Understanding predictors of pneumococcal vaccine uptake in older adults aged 65 years and older in high-income countries across the globe: a scoping review

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ABSTRACT

Background: Pneumococcal disease causes substantial morbidity and mortality in older adults. Pneumococcal polysaccharide vaccine (PPV23) is routinely recommended to reduce the disease burden in this population. However, the vaccination coverage in older adults remains suboptimal in high-income countries.

Objectives: We sought to understand the current landscape of published literature on the predictors of pneumococcal vaccine uptake in older adults aged 65 years and older in high-income countries, and to identify the gaps in literature to inform future research.

Methods: We conducted a scoping review employing the Arksey and O'Malley framework and Joanna Briggs Methods. We searched Medline, EMBASE, CINAHL, PsycInfo and Cochrane databases. We included quantitative and qualitative studies on predictors of pneumococcal vaccination in older adults that reported older adult- and pneumococcal vaccine-specific results, conducted in high-income settings, and published in English between January 2015 and April 2020. We excluded studies assessing interventions to improve vaccine uptake. We followed the Strategic Advisory Group of Experts on Immunization Working Group Vaccine Hesitancy Determinants Matrix to map the predictors within contextual, individual and social group, and vaccine and vaccination-specific influence determinants. Studies on providers and institutions were also included and results summarized separately.

Results: We included 52 publications in our review. Most of the predictors in 39 quantitative studies belonged to the individual and social group influences (n = 12), followed by contextual influences (n = 11) and vaccine and vaccination-specific issues (n = 3). Few qualitative studies explored the barriers to pneumococcal vaccination. Only five studies examined predictors from the healthcare providers' perspective. Three studies examined the institutional characteristics as the predictors of pneumococcal vaccination in older adults.

Conclusions: We identified enablers and barriers of pneumococcal vaccination among older adults in high-income settings. We also identified gaps in the literature and provide recommendations for future research to address the gaps.

Keywords: Pneumococcal vaccine; Predictors; Enablers; Barriers; Older adults; Scoping review; High-income countries

1. Introduction

Older adults, specifically individuals aged 65 years and older are at increased risk of pneumococcal disease, namely invasive pneumococcal disease (IPD) and community acquired pneumonia (CAP) because of immunosenescence and comorbidities [1]. Pneumococcus was attributed to an estimated 29.4 million episodes of lower respiratory infections, including pneumonia and 494,340 deaths among older adults aged >70 years globally in 2016 [2]. A high burden of IPD and CAP, including hospitalizations and deaths was also reported in high-income countries, including the United States (US), European countries and Australia [3-6]. Pneumococcal disease causes substantial morbidity and mortality in Canadian older adults, with 77% of hospitalizations for IPD and 17% of IPD-associated deaths occurring among older adults aged ≥65 years during 2007–2017 [7]. Similarly, 47% of hospitalizations for pneumococcal CAP from 2010 to 2015 were reported in Canadian older adults [8]. Pneumococcal disease also results in substantial cost associated with healthcare utilization, including ambulatory care, hospitalization and all medications in older adults [9-11].

The World Health Organization (WHO) Strategic Advisory Group of Experts (SAGE) on Immunization Pneumococcal Working Group recommends country-specific older adult population structure and demographics, monitoring serotypes for residual disease burden in older adults through enhanced surveillance together with the serotypes in the 23-valent pneumococcal polysaccharide vaccine (PPV23), 13-valent pneumococcal conjugate vaccine (PCV13) and other higher valent PCVs, and operational factors such as cost and cost-effectiveness should be considered for introduction of PPV23 or PCV13 for older adults in the national immunization program to provide direct protection [12]. ThePPV23 is recommended for routine use in adults

aged ≥65 years to reduce the burden of IPD and CAP in the US, Canada and most European countries [13-15]. The PCV13 is also recommended in addition to PPV23 in immunocompetent older adults without any previous pneumococcal vaccination in some high-income countries [14-16]. The Canadian National Advisory Committee on Immunization recommends one dose of PPV for all older adults. However, in the 2018-2019 Seasonal Influenza Vaccination Coverage Survey, an estimated 58% of older adults reported having received a pneumococcal vaccine in adulthood in Canada [17], which is well below the nationally defined target of vaccinating 80% of the older adult (aged ≥65 years) population [18]. Similar to Canada, the uptake of pneumococcal vaccine in this population was 59% in US in 2017 [19], well below the target of reaching 90% of older adults by 2020 [20]. Even lower vaccination coverage was reported in Europe; only 18% of older adults aged ≥65 reported receiving pneumococcal vaccination in nine high-income European countries (Austria, Czech Republic, France, Germany, Greece, Italy, Portugal, Spain and the United Kingdom) [21]. With an aging population, the burden of pneumococcal diseases is likely to increase. Identifying the predictors of pneumococcal vaccination could help inform policy and practice to improve vaccine uptake and reduce burden.

