3 while the mean number of citations per document was 9.7. The Travel Medicine and Infectious Disease was the most active journal (6.2%; n=17) while the Ministry of Education China was the most active institution (5.1%; n=14) on this topic. The top countries of author affiliation in terms of number of authored/co-authored publications were China (29.3%; n=81) and USA (25%; n=69). International research collaboration appeared to be strongest between these two countries. The retrieved publications were mainly on disease epidemiology and mathematical modelling (40.9%; n=113), public health interventions (38.4%; n=106), and clinical management (9.8%; n=27). These themes were clearly reflected in the keywords that dominated the clusters in the visualized maps. There was a limited number of publications on migrant-specific themes (i.e. migrant protection services and camp coordination management), candidate therapeutics and vaccines, and impact assessment and policy analysis (specifically on policy analysis). Moreover, the studies involving specific migrant populations were few and limited to international students, migrant workers, immigrants, migrants, refugees, and asylum seekers. Most of the studies investigated cases of COVID-19 in the context of population movement.

Conclusion: Findings from the bibliometric analysis provide an overview of the extent of research activities in COVID-19 and migration health including the key actors (i.e. authors and institutions) and major research areas in the field. The important research gaps identified suggest the need to push for an inclusive research strategy in the context of migration health in the investigation of COVID-19. As evidence on COVID-19 continues to develop, the overall research landscape is very likely to change; the study findings provide researchers and relevant stakeholders with a good starting point in developing further research and maximizing existing research networks that are tailored towards addressing the critical gaps identified.

Keywords: COVID-19, Coronavirus, SARS-COV-2, Bibliometric Analysis, Scopus, global migration health

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Ethics and dissemination: This analysis draws on publicly available data and does not directly involve human participants; ethics review is not required.

INTRODUCTION

Migration health and COVID-19

Human mobility played a central role in the spread of the coronavirus disease 2019 (COVID-19) [1, 2]. In late December 2019, a cluster of pneumonia cases of unknown etiology was detected in Wuhan City, a major transport hub in the People's Republic of China [3]. This quickly spread to other provinces in China including Guangdong Province, Beijing Municipality, and Shanghai Municipality. Within a month from the discovery of the novel coronavirus, officially named SARS-CoV-2, Thailand, Japan, and the Republic of Korea reported confirmed cases of COVID-19, which were all linked to travel in China [4]. Since then, the number of confirmed and suspected cases has expanded worldwide especially in populations with travel history to affected areas or contact with infected persons [5]. Three months later, on 11 March 2020, the World Health Organization (WHO) declared COVID-19 a pandemic [6]. As of 28 May 2020, there have been over 5.6 million confirmed cases of COVID-19 and over 350,000 deaths globally [7].

Several governments issued travel restrictions or outright bans on the entry of persons from countries or areas with known cases of COVID-19 and/ or suspension of domestic and international flights, which limited internal and international movement [1, 8]. A total of 216 countries, territories or areas have put into effect over 45,300 travel restrictions to contain and reduce the spread of COVID-19; about 69 per cent (524 out of 763) of airports were partially operational (n=281) or fully closed (n=243); and, about 81.8 per cent of land border crossings were partially (690 out of 2120) or fully closed (1,045 out of 2120) [9].

The relationship between migration and health is complex, and its impact varies considerably across migrant groups, and from person to person within such groups. Migration, among other factors, is considered a social determinant of health [10]. Conditions surrounding the migration process can increase the vulnerability to ill health. The process of migration exposes migrant groups to various "health risks through unsafe travel, exposure to diseases, limited access to health services, poor nutrition, psychosocial stressors, and harsh living and working conditions." [11, 12] There may be differences in the disease profiles and health risk factors between migrant and host populations, within various migrant categories, and inequalities in the access/uptake of preventive interventions and in treatment outcomes based on migration. Governments, international agencies and scholars have iterated the importance of integrating and including migration and population mobility as key components in formulating national, sub-national, regional and global health policy and interventions [11].

Although, various measures have been implemented in the COVID-19 pandemic response, these measures largely focus on protecting the local communities in host countries [13, 14]. Culturally appropriate public health measures inclusive of migrant populations are recommended [ibid]. It is also essential to consider migrants throughout the stages of an outbreak (i.e. initiation, propagation, resolution phase), and direct research endeavors toward exploring the migration and health nexus. For example, adverse working conditions and poor access to health service among the low-waged (and often undocumented) migrant workers in intensive animal rearing and meat processing industries in some countries and potential for such settings for cross-species transmission (zoonosis) remains poorly explored [13, 15].

Mitigating a global pandemic requires equal access to health services, regardless of migration status, or curtailing mobility for non-citizens. Addressing the health of migrants and mobile populations is an important aspect to ensuring global health security. Accessible and quality health care for migrant workers and their families protects the people in transit and the receiving communities— where “Migration health is a shared responsibility with public health impacts that extend beyond national boundaries.” [11]

Impact of COVID-19 among migrant populations

The International Organization for Migration (IOM) defines the term ‘migration’ as “the movement of a person or a group of persons, either across an international border, or within a State” [16, 17] The term ‘internal migration’ refers to the movement of people within a State involving the establishment of a new temporary or permanent residence. ‘Internal migrants’ include people who have been displaced from their habitual place of residence (i.e. internally displaced persons or IDPs), as well as persons who have decided to move to a new place (i.e. rural–urban migration)[17].

The term ‘international migration’ refers to the “movement of people between different countries” while the term ‘international migrant’ refers to “any person who is moving or has moved across an international border away from his/her habitual place of residence for at least one year regardless of the cause, legal status, and length of the stay.” [16, 18] In 2019, the number of international migrants was estimated at 272 million, which is 3.5 per cent of the global population, with higher estimates of internal migrants in year 2009 at 740 million [18].

The majority of ‘international migrants’ are ‘migrant workers’ who are moving to work in another country where labour or particular skills are needed. This mainly happens through formal employment pathways. Such ‘international migrant workers’ comprises more than half of the stock of international migrants (163.8 million), and is defined as “a person who is to be engaged, is engaged or has been engaged in a remunerated activity in a State of which he or she is not a national” [18, 19]. Migrants – particularly in lower paid jobs – may be more affected by and vulnerable to the spread of COVID-19 in countries already impacted and those countries where the pandemic is spreading[20]. Migrant workers accounted for 20.6 per cent and 17.8 per cent of all workers in Northern America, and in Northern, Southern and Western Europe respectively [21]. They therefore represent about one in five workers in those countries and may be among the first to be affected by lay-offs and movement restrictions and lockdowns impacting livelihoods such as losing their businesses. Living conditions in crowded housing pose a particular risk to the spread of COVID-19 among migrant workers.

However, migrant workers also play an important role in the response to COVID-19 by working in critical sectors As an illustration , available international data show that at least ten countries – the United States, Spain, Italy, Germany, France, the United Kingdom, Belgium, the Netherlands, Canada and Switzerland -- depend on foreign-born workers in the critical sector of healthcare services. On the higher end, 47 per cent of doctors and 32 per cent of nurses in Switzerland in 2015/6 were foreign-born. On the lower end, four per cent of doctors in Italy and four per cent of nurses in Spain were foreign-born [22].

Refugees and asylum seekers make up about 10per cent of all international migrants, with four out of every five hosted in economically poorer developing regions. In 2019, there were an estimated 25.9 million refugees (i.e. those who are forced to leave their country owing to a well-founded fear of conflict or persecution) and 3.9 million stateless persons (i.e., those who are not considered a national by any State) [18]. These forcibly displaced populations are at heightened risk of contracting diseases due to poor living conditions and high population

density with limited access to healthcare services, and often bounded by the political system of host countries [13].

The COVID-19 pandemic has affected these migrant and mobile populations in multiple pathways – and perhaps to a greater extent than the general population [23]. The unique conditions surrounding the migration process expose migrants, refugees, and internally displaced populations to additional health risks. In this pandemic, migrants and mobile populations are one of the most vulnerable populations. Factors that contribute to this vulnerability include: (1) Precarious working environment and poor living conditions (e.g. temporary shelters, refugee camps), particularly for low-waged migrant workers, refugees, asylum seekers, and IDPs; (2) Limited or no access to health care services due to the legal and practical barriers to healthcare. There is also clear evidence that migrants have been excluded in national pandemic plans [24]; (3) Travel restrictions that lead to mass exodus of migrant worker populations (international and internal); (4) Economic impact of the pandemic to migrant workers; and (5) Increasing xenophobia in migrant populations due to importation risks [15, 19, 25-27]. They are frequently neglected, stigmatized, and may face difficulties in accessing health services that are otherwise available to the general population. In the context of the Interim Guidance on Scaling-up COVID-19 Outbreak in Readiness and Response Operations in Camps and Camp-like Settings, the people in humanitarian situations affected by this guidance may include IDPs, host communities, asylum seekers, refugees and returnees, and migrants when in similar situations [28].

Global response strategies to COVID-19

IOM, as part of the Inter-Agency Standing Committee (IASC), and in partnership with WHO, other United Nations (UN) organizations and coordination groups as well as non-UN stakeholders, is assisting Member States (MS) and partners to prepare for and respond to COVID-19, with operational, technical and policy support. One of the priorities outlined in IOM's COVID-19 Global Strategic Preparedness and Response Plan (SRP) involves supporting efforts that properly consider the cross-cutting humanitarian and development needs of migrants, IDPs, and other vulnerable populations in reducing COVID-19-related illness and deaths [29].

Research mapping: A migration health research priority

The 2nd Global Consultation on Migrant Health (2017) recognized the need to “take stock of current research, map the existing landscape of published literature, identify areas of focus and gaps to better organize a global research agenda on migration health” [30].

Bibliometric analysis is the quantitative analysis of publications (e.g. research articles and books) using bibliographic data (i.e. author information, citation, and publication information) to produce measures of ‘research productivity’ (i.e. number of publications), ‘research impact’ (i.e. citation counts, journal impact factor, etc.), and national or international networks/ collaborations of authors/ researchers, institutions/ organizations, and country/author affiliation). Although, the bibliometric method does not provide analysis and interpretation of the content of a research publication, it has been firmly established as a scientific specialty and an integral part of research evaluation methodology. It provides useful information on the growth, impact, gaps, and trends of research publications within a particular field or discipline [31-33].

In this paper, we present the protocol for a bibliometric study that aims to identify and analyze research publications on COVID-19 focusing on migration, migrants and human mobility; specifically mapping research productivity on COVID-19 in the context of migration health by author, country, institution/ organization, health theme, and migrant topic (i.e. migrant type and country coverage). The findings from this study will provide useful

information in enhancing the strategic response to COVID-19 and will contribute to improving efforts in the successful integration of different migrant groups into the national health systems and ultimately support COVID-19 prevention and control.

METHODOLOGY

CITATION DATABASE

Scopus, a citation and abstract database of peer-reviewed literature developed by Elsevier, was used to retrieve publications on COVID-19 and migration health. Scopus provides a comprehensive overview of global research output in different disciplines and covers 100 per cent of MEDLINE publications. The advantage of Scopus over other citation databases was extensively discussed in previous studies [31, 34, 35].

SEARCH STRATEGY

INCLUSION STEP

The search strategy was developed on 30 March 2020 and updated on 4 May 2020. Two search queries were developed for COVID-19 and migration health (i.e. one query for each search component). For the COVID-19 search query, the identification and selection of keywords were based on reviewing the WHO COVID-19 repository [36] and bibliometric studies on COVID-19 [37] [38].

The COVID-19 search query was applied in the publication title to minimize false positive results. Search terms and Boolean separators for COVID-19 include “covid*” OR “covid-19” OR “covid19” OR “SARS-CoV-2” OR “ncov” OR “2019-nCov” OR “2019nCov” OR “corona virus” OR “coronavirus” and a combination of COVID-19 specific terms.

A separate search query was developed for migration (health). The search query was grouped into three main topics: ‘international’, ‘migration and migrant’, and ‘mobility and travel.’ The first two topics adopted the search strategy developed for global migration and health [31]. The ‘mobility and travel’ terms were captured using synonymous and related terms to mobility (i.e. ‘movement’, ‘displaced’, ‘displacement’, ‘travelling’, and ‘traveler’). The migration (health) search query was then applied in the title, abstract and keywords of publications.