Existing literature summarizing the determinants of vaccination uptake in older adults mostly focuses on seasonal influenza vaccination [22, 23]. There is no comprehensive review synthesizing the predictors of pneumococcal vaccine uptake specifically among older adults in high-income settings. As part of a larger scoping review project to gain insights into pneumococcal vaccination related interventions, enablers and barriers in older adults, this scoping review sought to understand what is known about the predictors of pneumococcal vaccine uptake in older adults aged 65 years and above across high-income settings. A secondary

aim of this scoping review was to identify the source and type of evidence and gaps in literature to inform future research.

2. Methods

We conducted a scoping review following the methodological framework described by Arksey and O'Malley and the guidance from the Joanna Briggs Methods Manual for Scoping Reviews [24, 25]. We followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist for reporting [26]. Methodological steps related to the search strategy, study selection and data charting were undertaken considering the broader scoping review project. However, only data relevant to the predictors of pneumococcal vaccination were collated to address the objectives of this study.

3.1. Search strategy for identifying relevant studies

We searched Medline (Ovid), EMBASE (Ovid), CINAHL (Ovid), PsycInfo and Cochrane in April 2020 using a search strategy that combined the concepts related to the population 'older adults aged ≥65 years' and the intervention 'pneumococcal vaccine' including both free text and controlled vocabulary (Medical Subject Headings). Search terms were finalized following consultation with a University of Toronto librarian. The search was limited to records published in English and published between 2015 to April 2020 to understand recent context. Appendix A provides the detailed search strategies.

3.2. Study selection

Identified records were managed using the online reference management software Covidence [27]. After duplicate records were automatically removed by Covidence, we screened all remaining records in two levels according to a set of inclusion and exclusion criteria. The first level screening included independent title and abstract screening by three authors (ML, AK and MT). The second level screening included full-text screening by five authors (ML, AK, MT, SN and GBG). Disagreements were resolved by discussion between two reviewers (ML and AK in the first level, and AK and SN in the second level) before finalizing the records. We included records if studies: 1) were conducted specifically in older adults aged ≥65 years or included adults with a mean age ≥50 years, 2) discussed key approaches, interventions, frameworks and recommendations to increase pneumococcal vaccine uptake,3) identified the determinants of pneumococcal vaccine uptake and vaccine hesitancy, and 4) were conducted in high-income settings based on the World Bank classification of countries by income [28]. Some studies on older adults or adults with comorbidities included adults with a mean age ≥50 years, and we did not think the predictors will be substantially different for them compared to adults aged ≥65 years; thus, we included these studies in our review. We excluded studies if they: 1) did not include older adults, 2) did not present older age group- or pneumococcal vaccine-specific results, 3) were not conducted in high-income settings, and 4) were published prior to 2015.

3.3. Charting the data

We created a data charting form in Microsoft Excel to extract the following key information from the publications: author, year of publication, study location, funding source, study design and methods, intervention type, comparator and duration where applicable, study population,

vaccine type and key findings pertinent to the overall scoping review. We piloted the data charting form before charting the data.

3.4. Collating, summarizing and reporting the results

The overall scoping review project intended to explore two areas related to pneumococcal vaccination in older adults: 1) interventions that aimed to increase vaccination, and 2) the predictors of vaccination uptake in older adults. This review focused on the latter. Thus, we collated findings from studies on predictors excluding intervention studies. We included all study designs, full articles and abstracts, and studies on older adults, healthcare providers and institutions (e.g., hospitals, and long-term care). We included all studies regardless of the funding source, including studies being conducted or funded by and/or disclosures related to pneumococcal vaccine producers (e.g., GlaxoSmithKline, Merck, Pfizer, and Wyeth). Since we focused on exploring the factors influencing vaccine uptake and not measuring or comparing efficacy or cost-effectiveness of different vaccines, we believe that the risk of bias is minimal [22].