The search queries for COVID-19 and migration (health) were combined using the Boolean operator “AND.” The search results of these queries contained all publications on COVID-19 with ‘migration’, ‘migrant’ and ‘mobility’ terms. It should be noted that while the analysis intends to capture publications on COVID-19 and “migration health”, the search query on migration health largely focused on migration-, migrant- and mobility-related terms as the health aspects of migration are effectively subsumed in the COVID-19 search query. The full search strategy is available in Appendix 1.

EXCLUSION STEP

The following steps were applied to the search strategy to eliminate irrelevant publications or false positive results.

- Restricted the publication year to 2020.
- Excluded publications indexed in irrelevant subject areas (e.g. Veterinary) after careful review of the retrieved publications. (NB: Scopus classifies retrieved publications based on the field and scope of the sources or publishing journal).
- Excluded publications with irrelevant or out-of-scope topics.
 - a. The assigned reviewers (JL, SA, MA) performed title and abstract (if available) screening of the retrieved publications using MS Excel. If no abstract was available in Scopus, the reviewers checked the source publication. To guide the screening, below exclusion criteria was applied stepwise:
 - (i) Animal model studies that do not include human subjects.
 - (ii) Title or abstract does not have terms related to ‘migrant’, ‘migration’, ‘mobility’ or ‘travel.’ NB: exemptions - publications that implied review of travel history and/or restriction in mobility were included.
 - (iii) Abstract does not refer to at least one of the following populations: migrants, displaced populations, refugees, asylum seekers, travelers, mobile populations. For example, publications that focus on the aviation industry (as a business component) with no health angle.
 - (iv) No abstract available (in Scopus and source publication) NB: exemptions - short commentaries with no abstract but with full article in the source publication.
 - (v) No English translation of the title and/or abstract (for non-English publications).
 - (vi) Retracted publications.
 - b. The reviewers discussed among themselves the publications identified as “uncertain” and “excluded (criteria iii)” until a consensus was reached on whether to include or exclude them. Note that other publications identified as “excluded” in other criteria items were not included because listed reasons were straight forward.
- Excluded confirmed duplicates; duplicates were identified using MS Excel and EndNote based on the following parameters: author names; publication title; source title; and, volume and issue number. One set of duplicate was found that differed in the author name. Upon closer review, the publications were found to refer to the same author, but the recorded names were slightly different. For this set of duplicates, the publication with incomplete bibliographic data (i.e. no author keywords) was excluded.

VALIDITY OF THE SEARCH STRATEGY

In every step of the search query, the search results were reviewed to check the publication yield. The search strategy was adjusted if known relevant publications were not captured in the search. Careful screening of the title and abstract (if available) was done to ensure validity of search results. The methodological rigor of the study was reviewed and validated by a bibliometric analysis expert.

DATA ITEMS AND DATA EXTRACTION

The Scopus search output will be exported into several formats including CSV (for screening, classification, analysis, and visualization), RIS (for screening duplicates in EndNote), and BibTex (for analysis). All fields will be exported including the broad categories citation information, bibliographic information, abstract and keywords, funding details (where available) and cited references.

Bibliometric information that will be recorded from the online Scopus analysis include the following:

- Author names (with number of publications by author)
- Source title (with number of citations by source)
- Institution or organization name (with number of publications by institution/ organization)
- Country name from author affiliation address in Scopus (with number of publications by country)
- Publication type (with number of publications by type)
- Subject area (as defined by Scopus)
- Author and index keywords
- Funding source (number of publications by source)

BIBLIOMETRIC ANALYSIS

Scopus and Biblioshiny will be used to analyze bibliometric information including authors, citations, publications, and sources (or journals). Biblioshiny is an open source web-interfaced bibliometrics tool that uses the R programme, a statistical software [39]. Scopus has a built-in analysis function that can generate a list of leading publications, sources (or journals), authors, country author affiliations, institutions or organizations, and aggregates of publication types, and subject areas. Further analysis can be done on the leading authors, publications, and sources (or journals) using the profile feature available in Scopus.

CITATION ANALYSIS

The two bibliometric tools (Scopus, Biblioshiny) provided the number of citations received for each publication and allowed sorting of publications based on the number of citations. Scopus has a built-in feature for comparing journal metrics. For this study, SCImago Journal Rank (SJR) was extracted. The SJR indicator is a measure of the scientific influence of scholarly journals, where higher SJR values are meant to indicate greater journal prestige. A journal's SJR indicates the average number of weighted citations received during a selected year per document published in that journal during the previous three years [40].

NETWORK VISUALIZATION MAPPING

VOSviewer version 1.6.15 [41], a software tool for constructing and visualizing bibliometrics networks, was utilized to analyze and visualize the networks of co-authorship relations between author, countries, and institution, and co-occurrence relations between keywords. To present a clean map, VOSviewer thesaurus files were prepared to standardize terms and exclude generic and out-of-scope terms.

Fractional counting method was selected in creating the co-authorship and co-occurrence keyword network maps. In the authors network map, fractional counting means that the strength of a co-authorship between two authors accounts for the number of publications they co-authored and the total number of authors of each of the co-authored publications. Therefore, each publication has the same overall weight [42].

A threshold number (i.e. number of occurrences of keywords and number of co-authored publications) was set for each type of map. To present a clean map, VOSviewer thesaurus files were prepared to standardize terms and exclude generic or out-of-scope terms. In the keyword maps, for example, coronavirus-related terms, generic terms (e.g. health survey, diseases, humans, viral disease), and type of publication or study (e.g. article, case report, editorial) were excluded.

Network visualization mode in Vosviewer was used in the creation of all network maps. Table 1 lists the bibliographic data used for the four visualization network maps (i.e. authorship, institution, country, and keyword networks) [43]. Items in networks are represented by circles. A network consists of a set of items linked together by lines. A network map contains at least one cluster; each cluster represented by a different color. The maps generated only present those networks with the largest set of links or connections. For example, the size of the circle represents the more frequently occurring keyword or the highest number of co-authored publications in the retrieved set of publications from Scopus. The strength of links indicates the number of publications that two authors have co-authored (for co-authorship links) or the number of publications in which two keywords occur together (for co-occurrence links). The distance between two items in the visualization indicates the relatedness (i.e. co-authorship or co-occurrences) of items. The shorter the distance between two items, the stronger the relatedness. Colors represent clusters of items that are relatively strongly related to each other based on their co-occurrence in the bibliometric data (i.e. not necessarily a conceptual link).

Table 1. Bibliographic data used in creating the visualization network maps in VOSviewer

Links*	Items**	Network
Co-authorship	Institutions/ Organizations	Institution collaboration
	Authors	Author collaboration
	Countries	Country collaboration
Co-occurrences	Keywords***	Keyword co-occurrences network

* A connection or a relation between two items in a visualization network map, represented by lines.

** Refers to the specified bibliographic data that will be used in the network mapping.

*** For this study, both author and indexed keywords were selected to ensure thorough coverage especially because some publications do not include author keywords (i.e. keywords chosen by authors themselves). The indexed keywords are keywords chosen by Scopus content suppliers and are standardized based on publicly available vocabularies.

RESEARCH THEMES AND SUBTHEMES

The retrieved publications were classified into themes and subthemes reflective of the relevant migration health-related topics and IOM's COVID-19 Strategic Preparedness and Response Plan (SPRP) [29].

Below is a description of each of the themes and subthemes:

1. Public health intervention

Description: Publications that cover topics on any combination of programme elements or strategies related to addressing COVID-19-related health concerns in different populations.

Subthemes: Government measures; travel-related measures (e.g. travel restrictions and point-of-entry health screening); disease surveillance; community screening; case identification and management; contact tracing and management; personal protective measures (e.g. face masks and hand washing); social distancing measures (e.g. city lockdown and quarantine); environmental measure (e.g. disinfection of public spaces); health education; health promotion (e.g. awareness campaign); and, mental health support.

2. Health system capacity

Description: Publications involving topics related to health system capacity.

Subthemes: health systems; leadership and governance (e.g. legal frameworks); health workforce (i.e. adequacy and capacity); medical products, vaccine, and technology (i.e. availability and procurement); health facility information (e.g. patient database); health financing; service delivery; continuity of routine health programmes (e.g. maternal, child and reproductive health); and, coordination and partnerships (i.e. coordination among relevant actors to support the pandemic response).

3. Clinical management

Description: Publications that cover topics on characterizing the disease based on observing actual patients, treatment algorithms, management of patients and preventing and controlling infections (i.e. patient-level management)

Subthemes: clinical examination; clinical characterization (i.e. symptoms, characteristics, and disease progression); clinical guidance; and, clinical management (e.g. patient-level supportive treatment)

4. Candidate therapeutics and vaccine

Description: Publications that cover topics on the use of potential therapeutics (existing therapeutics) and vaccines (development of new ones).

Subthemes: Potential therapeutics; and, candidate vaccines

5. Disease epidemiology and mathematical modelling

Description: Publications that cover topics on disease etiology, distribution, and potential determinants (may include epidemiological approaches or other mathematical modelling).

Subthemes: disease etiology (e.g. virus origin, viral structure); disease transmission; disease distribution (e.g. frequency, pattern); disease determinants (e.g. exposure variables and importation risks); and, mathematical modelling

6. Diagnostic and testing strategies

Description: Publications that cover topics on diagnostic procedures and tests for COVID-19.

Subthemes: diagnostic procedures; and, COVID-19 tests

7. Impact assessment and policy analysis

Description: Publications that cover topics on socio-economic and health impact of COVID-19, health policy analysis and health diplomacy.

Subthemes: cost-effective analysis; socio-economic analysis; and, health impact analysis

8. Migrant-specific themes

Description: Publications that cover topics specific to migrant support services.

Subthemes: camp coordination and management (i.e. refugee camp and displacement site level); and, migrant protection (i.e. support services or programmes for migrant health protection)

Search terms were identified for each theme and subtheme based on careful review of related publications. The search terms were then applied in the publication title and validated by title and abstract (if needed) screening.

MIGRATION, MOBILITY AND COUNTRY COVERAGE

Migrants and mobile populations (e.g. international students, tourists, migrant workers, immigrants, refugees, and travelers) were identified in the set of retrieved publications. Publications with no specific migrant or mobile population group were screened for terms relevant to 'human mobility' (i.e. travel, transportation, and any form of movement within and across countries). The search terms were applied in the publication title and abstract (if needed and available).

Further, 'country coverage' was determined by scanning the title and abstract (if needed and available) of the publications. The term 'country coverage' refers to the country or countries identified as the main topic of the publication (i.e. where the study was implemented, where the data used in the study was obtained, or the country of citizenship and/or origin of the study population).

RESULTS

Number, type, and subject area of retrieved publications

The search retrieved a total of 276 publications from 134 different sources on COVID-19 and migration health, published from 1 January 2020 to 4 May 2020. Majority of the retrieved publications were research articles³ (56.9%, n=157) followed by letters⁴ 15.6%, n=43), notes⁵ (10.5%, n=29), reviews⁶ (9.1%, n=25), and editorials⁷ (5.8%, n=16) short surveys⁸ (1.4%, n=4), data papers⁹ (0.4%, n=1), and erratum¹⁰ (0.4%, n=1). Nearly all publications were on medicine (85.9%, n=237)¹¹, followed by immunology and microbiology (11.2%, n=31), social sciences (7.2%, n=20), and environmental science (6.9%, n=19). Only a few of the publications were on biochemistry, genetics and molecular biology (3.6%, n=10), health professions (3.6%, n=10), multidisciplinary (3.3%, n=9), business, management and accounting (2.2%, n=6), neuroscience (2.2%, n=6), nursing (1.8%, n=5), and others.¹² The subject categories are not mutually exclusive.

³ Scopus definition: Original research or opinion.

⁴ Scopus definition: Letter or correspondence with the editor.

⁵ Scopus definition: Note, discussion or commentary.

⁶ Scopus definition: Significant review of original research, also includes conference papers. The two review articles in this study pertain to the following topics: (1) an overview of the COVID-19 outbreak; and, (2) a review of publications on the effects of SARS, MERS, and other coronavirus infections on pregnant women and their infants. Reviews refers to an article with a significant review of original research, also includes conference papers. (Elsevier, 2017).

⁷ Scopus definition: Summary of several articles or provides editorial opinions or news.

⁸ Scopus definition: Short or mini-review of an original research. NB: short surveys are similar to reviews, but usually are shorter (not more than a few pages) and with a less extensive bibliography.

⁹ Scopus definition: Searchable metadata documents describing an online accessible dataset, or group of datasets.

¹⁰ Scopus definition: Report of an error, correction, or retraction of a previously published paper. In this study, the erratum publication was a correction of a previously published article in the same journal. This was included because the link to the original publication was not available in Scopus at the time of extraction.

¹¹ Denominator, n=276. Note that subject areas are not mutually exclusive; the total percentage is more than 100%.

¹² Other publications (n≤3 publications) include: agricultural and biological sciences, arts and humanities, computer sciences, engineering, psychology, decision sciences, pharmacology, toxicology and pharmaceuticals, etc.

The study flowchart shows the steps in the search strategy and the number of retrieved publications in each step (Figure 1). The complete search strategy is available in the appendices section.

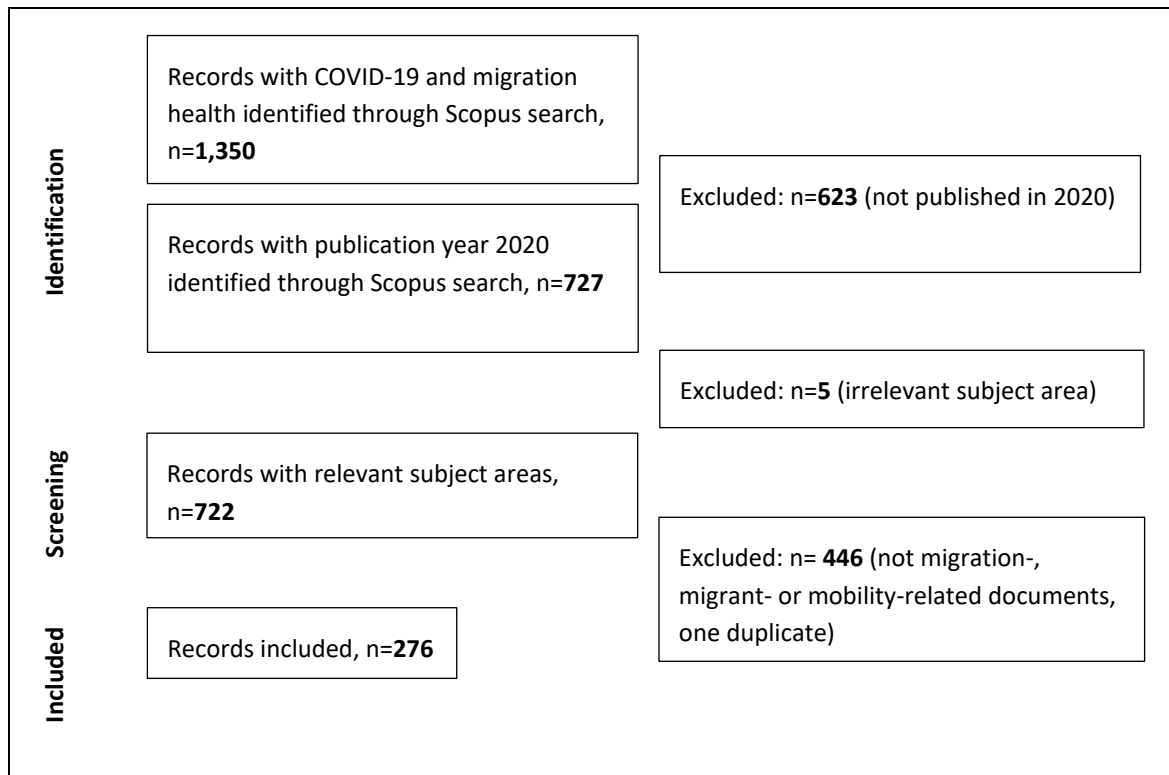


Figure 1. Search and Selection Flow Chart

Top active authors and research networks

A total of 157 authors with two or more publications, were found in the retrieved publications, with a mean of 8.3 authors per publication. About 13 per cent ($n=37$)¹³ of the publications were single-authored publications while the remaining were multi-authored (≥ 2 authors) publications. The top active authors and list of co-authored publications are listed in Tables 1 and 2, respectively. Two authors, one from the United Kingdom (Kraemer, M.) and the other from the United States of America (Pybus, OG) co-authored four publications (Table 3). Other top authors were from Singapore and Hong Kong Special Administrative Region, China. The author that ranked 6th in the list had affiliations from Africa and Asia.

A mapping of authors with co-authorship of at least three or more publications revealed three clusters (Figure 2). The largest research network included four authors from the UK, USA, and Canada, mainly from one institution (University of Oxford). The smallest cluster with two authors were both from USA. The lines indicate the number of co-authorship links. The thicker lines mean that these authors have co-authored more publications together than other links. Table 2. List of most active* authors on COVID-19 and migration health, 1 January 2020 to 4 May 2020 (N=276)

¹³ The count included one publication with no author name recorded.

Table 2. List of most active* authors on COVID-19 and migration health, 1 January 2020 to 4 May 2020

No.	Author	n	%	C	Affiliation**	Country***
1	Kraemer, Moritz U.G.	7	2.5	63	2014-2020 University of Oxford, Oxford, United Kingdom 2017-2020 Harvard University, Cambridge, United States 2017-2020 Children's Hospital Boston, Boston, United States 2017-2020 Harvard Medical School, Boston, United States 2020 London School of Hygiene & Tropical Medicine, London, United Kingdom	United Kingdom, United States of America
2	Chiew, Calvin J.	4	1.4	22	National University Health System, Singapore City, Singapore	Singapore
3	He, Daihai	4	1.4	18	2013-2020 Hong Kong Polytechnic University, Kowloon, Hong Kong	Hong Kong Special Administrative Region, China
4	Pybus, Oliver George	4	1.4	14	1999-2020 University of Oxford, Oxford, United Kingdom 2020 Royal Veterinary College University of London, London, United Kingdom	United Kingdom
5	Viboud, Cécile G.	4	1.4	52	2003-2020 John E. Fogarty International Center for advanced study in the health sciences, Bethesda, United States 2003-2020 National Institutes of Health, Bethesda, Bethesda, United States	United States of America
6	Wiwanitkit, Viroj	4	1.4	0	2018-2020 Hainan Medical University, Haikou, China 2018-2020 Joseph Ayo Babalola University, Ikeji-Arakeji, Nigeria 2019-2020 Dr. D.Y. Patil Vidyapeeth Deemed University, Pune, Pune, India 2020 Chulalongkorn University, Bangkok, Thailand 2020 DY Patil University, India 2020 Adjunct Professor, Ikeji-Arakeji, Nigeria	China, India, Thailand, Nigeria

N= total number of publications; C = total number of citations

*Refers to top authors by number of authored/ co-authored publications.

**Refers to author affiliated institutions/ organizations in 2020. Taken from the Scopus author profile on 20 May 2020.

***Refers to the country address of the author affiliated institution/ organization. See affiliation note.

Table 3. List of publications co-authored by the active* authors on COVID-19 and migration health, 1 January 2020 to 4 May 2020

No.	Author	Country**	Title	Source	C
1	Kraemer M.U.G.	USA, UK, Belgium, France, Cote d'Ivoire	Preparedness and vulnerability of African countries against importations of COVID-19: a modelling study	The Lancet	25
2	Kraemer M.U.G.	UK, Canada	Potential for global spread of a novel coronavirus from China	Journal of Travel Medicine	22
3	Kraemer M.U.G., Pybus O.G.	China, USA, UK, Italy, Ecuador, France	The effect of human mobility and control measures on the COVID-19 epidemic in China	Science (New York, N.Y.)	10
4	Pybus O.G., Kraemer M.U.G.	China, USA, UK, France, Ecuador	Epidemiological data from the COVID-19 outbreak, real-time case information	Scientific Data	3
5	Kraemer M.U.G., Viboud C.	USA, UK	Aggregated mobility data could help fight COVID-19	Science	2
6	Kraemer M.U.G., Pybus O.G.	USA, UK, Canada, Brazil	Routes for COVID-19 importation in Brazil	Journal of travel medicine	1
7	Kraemer M.U.G., Pybus O.G.	China, UK	Genomic Epidemiology of SARS-CoV-2 in Guangdong Province, China	Cell	0
8	Chiew C.J.	Singapore	Interrupting transmission of COVID-19: lessons from containment efforts in Singapore	Journal of travel medicine	10
9	Chiew C.J.	Singapore	Investigation of three clusters of COVID-19 in Singapore: implications for surveillance and response measures	The Lancet	9
10	Chiew C.J.	Singapore	SARS-CoV-2 infection among travelers returning from Wuhan, China	New England Journal of Medicine	3
11	Chiew C.J.	Singapore	Reducing onward spread of COVID-19 from imported cases: quarantine and 'stay at home' measures for travellers and returning residents to Singapore	Journal of travel medicine	0
12	He D.	USA, China, HKSAR	A conceptual model for the coronavirus disease 2019 (COVID-19) outbreak in Wuhan, China with individual reaction and governmental action	International Journal of Infectious Diseases	8
13	He D.	China, HKSAR, USA	Preliminary estimation of the novel coronavirus disease (COVID-19) cases in Iran: A modelling analysis based on overseas cases and air travel data	International Journal of Infectious Diseases	2

No.	Author	Country**	Title	Source	C
14	He D.	China, HKSAR	Quantifying the association between domestic travel and the exportation of novel coronavirus (2019-nCoV) cases from Wuhan, China in 2020: A correlational analysis	Journal of Travel Medicine	0
15	He D.	China, HKSAR	The association between domestic train transportation and novel coronavirus (2019-nCoV) outbreak in China from 2019 to 2020: A data-driven correlational report	Travel Medicine and Infectious Disease	8
16	Viboud C.	USA	Early epidemiological analysis of the coronavirus disease 2019 outbreak based on crowdsourced data: a population-level observational study	The Lancet Digital Health	16
17	Viboud C.	China, USA, Italy	The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak	Science	28
18	Viboud C.	China, USA, Italy, HKSAR	Evolving epidemiology and transmission dynamics of coronavirus disease 2019 outside Hubei province, China: a descriptive and modelling study	The Lancet Infectious Diseases	6
19	Wiwanitkit V.	China, India, Thailand	Exported Wuhan novel coronavirus infection: An expected rate with reference to main destination of Chinese tourist, Thailand	International Journal of Preventive Medicine	0
20	Wiwanitkit V.	China, India, Thailand	Positive screening for Wuhan novel coronavirus infection at international airport: What's the final diagnosis for positive cases	International Journal of Preventive Medicine	0
21	Wiwanitkit V.	China, India, Thailand	Imported Wuhan coronavirus infection: Is there any correlation with number of immigrants from endemic area and period after the first outbreak?	International Journal of Preventive Medicine	0
22	Wiwanitkit V.	China, India, Thailand	COVID-19, guests and crews of cruise: observation on Thai citizens	International maritime health	0

C = total number of citations

*Refers to top authors by number of authored/ co-authored publications.

**Refers to the country address of author affiliated institution/ organization. Listed country is from the records of all recorded authors of the publication. See affiliation note.

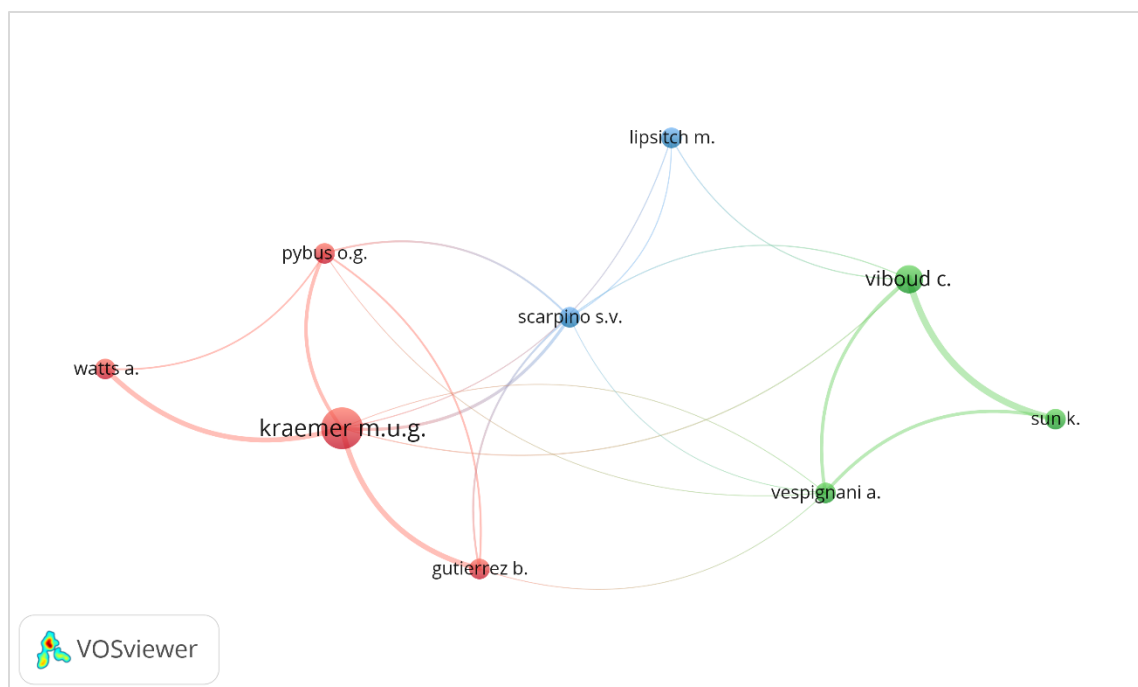


Figure 2. Network visualization map of authors on COVID-19 and migration health (linked by co-authorship) with a minimum of 3 co-authored publications

Most active countries by authors' affiliation

The authors of retrieved publications came from over 60 countries. The country information in Scopus was taken from the authors' affiliated institution or organization address in the retrieved publications. China ranked first in the list of most active countries with 81 publications having at least one author affiliated to China, followed by the United States of America with 69 publications. Authors from these countries have the greatest number of collaborations with other countries. China has the highest number of citations at 1482. There were no countries from Africa, South America and the Caribbean, and Middle East (Table 4) in the list of most active countries.