For studies reporting barriers and enablers to vaccine uptake from the perspective of older adults, we included quantitative studies that used multivariable analyses or presented senior-reported barriers. We included only statistically significant factors from multivariable analyses; and factors that increased the odds of pneumococcal vaccination were considered as enablers while those that decreased the odds of pneumococcal vaccination were considered as barriers. Predictors from other study designs were considered as enablers and/or barriers as reported by the authors. We followed the WHO Strategic Advisory Group of Experts (SAGE) on

Immunization Working Group recommended Vaccine Hesitancy Determinants Matrix to chart the predictors of pneumococcal vaccine uptake identified in all studies focused on the perspectives of older adults [29]. The matrix grouped factors that can influence vaccine hesitancy into three main determinants: contextual, individual and social group, and vaccine and vaccination-specific influences. Each determinant included different categories and subcategories comprising different factors. We mapped the enablers and barriers within these categories and corresponding subcategories (Appendix B); and mapped the predictors separately for studies specifically conducted in older adults with chronic medical conditions and for other studies in older adults regardless of comorbidity status.

Studies that focused on provider-level and institution-level predictors of vaccine uptake are summarized separately from those that take the perspective of the vaccine recipients. For studies taking the providers' perspective, we considered all factors related to pneumococcal vaccination, including assessing need for, recommending and stocking vaccines as enablers. As such, statistically significant factors positively associated with vaccination practices in multivariable analyses or factors positively correlated with intent to recommend were considered as enablers; reported barriers to pneumococcal vaccination practices were considered as barriers. For studies in institutional settings, we considered statistically significant factors associated with increased pneumococcal vaccination as enablers and factors associated with decreased pneumococcal vaccination as barriers. As the institutional settings vary among the studies, we separately summarize the predictors from each study.

3. Results

We identified a total of 6,138 records from five databases: 1,689 from Medline (Ovid), 3,388 from EMBASE (Ovid), 536 from CINAHL (Ovid), 23 from PsycInfo and 502 from Cochrane. After screening, 52 publications were included in this review [30-81], including three abstracts [31, 53, 59] (Figure 1).

3.1. Publication characteristics

The majority of the studies were conducted in the US; study designs included: quantitative (n=48), qualitative (n=2), mixed method (n=1) and systematic review (n=1) (Table 1). Of the qualitative studies, one explored the barriers in Chinese adults in senior citizen's centers and the other explored the enablers in French rheumatoid arthritis patients [71, 72]; the mixed method study explored the cause of pneumococcal vaccine refusal among older Black adults [70]. The systematic literature review of studies on determinants of pneumococcal vaccination uptake in European countries included two studies in older adults [73]. Fourteen studies were specifically conducted among older adults with chronic medical conditions such as type 2 diabetes, systemic autoimmune diseases[1], chronic obstructive pulmonary disease, inflammatory bowel disease, hematological malignancy and solid cancer, secondary immune deficiency or receiving immunosuppressive or biological disease-modifying antirheumatic drugs for autoimmune or inflammatory diseases. Four studies were on healthcare providers, one study on both older adults and healthcare providers, and three studies focused on institutional determinants of pneumococcal vaccine uptake. Funding information was unavailable for 14 studies, and no

[1] Rheumatoid arthritis, spondyloarthritis, Behçet's disease, myositis, vasculitis, systemic lupus erythematosus, psoriatic arthritis, sarcoidosis and autoimmune hematological disorders

247 funding or specific funding was received for 8 studies; 25 studies were conducted with non-
248 pharmaceutical funding, while 3 studies from the US [42, 51, 81], and one study each from Japan
249 [77] and France [57] were funded by pneumococcal vaccine producers.
250
251 *3.2. Predictors from older adults' perspective*
252 Thirty-nine publications reported predictors of pneumococcal vaccination in older adults
253 using multivariable analyses, including 14 studies in older adults with specific comorbidities
254 (Table 2). Ten studies were among adults aged ≥50 years or with a mean age 50–60 years. Seven
255 studies presented senior-reported barriers to pneumococcal vaccination with four reporting on
256 older adults with chronic medical conditions. The majority of the determinants were identified
257 from the quantitative studies (Figure 2A). Most of the predictors belonged to the subcategories
258 within the individual and social influence determinant (Figure 2B). Some predictors were
259 identified both as enablers and barriers although the reasoning was often not provided.
260
261 *3.2.1.Contextual influences*
262 **Socio-economic**
263 Most of the studies identified predictors within socio-economic factor subcategories (Table
264 2). An increasing age was reported as an enabler of pneumococcal vaccination in nine studies
265 [30, 36, 38, 40, 42, 44, 47, 53, 66] conducted in Canada, Germany, Spain, US and France.
266 However, increasing age was associated with decreased vaccination in two studies in the US [41,
267 59], including one study where the odds of vaccination decreased with age before inflammatory
268 bowel disease diagnosis among the patients [41]. In addition, being in the lower age group (65–
269 74 years vs. ≥85 years) was found to be a barrier in one US study [35]. Race or ethnicity was

identified as both an enabler and a barrier in the US; individuals who identified as African-American, Hispanic [46], non-Hispanic White [53] and North American Native [32] were more likely to be vaccinated in some studies, while individuals who identified as non-Hispanic Black, Hispanic and Black were less likely to be vaccinated other studies [35, 42, 67, 81]. Being non-US born was reported as an enabler in a study in the US [66]. Higher income was an enabler in Singaporean older adults [62] and lower income was a barrier in three studies in the US [35, 48, 81]. However, annual household income of <50,000 USD was found to be an enabler in a US study [46]. Both higher education (college level vs. <high school) [42] and lower education (≤high school vs. >high school) were enablers in the US [46]; less than high school level education was a barrier to pneumococcal vaccination in the US [35, 66, 81].