Table 4. List of most active* countries by authors' affiliation** on COVID-19 and migration health, 1 January 2020 to 4 May 2020 (N=276)

No.	Country	n	%	C	SCP, n (%)	MCP, n (%)
1	China	81	29.3	1482	43 (53.1)	38 (46.9)
2	United States of America	69	25.0	572	24 (34.8)	45 (65.2)
3	United Kingdom	45	16.3	371	18 (40.0)	27 (60.0)
4	India	19	6.9	15	9 (47.4)	10 (52.6)
5	Hong Kong Special Administrative Region, China	17	6.2	991	7 (41.2)	10 (58.8)
6	Germany	14	5.1	127	2 (14.3)	12 (85.7)
7	Italy	14	5.1	102	2 (14.3)	12 (85.7)
8	Australia	11	4.0	20	4 (36.4)	7 (63.6)
9	France	10	3.6	91	2 (20.0)	8 (80.0)

C = total number of citations; SCP = single country partnership, means that the authors of a publication come from the same country; MCP = multiple country partnership, means that the authors of a publication come from different countries

*countries with ten or more publications.

**This is based on the recorded author affiliation address from the retrieved publications.

Most active international research collaborations

The network visualization map showing the largest set of international research collaboration among the active countries in the field of COVID-19 and migration health formed three clusters (Figure 3). The red cluster consists of France, Germany, Italy, United Kingdom, and the United States of America. The green cluster consists of Australia, China, and India. The blue cluster includes Hong Kong Special Administrative Region, China. The thickness of the line connecting countries represents the strength of research collaboration between two countries, whereas the circles represent the number of co-authored publications as presented in Table 4. International research collaboration appears to be strongest between the United States of America and China, followed by United States of America and the United Kingdom, and China and Hong Kong Administrative Region, China.

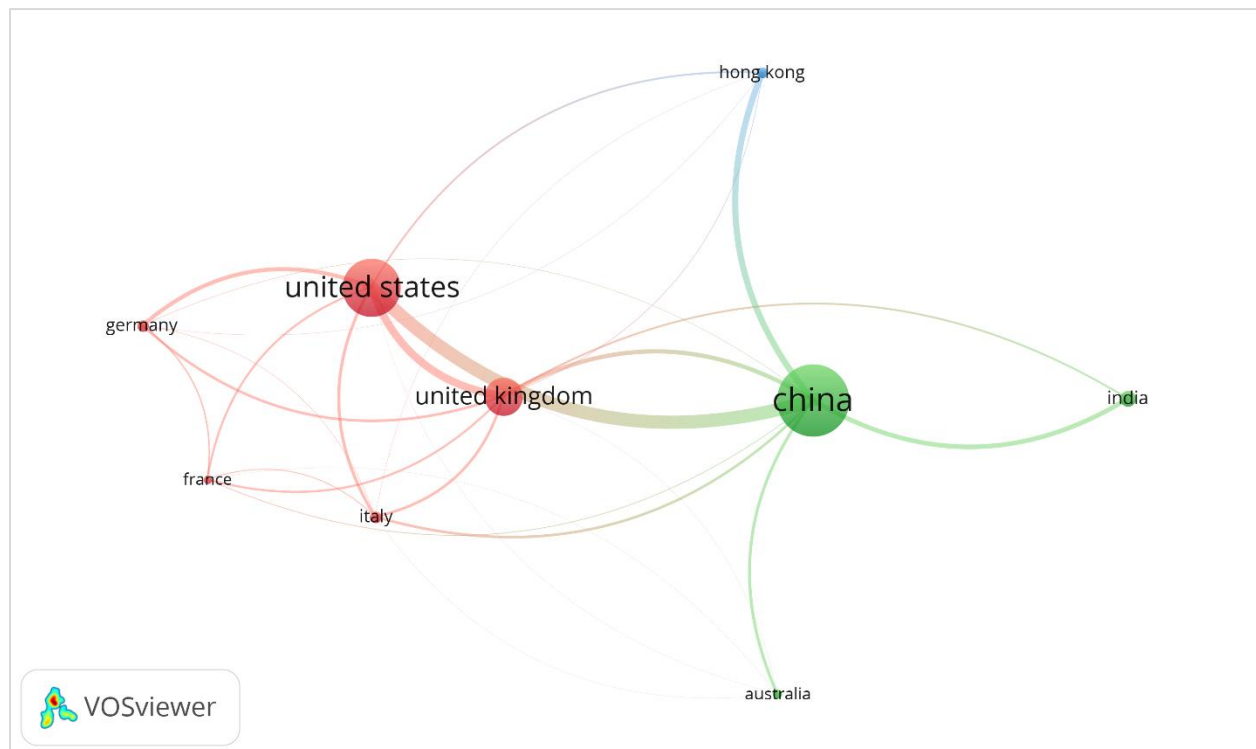


Figure 3. Network visualization map (international research collaboration) of countries active on COVID-19 and migration health (linked by co-authorship) with a minimum of 10 co-authored publications

Most cited country coverage or topic of study

Approximately 34 per cent of the retrieved publications were about China ($n=93$), followed by the United States of America (8%, $n=22$), Italy (3.3%, $n=9$), the United Kingdom (2.5%, $n=7$), Taiwan Province of the People's Republic of China ($n=2.2\%$, $n=6$), Islamic Republic of Iran (2.2%, $n=6$), Japan (1.8%, $n=5$), Thailand (1.8%, $n=5$), Australia (1.4%, $n=4$), India (1.4%, $n=4$), and France (1.4%, $n=4$). Other countries covered in two or three publications were: Brazil ($n=3$); Singapore ($n=3$); Hong Kong Special Administrative Region, China ($n=2$); South Korea ($n=2$); Germany ($n=2$); Bangladesh ($n=2$); Romania ($n=2$); and, Greece ($n=2$). Note that some publications may cover two or more countries.

Most preferred Journals

The retrieved publications were published in 134 journals. The most preferred journals were Travel Medicine and Infectious Disease (6.2%, n=17), Journal of Travel Medicine (5.8%, n=16), and The Lancet (5.4%, n=15). Table 5 shows the list of top journals with five or more publications and the corresponding publisher and subject areas, nearly all were categorized as high (Q1) ranking journals. Majority of the active journals were published from the United Kingdom. Half of the of active journals were in the field of infectious diseases. There were three journals on public health, three on environmental and occupational health, and three on general medicine. Note the overlapping of publications in terms of subject areas.

Table 5. List of top* journals on COVID-19 and migration health, 1 January 2020 to 4 May 2020 (N=276)

No.	Source/ Journal Title	n	%	C	Publisher	Country	Subject area (category)**	SJR ***
1	Travel Medicine and Infectious Disease	17	6.2	61	Elsevier BV	Netherlands	Medicine: Public health, environmental and occupational health; infectious diseases	Q1
2	Journal of Travel Medicine	16	5.8	72	Oxford University Press	United Kingdom	Medicine: Public health, environmental and occupational health; Infectious diseases	Q1
3	The Lancet	15	5.4	815	The Lancet Publishing Group	United Kingdom	Medicine: General medicine	Q1
4	Eurosurveillance	11	4.0	180	European Centre for Disease Prevention and Control (ECDC)	France	Medicine: Public Health, environmental and occupational health; epidemiology Immunology and Microbiology: Virology	Q1
5	Lancet Infectious Diseases	11	4.0	41	The Lancet Publishing Group	United Kingdom	Medicine: infectious Diseases	Q1
6	Emerging Infectious Diseases	9	3.3	83	Centers for Disease Control and Prevention (CDC)	United States	Medicine: infectious Diseases; microbiology (medical); epidemiology	Q1
7	BMJ (Clinical Research Ed.)	7	2.5	5	British Medical Association	United Kingdom	Medicine: General Medicine	-
8	International Journal of Infectious Diseases	6	2.2	44	Elsevier BV	Netherlands	Medicine: Infectious Diseases; Microbiology (medical)	Q1
9	JAMA - Journal of The American Medical Association	6	2.2	224	American Medical Association	United States	Medicine: General medicine	Q1

No.	Source/ Journal Title	n	%	C	Publisher	Country	Subject area (category)**	SJR ***
10	Science of the Total Environment	5	1.8	7	Elsevier BV	Netherlands	Environmental Science: Environmental Engineering, Pollution; Waste Management and Disposal; Environmental Chemistry	Q1

*Refers to journals with the greatest number of publications, five or more.

**Subject area and category taken from the Source Profile in Scopus on 20 May 2020.

*** SJR rank refers to journal ranking quartiles within a subdiscipline using the SJR citation index. Thus, a first quartile journal (i.e., Q1) has an SJR in the top 25% of journals for at least one of its classified subdisciplines. The SJR indicator accounts for both the number of citations received by a journal and the importance or prestige of the journals where the citations come from [40].

Most active institutions

The most active institutions or organizations (i.e. with seven or more publications) are shown in Table 6. The Ministry of Education China ranked first with 14 publications. Other active institutions were based in the United States of America (n=4), Hong Kong Administrative Region, China (n=3), and United Kingdom (n=3).

Table 6. List of top institutions or organizations in COVID-19 and migration health, 1 January 2020 to 4 May 2020 (N=276)

No.	Institution/ Organization	n	%	Country
1	Ministry of Education China	14	5.1	China
2	The University of Hong Kong (HKU)	13	4.7	Hong Kong Special Administrative Region, China
3	London School of Hygiene & Tropical Medicine	11	4.0	United Kingdom
4	Harvard Medical School	10	3.6	Unites States of America
5	The University of Hong Kong Li Ka Shing Faculty of Medicine (HKUMed)	10	3.6	Hong Kong Special Administrative Region, China
6	University of Oxford	9	3.3	United Kingdom
7	Johns Hopkins Bloomberg School of Public Health	8	2.9	Unites States of America
8	University College of London (UCL)	8	2.9	United Kingdom
9	Harvard T.H. Chan School of Public Health	8	2.9	Unites States of America
10	Chinese University of Hong Kong	7	2.5	Hong Kong Special Administrative Region, China
11	Harvard University	7	2.5	Unites States of America

Research collaboration among institutions/ organizations

The visualized map of institutions showing the most number of research collaboration (in terms of co-authorship) formed two clusters. The University of Oxford, United Kingdom, has the most number of co-authored publications (n=7), represented by the biggest bubble. This institution has collaborated with the University of Toronto, Canada, Universidad San Francisco de Quito (USFQ), Ecuador, and the Royal Veterinary College, United Kingdom (green cluster). In the red cluster, The ISI Foundation, Italy has collaborated with the Ministry of Education, China, Bruno Kesler Foundation, Italy and the University of Washington, United States of America.

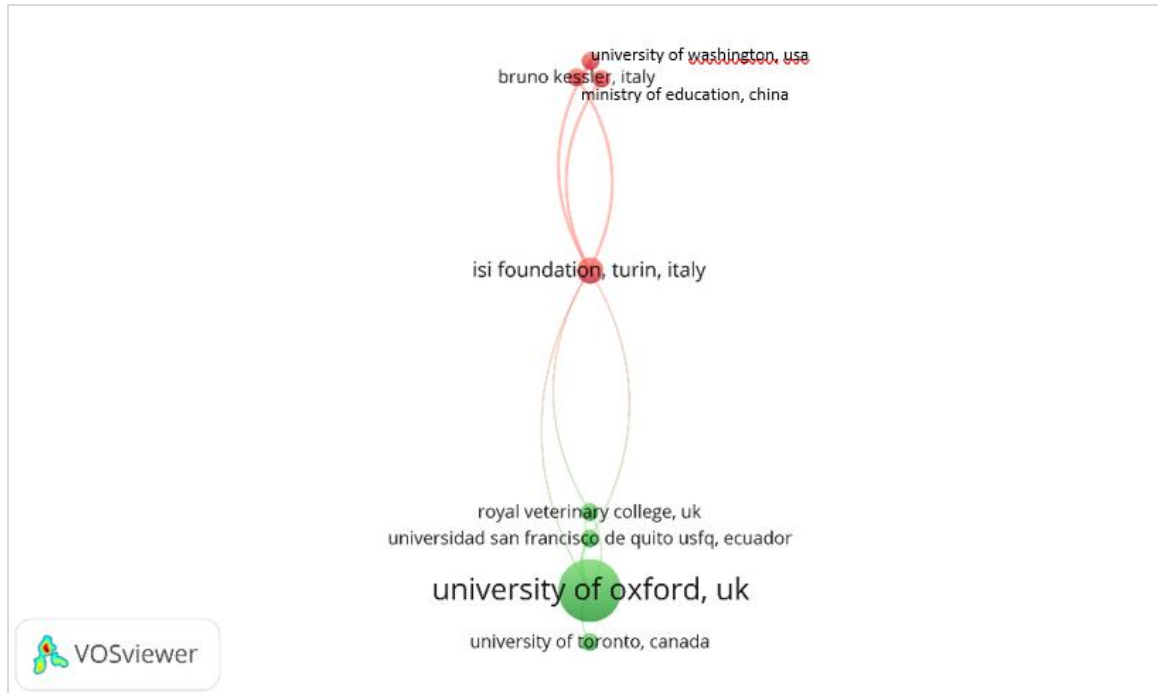


Figure 4. Network visualization map (research collaboration) of institutions on COVID-19 and migration health (linked by co-authorship) with a minimum of two co-authored publications

Citation analysis and top cited articles

The retrieved documents received 2,669 citations with an average of 9.7 citations per document. Nearly all the top cited publications involved disease epidemiology and management, specifically disease transmission (Table 7). The majority of the list of top cited publications were authored in China and Hong Kong Administrative Region, China. The article that received the highest citation presents the epidemiological, clinical, laboratory, radiological, and microbiological findings of five patients in a family cluster who presented with unexplained pneumonia after returning to Guangdong province, China, following a visit to Wuhan, and an additional family member who did not travel to Wuhan.

Table 7. List of most cited publications on COVID-19 and migration health, 1 January 2020 to 4 May 2020

No.	Title	Journal	C	Publication type	Country*
1	A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster	The Lancet	504	Article	China, Hong Kong Administrative Region, China
2	Pathological findings of COVID-19 associated with acute respiratory distress syndrome	The Lancet Respiratory Medicine	227	Article	China
3	Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study	The Lancet	200	Article	Hong Kong Administrative Region, China
4	Presumed Asymptomatic Carrier Transmission of COVID-19	JAMA - Journal of the American Medical Association	150	Letter	China, Hong Kong Administrative Region, China
5	Genomic characterization of the 2019 novel human-pathogenic coronavirus isolated from a patient with atypical pneumonia after visiting Wuhan	Emerging Microbes and Infections	108	Article	China, Hong Kong Administrative Region, China
6	Substantial undocumented infection facilitates the rapid dissemination of novel coronavirus (SARS-CoV2)	Science (New York, N.Y.)	76	Article	China, USA, UK, Hong Kong Administrative Region, China
7	Incubation period of 2019 novel coronavirus (2019- nCoV) infections among travellers from Wuhan, China, 20 28 January 2020	Eurosurveillance	65	Review	Netherlands
8	Estimating the asymptomatic proportion of coronavirus disease 2019 (COVID-19) cases on board the Diamond Princess cruise ship, Yokohama, Japan, 2020	Eurosurveillance	44	Review	USA, UK, Japan
9	Evidence of SARS-CoV-2 infection in returning travelers from Wuhan, China	New England Journal of Medicine	42	Letter	Germany
10	The SARS, MERS and novel coronavirus (COVID-19) epidemics, the newest and biggest global health threats: what lessons have we learned?	International journal of epidemiology	41	Article	China, Bangladesh, Islamic Republic of Iran, Malaysia, USA

*Refers to the authors' country affiliation as recorded in Scopus as of 20 May 2020.

C=number of citations

Migrant and mobile population

Approximately 20 per cent (n=54) of the retrieved publications mentioned 'traveler' in the title or abstract (Table 8) but did not specify whether tourist or migrant. Of the publications that covered 'travelers', about 41 per cent (n=22) involved China.

Of the retrieved publications, about 8 per cent specifically mentioned 'migrants' (n=21), of this figure three publications pertain to 'migrant workers.' Approximately 3 per cent of the publications included the term 'refugee' (n=8) and 'tourist' (n=7). Less than 2 per cent covered immigrants (n=5), international students (n=5), asylum seekers (n=3), and displaced population (n=1). The rest of the retrieved publications pertain to travel or mobility within and across international borders.

Table 8. Number of publications by migrant or mobile population group*, 1 January 2020 to 4 May 2020 (N=276)

Migrant group/ mobile population	n	%
Travelers**	54	19.6
Migrants***	21	7.6
Refugees	8	2.9
Tourists	7	2.5
Immigrants****	5	1.8
International students	5	1.8
Asylum seekers	3	1.1
Displaced population	1	0.4

*Includes publications with the search terms specific to a migrant group or mobile population; the study population, source data, or main topic covered in the publication.

**Includes 'returning travelers' (n=7)

***Includes 'returning migrants' (n=1), 'undocumented migrants' (n=3), and 'migrant workers' (n=3)

****Includes 'immigrants in detention' (n=1)

Research themes

The majority of the retrieved publications were on: (1) disease epidemiology and mathematical modelling (40.9%, n=113) 59 per cent of which involved disease transmission; (2) public health interventions (38.4%, n=106) with about 46 per cent of this covering topics on government measures; and, (3) clinical management (19.2%, n=53) with about 85 per cent of publications discussing clinical characterization. Other research themes included the following: health system capacity (9.8%, n=27); diagnostic and testing strategies (6.9%, n=19); migrant-specific theme (4.3%, n=12); candidate therapeutics and vaccine (1.4%, n=4); and, impact assessment and policy analysis (n=1.1%, n=3). The number of publications by theme and subtheme are shown in Tables 9 and 10. The classification of themes and subthemes was not mutually exclusive – some publications may be classified under two or more themes.

Table 9. Number of publications by theme on COVID-19 and migration health, 1 January 2020 to 4 May 2020 (N=276)

No.	Research Theme	n	%
1	Disease epidemiology and mathematical modelling (DEM)	113	40.9
2	Public health intervention (PHI)	106	38.4
3	Clinical management (CM)	53	19.2
4	Health system capacity (HSC)	27	9.8
5	Diagnostic and testing strategies (DTS)	19	6.9
6	Migrant-specific themes (MST)	12	4.3
7	Candidate therapeutics and vaccine (CTV)	4	1.4
8	Impact assessment and policy analysis (IAPA)	3	1.1

Table 10. Number of publications by theme and subtheme on COVID-19 and migration health, 1 January 2020 to 4 May 2020

Theme: DEM	n	%, N=113	Theme: CM	n	%, N=53
Disease transmission	78	58.6	Clinical characterization	45	84.9
Disease distribution	27	20.3	Clinical management	8	15.1
Disease determinants	14	10.5	Clinical examination	4	7.5
Mathematical modelling	14	10.5	Clinical guidance	2	3.8
Disease etiology	10	7.5			

Theme: PHI	n	%, N=106	Theme: HSC	n	%, N=27
Government measures	49	46.2	Continuity of routine programmes	10	37.0
Travel-related measures	33	31.1	Health system	6	22.2
Social distancing measures	30	28.3	Medical products, vaccine & technology	5	18.5
Mental health support	13	12.3	Health workforce capacity	4	14.8
Disease surveillance	7	6.6	Leadership and governance	3	11.1
Health promotion	7	6.6	Health financing	3	11.1
Case identification & management	6	5.7	Coordination and partnership	3	11.1
Contact tracing & management	6	5.7	Service delivery	2	7.4
Personal protective measures	6	5.7	Health facility information system	0	0.0
Health education	4	3.8			
Community screening	3	2.8			
Environmental measures	2	1.9			

Theme: DTS	n	%, N=19	Theme: CTV	n	%, N=4
Diagnostic procedures	17	89.5	Potential therapeutics	3	75.0
COVID-19 tests	3	15.8	Candidate vaccines	2	50.0

Theme: MST	n	%, N=12	Theme: IAPA	n	%, N=3
Migrant protection	8	66.7	Cost-effective analysis	1	33.3
Camp coordination & management	4	33.3	Socio-economic analysis	2	66.7
			Policy impact analysis	0	0.0

Visualization of keywords

Mapping of frequently occurring keywords reveals a network or clusters of linked keywords. The selected maps show only those keywords with the largest network. The bubble size reflects the most frequently used keywords in the co-occurrence network, while the line thickness and color refer to link strength and clustering, respectively. By default, the clusters are represented by the colors: red, green, blue, and yellow denoting a range of cluster sizes from the largest (red) to the smallest (yellow). The distance between two keywords indicates relatedness in terms of co-occurrence links.

The visualization of all keywords found in the retrieved publications revealed three clusters (red, green, and blue) consisting of 36 keywords (Figure 5). The map was dominated by keywords related to disease epidemiology ('epidemic', 'pandemic', 'pandemic, adult', 'male', 'female', 'elderly', etc.), public health measures (e.g. 'quarantine', 'social distancing', 'risk assessment', 'infection prevention and control') and clinical management (i.e. 'pneumonia', 'incubation time', etc.). A few keywords were related to diagnostic procedures – such as 'PCR', 'tomography', and 'radiography'. In terms of the number of occurrences, the most commonly encountered keywords were: 'pneumonia' (n=115), 'China' (n=106), 'pandemic' (n=97), 'travel' (n=93), 'epidemic' (n=88), and 'disease transmission' (n=66).

A closer look at the clusters show that 'travel' and population-related keywords (i.e. 'adult', 'male', etc.) were mainly associated with clinical management (i.e. 'fever', 'cough', 'incubation time', 'hospitalization') and diagnostic procedures (i.e. 'tomography', 'radiography', 'isolation and purification'). The green cluster were mainly related to public health measures (i.e. 'global health', 'public health', 'risk assessment', 'social distancing', 'prevention and control', 'high risk population', 'air travel'), and disease epidemiology (i.e. 'pandemic', 'epidemic', 'mortality', 'disease transmission'). The blue cluster depicts the term 'pneumonia' as strongly linked with 'pandemic', this indicates the number of publications in which these keywords co-occurred. The terms 'global health' and 'outbreak' were associated with the terms 'United States', 'Wuhan', 'virology', 'pathogenicity'.

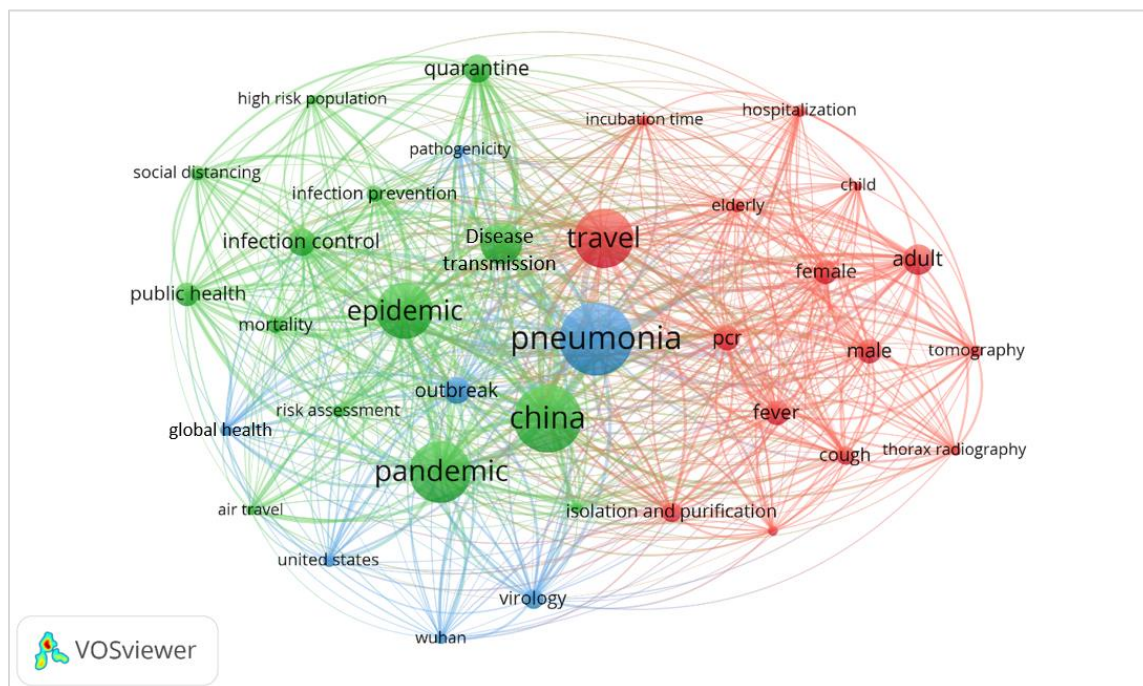


Figure 5. Co-occurrence network visualization map of keywords in COVID-19 and migration health (minimum of 15 co-occurrences)

A closer look at the common keywords encountered by research theme were as follows (Figures 6a to 6f):

1. Disease epidemiology and mathematical modelling (Figure 6a)

The red cluster showed that the keyword 'travel' was associated with population characteristics (i.e. 'male', 'female', 'adult', 'elderly'), control measure (i.e. 'quarantine' and 'contact examination'), and clinical symptoms (i.e. 'fever' and 'cough'). The keywords 'pneumonia' and 'infection control' were associated with 'outbreak', 'disease transmission', and disease etiology related keywords (i.e. 'isolation and purification', 'virology', and 'pathogenicity') (green cluster). In the blue cluster, the keyword, 'China', was mainly associated with disease distribution-related terms (i.e. 'epidemic', 'mortality,' and, 'pandemic'). In the same cluster, the keywords, 'air travel,' 'risk assessment,' 'surveillance' were closely linked together. There were no keywords related to mathematical modelling.

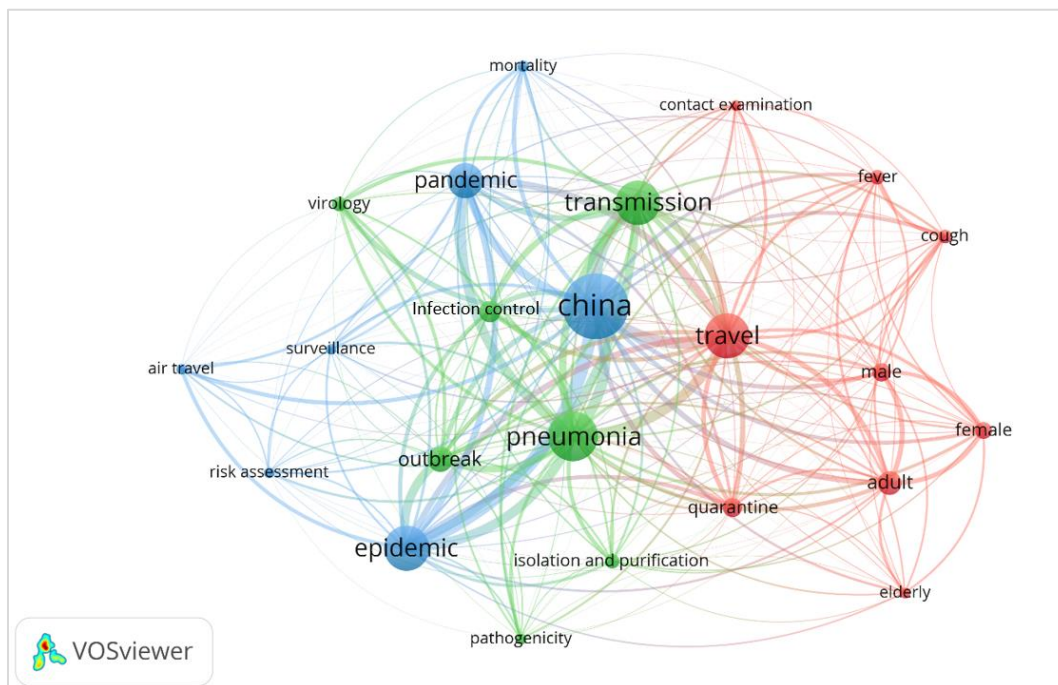


Figure 6a. Most frequent keywords in publications pertaining to **disease epidemiology and mathematical modelling** in COVID-19 and migration health (with minimum occurrence of ten keywords)

2. Public health intervention (Figure 6b)

The keywords related to disease distribution ('China', 'epidemic', 'mortality') and health system capacity ('health system', 'health care system', 'international cooperation', 'health care access') were associated with keywords related to government measures (i.e. 'risk assessment', 'social distancing', 'infection risk'). The green cluster linked keywords, 'global health' and 'outbreak' with the keywords related to population characteristics (i.e. 'elderly', 'adult', 'female', and 'male'). The blue cluster showed linked between 'travel', 'disease transmission', 'quarantine', 'practice guidelines', 'incubation time', and 'fever'.

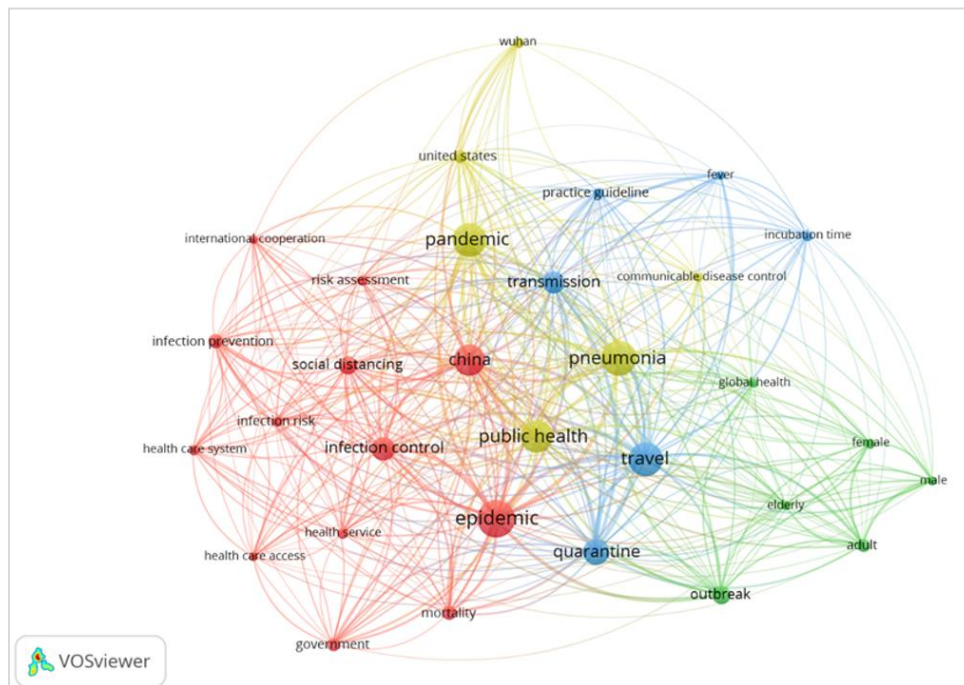


Figure 6b. Most frequent keywords in publications pertaining to **public health intervention** in COVID-19 and migration health (with minimum occurrence of seven keywords)

3. Clinical management research theme (Figure 6c)

The largest cluster focused on the adult male population and was associated with clinical characteristics ('cough', 'fever', 'myalgia', 'headache', 'sore throat', 'fatigue', 'asymptomatic infection'), and diagnostic procedures ('real-time PCR', 'thorax radiography'). The green cluster connects the terms 'China', 'travel' and 'disease epidemiology' ('epidemic', 'outbreak') with terms related to clinical characteristics ('incubation time', 'severity'), and clinical management ('infection control', 'artificial ventilation'), and 'disease transmission'. The blue cluster linked keywords— 'patient isolation', 'pathology,' 'genetics', 'female' and 'child'. In the yellow cluster, the term 'pandemic' was associated terms related to diagnostics ('throat culture', 'tomography', 'diagnostic imaging') and clinical characteristics (i.e. 'pneumonia', 'complication').

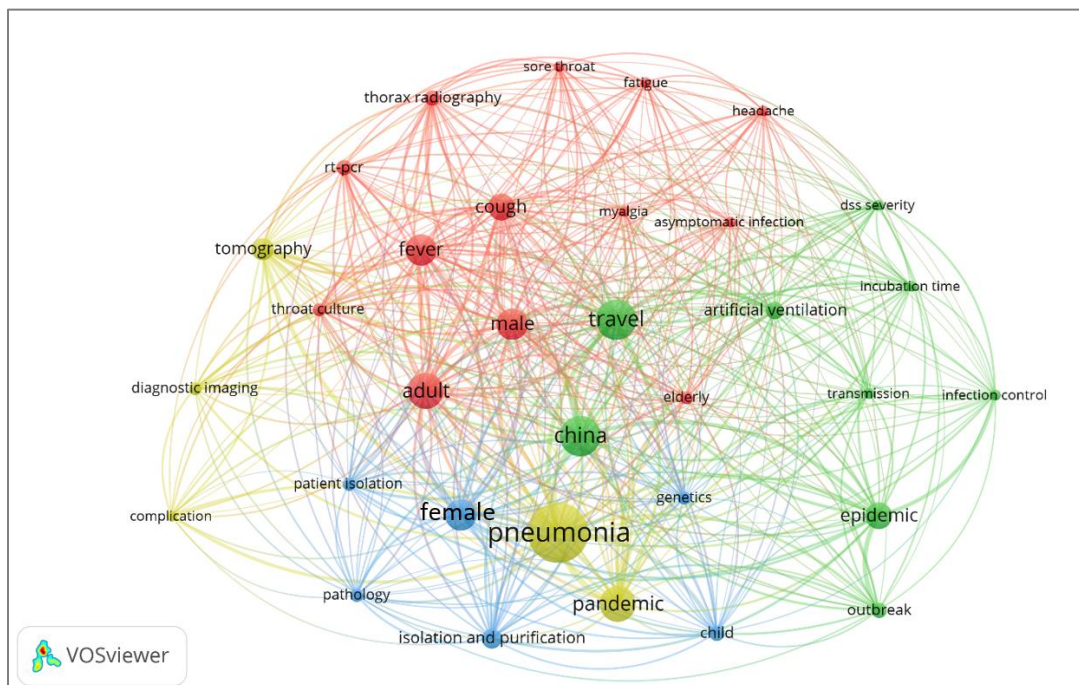


Figure 6c. Most frequent keywords in publications pertaining to **clinical management** in COVID-19 and migration health (with minimum occurrence of five keywords)

4. Health system capacity (Figure 6d)

The keywords 'travel' and 'mobility' were associated with 'disease transmission', 'risk assessment', 'health policy', 'infection and control', and 'health service' (red cluster). The term 'pandemic' was associated with keywords related to routine healthcare services (i.e. 'hospitalization', 'teleconsultation', 'physician', 'medical research', 'practice guidelines', 'health organization'), and symptoms (i.e. 'headache' and 'fever') (green cluster). The term 'pneumonia' was associated with 'United States' and 'public health' (blue).

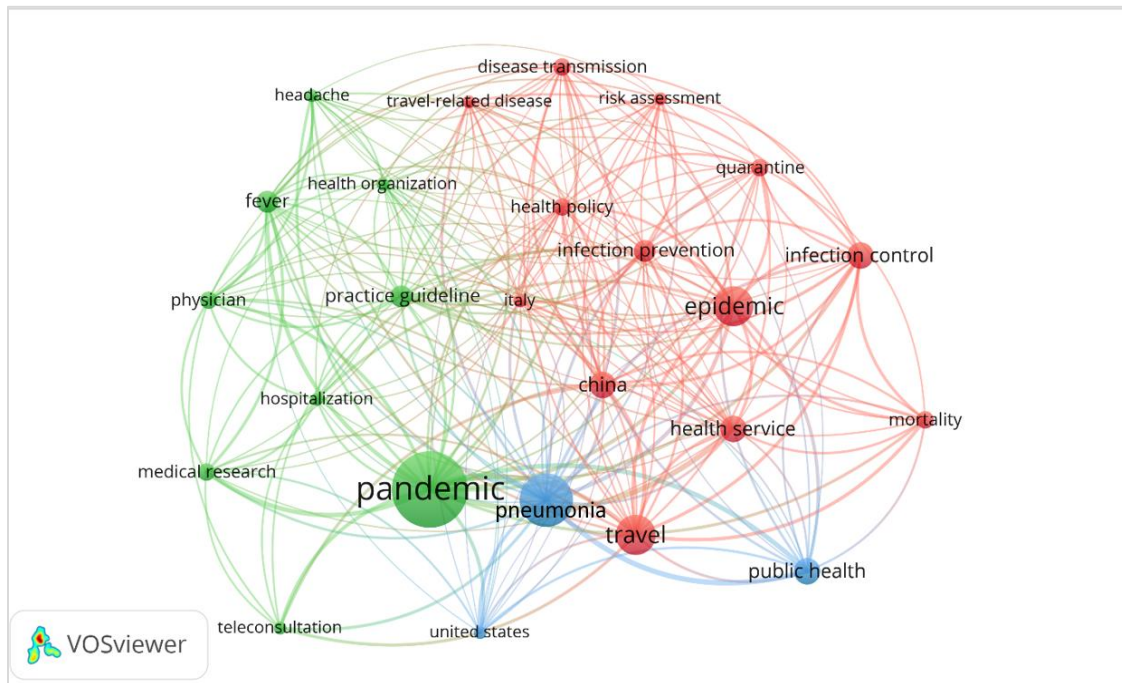


Figure 6d. Most frequent keywords in publications pertaining to **health systems capacity** in COVID-19 and migration health (with minimum occurrence of three keywords)

5. Diagnostic and testing strategies (Figure 6e)

Keywords in the red cluster were mainly related to diagnostic procedures (i.e. 'diagnostic imaging', 'isolation and purification', 'pathology', 'throat culture', and 'virology') and associated with terms related to population characteristics ('adult', 'female', 'male'), and clinical symptoms ('pneumonia', 'lung'). There were no keywords related to diagnostics and testing procedures in the green cluster. The keywords were mainly related to clinical symptoms ('cough', 'fever', 'myalgia') and disease epidemiology (i.e. 'China', 'epidemic', and 'travel'). The least number of keywords, the blue cluster, were mainly related to diagnostic procedures ('lung lesion', 'PCR', 'thoracic radiography', and 'tomography'), and associated with the term 'pandemic.' There were no keywords on COVID-19 tests in all the clusters.

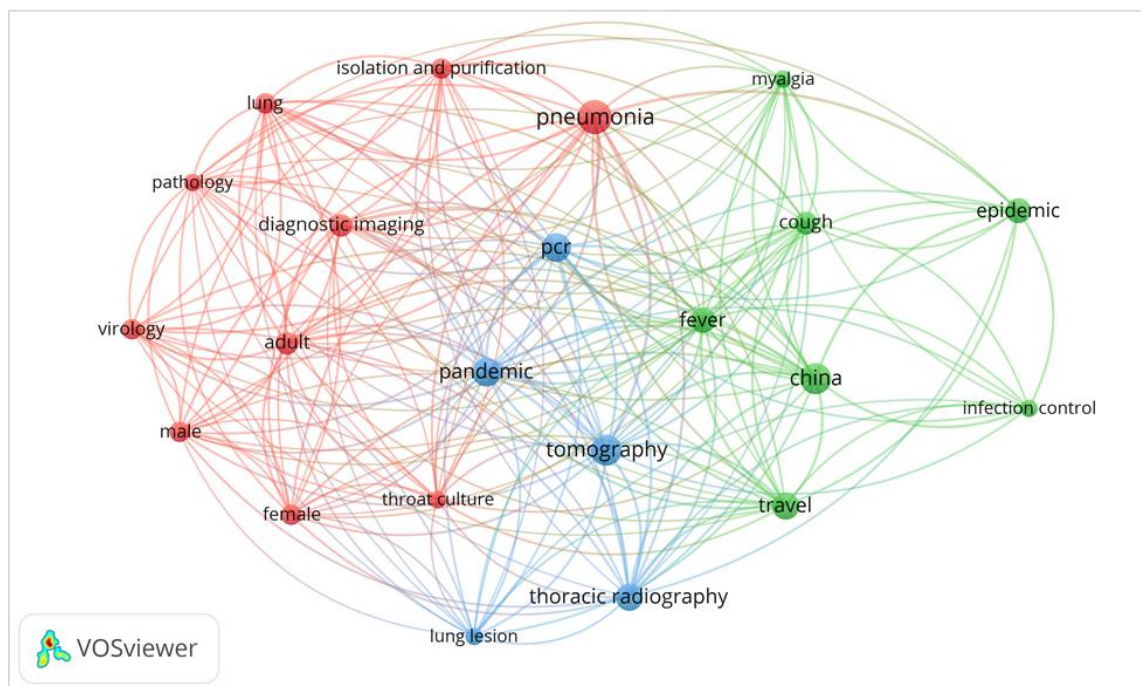


Figure 6e. Most frequent keywords in publications pertaining to **diagnostic and testing strategies** in COVID-19 and migration health (with minimum occurrence of three keywords)

6. Migrant-specific themes (Figure 6f)

The most frequent keywords included: migrant (n=5), pandemic (n=5), refugee (n=3), asylum seeker (n=3), and public health (n=3). The red and yellow clusters were mainly related to infection and control measures (i.e. hygiene, quarantine, social distancing, sanitation, crowding) and access to health care (i.e. health care, health care access, health equity).

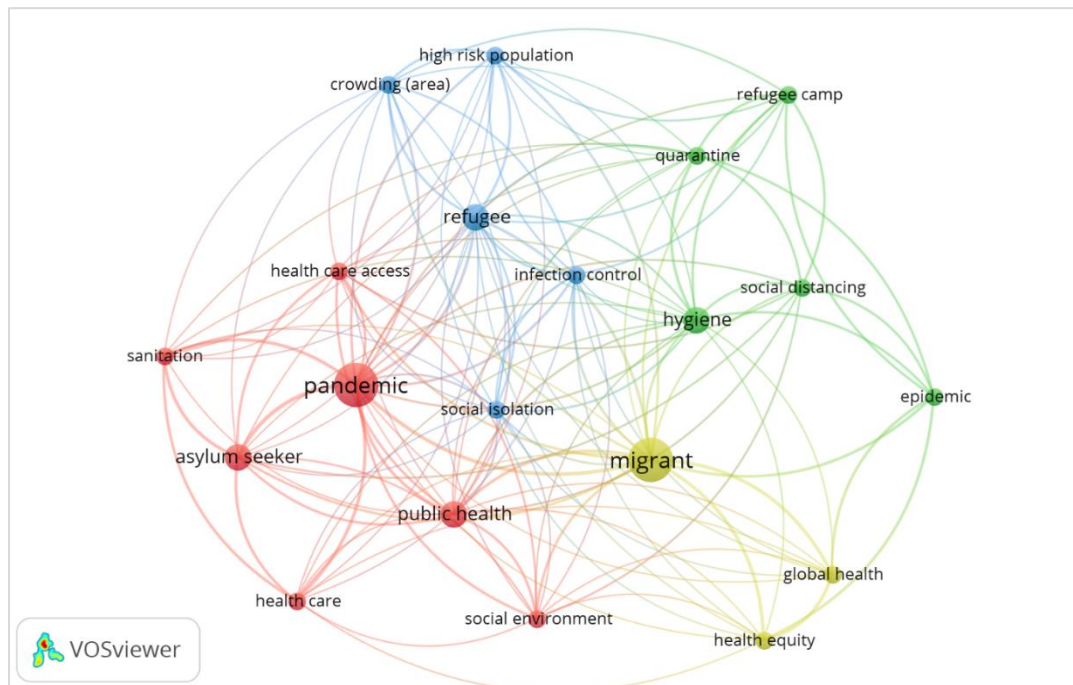


Figure 6f. Most frequent keywords in publications pertaining to **migrant-specific themes** in COVID-19 and migration health (with minimum occurrence of two keywords)

LIMITATIONS

This is the first bibliometric study on COVID-19 and migration health publications. Although there have been several bibliometric studies on COVID-19 [37, 38, 44], none were done in the context of migration health. At the start of the year, the research community across the globe has focused its efforts in coming up with useful scientific evidence on COVID-19. This is evidenced by the increasing number of publications on COVID-19 from 1 January 2020 to 4 May 2020.

The depth and breadth of the findings from bibliometric analysis will depend on the information available in Scopus and the search strategy applied. Noted limitations inherent in a bibliometric study are as follows: (1) Relevant publications might be missed, particularly, those published in preprint servers. Research papers in the online preprint servers are not indexed in Scopus as these have yet to be peer-reviewed or accepted by traditional academic journals. Nevertheless, articles-in-press (i.e. pre-published versions of accepted research articles) are included in Scopus. (2) There are some scientific sources or journals that are not indexed in Scopus. Therefore, relevant publications published in non-indexed journals cannot be captured by the search. (3) New publications might be missed due to time lag in the Scopus indexing (NB: fully-indexed publications are estimated to appear in Scopus

within three to four weeks from publication on the publisher's website). However, publishers and database producers are handling COVID-19 articles on a priority basis. (4) Bibliometrics only measures impact in terms of research productivity and not the research quality. (5) The Scopus yield or search results will depend on the overall search strategy. The search query for COVID-19 was applied on the publication title. Therefore, any relevant publication with no COVID-19 related terms in the publication title will be missed. (6) Results obtained reflect how publication information were recorded and presented in Scopus. For example, active institutions, author names, and countries with different spellings will be spread out in the results. Another possible scenario is that certain publications indexed as a 'research article' may be a 'letter to editor' upon reviewing the full text. (7) COVID-19 research is a growing field. Thus, the publications retrieved at the time of search may change in time. Also, any change of information or indexing of the retrieved publications will affect the search results. (8) Lastly, a bibliometric analysis uses the bibliographic attributes or metadata (i.e. authors' names, title, keywords, etc.) of retrieved publications to describe the scope of research. This method does not synthesize the research findings.

DISCUSSION

Findings from the bibliometric analysis of publications on COVID-19 in the context of migration and health present the gradually developing research landscape in this field. As the pandemic continues to unfold, the number of relevant research publications now cover all the research themes. Nevertheless, a limited number of publications on migrant-specific themes (i.e. migrant protection services and camp coordination management), candidate therapeutics and vaccines, and impact assessment and policy analysis was still noted. No publication specifically looked at policy analysis. There were 14 publications that used mathematical modelling to predict spread, and model social distancing, border closures and impacts on the health care system capacities. Of this number, about 57 per cent covered China (n=8) followed by publications that were global in scope (n=3). There were only three studies (India, Iran, and African countries) that model importation risk of COVID-19 using volume of air travel. None hitherto have investigated situations in camps and camp-like settings. These findings highlight the importance of considering the migrant- and migration-health-related concepts in research and scientific communications.

The most productive authors and country in the field of COVID-19 and migration health come from the United Kingdom, United States of America, and China (the first reported place of origin of the virus). The institutions with the highest number of publications also suggest how the pandemic has developed in the past three months. Although China was initially observed as the epicenter of the early outbreak, the United States and a few European countries have seen an increasing number of confirmed cases in the last few weeks. While establishing a direct correlation between the number of confirmed cases and the research productivity may not be necessary, the finding on the most productive countries suggests a geographic outlook of the early developments in the global scientific knowledge base on COVID-19 specific to migration health. This information can help researchers, practitioners, and policy makers especially those coming from resource-limited settings in maximizing the research productivity of existing networks and reaching out to relevant experts if needed. The inclusion of vulnerable populations such as migrants and displaced populations in COVID-19 research is critical given the potentially differential impact of the pandemic in these settings. The diversity of subject areas of the top journals on COVID-19 and migration health – which ranged from journals on infectious diseases, general medicine, public health, environmental science – also provides insights into the importance of approaching COVID-19 as a complex health problem from a multidisciplinary perspective.

Despite the large number of global publications on COVID-19, the coverage of migrant and migration health aspects of the pandemic in the current scientific knowledge base has so far been limited to concepts related to “travel and mobility or movement within and across international borders” – primarily viewing population movement as an important factor in disease transmission and suppression strategies. Only a small number of publications (n=35, 12.7% out of 276) covered specific migrant groups (i.e. international students, migrant workers, immigrants, migrants, refugees, and asylum seekers), with majority covering public health interventions (n=22, 63% out of 35). Less than one-fourth (n=61, 22%) of the publications covered non-specific mobile populations (i.e. tourists and travelers) with slightly over half covering disease epidemiology management (n=33, 54% out of 61) (Table 8). In any migrant research, it should be noted that there is limited inclusion of migrant status within data collection practices in routine health information systems, hospital registries and disease surveillance systems globally. This also extends to research where migrant status remain poorly captured. Data disaggregation by migrant flows and categories on COVID-19 testing, hospitalizations and deaths by migrant status is a poorly described national data set.

There were only three publications (two letters and one research article) retrieved from the search that specifically involved migrant workers despite being an important subgroup of migrants greatly affected by the pandemic. The research article discussed the vulnerability among migrant workers [19] (NB: the term ‘international’ was not used but implied) due to the biomass exposure [45]. The two other publications (i.e. letters), which explicitly referred to international migrant workers, discussed the lack or limited response for migrant workers and the emotional impact of COVID-19 among migrants [46].

Most of the publications involving refugees stressed the urgent need for inclusion of refugees in the national and global health response against COVID-19. Further, these publications discussed in length the risks and pre-existing vulnerabilities (i.e. overcrowded and poor living conditions, multiple barriers to health care, and others), and the humanitarian barriers that refugees face due to the mobility restrictions implemented by the governments [13, 14, 25, 27, 47, 48]. There was one publication that discussed a successful phone-based method used by a non-profit group to follow-up war-affected refugee caregivers under COVID-19 lockdown in Tripoli, Lebanon [49].

There were two publications that discussed the impact of COVID-19 to the mental health of Chinese students abroad [26] and foreign students in China [50] due to the belief that they are seen as potential carriers of the COVID-19 virus and also because of fear and anxiety during the crisis [26, 51].

As of the last date of search, this mapping exercise retrieved one publication that mentioned ethnic minorities alongside migrants as a high-risk group. However, it should be noted that the methodology of this mapping exercise was not designed to capture ‘ethnic minorities’. Beyond, the search results, a relevant systematic review that emphasized the importance of gathering robust evidence on the role of ethnicity in COVID-19 [52]. From the said review, several publications in the UK and the US indicated the disproportionate risk of having COVID-19 and suffering from more serious clinical outcomes (e.g. hospitalization, intensive care admission, and deaths) among individuals from Black, Asian, and Minority Ethnic (BAME) groups relative to White patients. Although, ethnicity is different from migrant status, the disparities in health outcomes of specific ethnic minority groups may provide better understanding of the intersection between migrant status and ethnicity.

Other than identifying the relevant migrant population groups examined in the extant literature, the scope of the current bibliometric analysis (i.e. ending in the screening of abstracts), precludes providing more insights on the study types, specific variables and outcome measures investigated and the research findings in the publications included in the analysis. Nevertheless, the common constructs covered in the relevant publications to date can be inferred from the network visualization map of the keywords. However, these maps only provide information on the

frequently co-occurring keywords in relevant publications and do not represent a formative or reflective construct of the conceptual relationship between the commonly used terms. As such, the relatedness of keywords described in the main findings of the bibliometric analysis cannot be taken to mean any more than an association of co-occurring keywords. Despite this limitation, the network visualization maps can still provide researchers with a good starting point in developing related research studies in the future.

Implications for migrants and migration and health research

Classifying the clusters of keywords that emerged from the bibliometric analysis into meaningful categories within a migration health context can provide insights into the role of migrant-, and migration-and-health-related concepts in the literature (Tables 11 and 12) especially when understood through the lens of the eight research themes. For example, the red cluster highlights the potential role of travel-related constructs in disease epidemiology and clinical management, whereas, the green cluster relates to concepts on public health interventions. Understanding the keywords through the lens of migration health research themes also addresses the inherent limitations in interpreting the co-occurrence maps.

Fitting the keywords to the research themes provides a rudimentary but clear-cut approach in coding the common keywords in the bibliometric findings, which can provide additional insights on the current state of research productivity on COVID-19 related to migrants and migration health. It is clear from the findings that the migration angle in the current literature largely focuses on mobility (i.e. migration, travel) as a key factor in understanding disease epidemiology and clinical management, and an important aspect in developing public health interventions.

Table 11. Keyword clusters by relevant research theme on COVID-19 and migration health* (n=276)

Cluster	Keywords	Research Theme
Red	adult, elderly, child, travel, genetics	DEM
	fever, cough, hospitalization, incubation time	CM
	pcr, thorax radiography, isolation and purification, tomography	DTS
Green	quarantine, infection control, infection prevention	PHI
	social distancing, risk assessment, contact examination	
	China, epidemic, mortality, disease transmission, air travel, high risk population	DEM
Blue	pandemic, outbreak, united states, wuhan, virology, pathogenicity	DEM
	Pneumonia	CM
	public health, global health	PHI

DEM=Disease epidemiology and management; CM=clinical management; DTS=diagnostics and clinical management; PHI=public health intervention

*This keyword cluster covers all publications in COVID-19 and migration health for the period, 1 January 2020 to 4 May 2020

Table 12. Keyword clusters by relevant subtheme and top research theme* on COVID-19 and migration health

Cluster	DEM (n=113)	PHI (n=106)	CM (n=27)
Red	<p><i>Disease distribution:</i> adolescent, adult, child, elderly, female, male</p> <p><i>Disease etiology:</i> genetics, phylogeny, viral genome</p> <p><i>Other, CM:</i> asymptomatic infection, clinical feature, cough, dyspnea, fever, sore throat, incubation time</p> <p><i>Other, DTS:</i> PCR, throat culture, thorax radiography</p>	<p><i>Government measures:</i> government, infection control, infection prevention</p> <p><i>Social distancing measures:</i> social distancing</p> <p><i>Community screening:</i> risk assessment</p> <p><i>Other, HSC:</i> health care access, health care system, health service, international cooperation</p>	<p><i>Clinical characteristics:</i> asymptomatic infection, cough, fatigue, fever, headache, myalgia, sore throat</p> <p><i>Other, DEM:</i> adult, male, elderly</p> <p><i>Other, DTS:</i> RT-PCR, thorax radiography, throat culture</p>

Cluster	DEM (n=113)	PHI (n=106)	CM (n=27)
		<i>Other, DEM:</i> china, epidemic, infection risk, mortality	
Green	<i>Disease distribution:</i> epidemiology, Australia, China, Thailand, united states, japan, outbreak, epidemic, pandemic <i>Disease determinants:</i> risk assessment, air travel <i>Other, PHI:</i> surveillance, global health	<i>Government measures:</i> Global health <i>Other, DEM:</i> adult, elderly, female, male, outbreak	<i>Clinical characteristics:</i> disease severity, incubation time <i>Clinical management:</i> artificial ventilation, infection control, <i>Other, DEM:</i> china, epidemic, outbreak, transmission, travel
Blue	<i>Disease distribution:</i> geographic distribution, incidence, case fatality rate, mortality <i>Disease transmission:</i> transmission, <i>Disease determinant:</i> migration, travel <i>Other, PHI:</i> public health, quarantine, social distance, infection control, infection prevention, contact examination <i>Other, CM:</i> pneumonia, disease severity <i>Other, DTS:</i> isolation and purification, pathogenicity	<i>Social distancing measure:</i> quarantine <i>Cas and/or contact identification & management:</i> practice guideline** <i>Other, DEM:</i> transmission <i>Other, CM:</i> fever, incubation time, travel	<i>Clinical management:</i> patient isolation <i>Other, DEM:</i> child, female, genetics <i>Other, DTS:</i> isolation and purification, pathology
Yellow	<i>Disease distribution:</i> Europe, Wuhan <i>Disease etiology:</i> respiratory infections, zoonosis, virology	<i>Government measures:</i> communicable disease control, public health <i>Other, DEM:</i> pandemic, public health, United States, Wuhan <i>Other, CM:</i> pneumonia	<i>Clinical characteristics:</i> complication, pneumonia <i>Other, DEM:</i> pandemic <i>Other, DTS:</i> diagnostic imaging, tomography

DEM=Disease epidemiology and management; CM=clinical management; DTS=diagnostics and clinical management; PHI=public health intervention

*Top three research themes based on the number of relevant publications. Note that assigned research theme and subtheme is not mutually exclusive.

**The keyword 'practice guideline' is broad and can be classified under CM or HSC.

RECOMMENDATIONS

Findings from the bibliometric analysis demonstrate that studies on diagnostics and therapeutics and impact assessments and policy analysis in the context of migrants, and migration health are lacking in the current knowledge base. Moreover, the studies involving specific migrant populations were limited to international students, migrant workers, immigrants, migrants, refugees, and asylum seekers. Most of the studies investigated cases of COVID-19 in the context of population movement [53-55], which did not necessarily aim to describe the epidemiology of the disease in the migrant setting.

Although limited to the analysis of relevant publications using the metrics available (i.e. number of publications, co-occurrence of keywords, etc.) the key findings from the analysis can provide a useful starting point that can facilitate ongoing and future research on COVID-19 and migration health in terms of the critical areas that need more attention.

To strengthen the current knowledge base, more studies that examine health-related outcomes in specific migrant groups [19, 26] should be explored especially when sound historical and epidemiological data become available for the different migrant populations. This need highlights the importance of capturing the important variables that can more widely cover the different populations affected by COVID-19. Viewing COVID-19 through a migration lens should not be limited to the role of movement in the dynamic importation of cases in a pandemic but should aim for a more inclusive research strategy that considers the migrant populations as well as their relevant interests.

CONCLUSION

To strengthen the current knowledge base on COVID-19 and migration health, the scientific and research community should consider examining specific health-related outcomes in specific migrant groups as well as other relevant variables that can impact on migrants (i.e. structure and process measures). Investigations on COVID-19 and migration health should not be limited to the role of movement/mobility in the dynamic importation of cases in a pandemic; a more inclusive research strategy integrating the relevant interests of migrant populations is suggested.

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Availability of data and materials

All data presented in this study can be retrieved from Scopus using the search strategy available in Appendix 1.

Author's contributions

KW conceived the idea for the study. SA designed the methodology and prepared the first draft of the paper. All authors critically reviewed, revised, and approved the subsequent and final version. SA, MB, and JL contributed to the analyses and interpretation of the results. MS reviewed and validated the methodology and provided feedback on the search strategy development.

Conflict of interest

The authors declare that they have no competing interest.

Disclaimer: This paper has not been externally peer-reviewed; it should not replace individual clinical judgement and the sources cited should be checked. The views expressed in this commentary represent the views of the authors and not necessarily those of IOM. The views are not a substitute for professional medical advice.

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APPENDIX 1: SEARCH STRATEGY AND NUMBER OF RETRIEVED PUBLICATIONS

No.	Strategy	Search query (applied in Scopus)	N
1	Applied COVID-19 search query in the publication title (to minimize false positive results)	TITLE (covid* OR "covid-19" OR covid19 OR "SARS-CoV-2" OR ncov OR "2019-nCov" OR "2019nCov" OR "corona virus" OR coronavirus) OR TITLE (wuhan W/3 *virus* OR corona*) OR TITLE (china W/3 corona* OR *virus*)	15,388
2	Applied migrant, migration, and mobility search query in the publication title, publication source, and keywords (to retrieve larger number of publications)	TITLE-ABS-KEY (international OR overseas OR "cross-border" OR "non-citizen*" OR "non-national*" OR foreign* OR transnational* OR expatriate* OR alien* OR transient*) OR TITLE-ABS-KEY (*migrant* OR *migrat*) OR TITLE-ABS-KEY (refugee* OR "non-asylum") OR TITLE-ABS-KEY (asylum) OR TITLE-ABS-KEY (stateless PRE/2 person* OR population* OR people) OR TITLE-ABS-KEY (mobile OR mobility OR movement* OR displace* OR travel*)	7,117,478
3	Combined strategies 1 and 2	1 AND 2	1,350
4	Limited publication year, 2020	LIMIT-TO (PUBYEAR, 2020)	727
5	Excluded irrelevant subject areas	EXCLUDE (SUBJAREA, "VETE")	722
6	Excluded irrelevant publications identified by title and abstract screening (using Scopus saved list and MS Excel)		276

N=Number of publications retrieved; Note that search strategy was applied on 4 May 2020.