Access to healthcare or healthcare seeking behaviour/utilization, including preventive care, were consistent predictors of vaccination in Canada, US, Spain and Singapore [30, 35, 42, 48, 50, 53, 59, 61, 62, 64, 66, 69]; one or more hospitalizations within the first year after turning 65 years of age was a barrier in a US study [64]. One study in the US found pharmacy visits in the first year after 65 years to be associated with PCV13-PPV23 vaccination completion [64]. Both not having [48] and having [53, 59, 66, 69] health insurance were identified as enablers of vaccination in the US. Health status (comorbidity or high-risk conditions), including disability was identified both as an enabler [30, 32, 35, 38-41, 44, 46-48, 51, 53, 59, 66] and a barrier [34, 44, 46, 56, 58, 61, 64] in different studies; was an enabler in Canada, the US, Spain, Poland, Spain and France, and a barrier in Taiwan, Spain, the US, France, and Japan.

Gender/sex

Gender or sex was identified as a predictor in seven studies. Being female was an enabler in two studies in older adults with chronic medical conditions in Canada [30] and France [33] and one other study in older adults in the US [42], but a barrier in two other studies in the US [46] and Taiwan [34]. On the other hand, being male was identified as a barrier in two studies in the US [35, 64].

Geography

Geographical barriers were identified both as an enabler and a barrier in several studies. Geographical region of residence within the country (e.g., state) was both an enabler [41, 46] and a barrier [64] in the US, and an enabler in Germany [55]. Rural residence was an enabler among at-risk adults aged ≥50 years in Spain [44] and a barrier to pneumococcal vaccine uptake among older adults in the US [81].

3.2.2.Individual and social group influences

Beliefs, attitudes, perceptions and practice/behaviour about health and prevention

Several studies identified attitudes and health behaviours that predicted vaccine uptake in older adults (Table 2). Positive or favourable attitude/opinion towards vaccines were enablers of pneumococcal vaccination in the US, Italy, and France [47, 54, 57]. Seasonal or pandemic influenza vaccination or adherence (among older adults in France, Canada, Japan, Spain and the US, including those with chronic medical conditions) [32, 33, 40, 45, 49, 52, 61, 64, 77], and receipt of tetanus vaccination (in Germany) [55] or hepatitis B vaccination (among Medicare beneficiaries in the US) [32] were identified as enablers in different countries. Better self-rated health was an enabler in Singapore and the US [62, 66] while moderate, bad or very bad self-

316 rated health was identified as a barrier among Singaporean older adults [62]. Caregiving
317 responsibility (i.e., providing regular care or help to another aging adult or an adult with long-
318 term illness or disability in the past month) combined with the type of relationship with the care
319 recipient were identified as an enabler in older adults who identified as African-American and
320 Latino in the US; being an 'other related caregiver' such as a sibling of the care recipient was an
321 enabler of ever receiving pneumococcal vaccine compared to those without any caregiving
322 responsibility [48].
323
324 Lifestyle and health behaviour factors were also identified as predictors of pneumococcal
325 vaccination. Using vitamins and minerals were identified as enablers, while using herbal
326 medicines sometimes was identified as a barrier in a study conducted in Australian elderly
327 women [65]. Being a smoker was identified as an enabler in the US [46] and as a barrier in
328 Taiwan [34]; physical inactivity was a barrier in both these studies, specifically among
329 Taiwanese older adults with low peak expiratory flow.
330
331 **Knowledge of vaccines and risk/benefits related to pneumococcal vaccine**
332 Good knowledge of pneumococcal vaccine, including availability and recommendations and
333 vaccines in general, was an enabler of pneumococcal vaccine uptake in Germany, Japan and the
334 US [55, 58, 68], while a lack of knowledge acted as barriers to vaccination in European countries
335 and Australia [31, 39, 43, 73]. Similarly, perceptions of better vaccine efficacy/effectiveness was
336 an enabler in Japan and European countries [58, 73], while fear of side effects, adverse effects or
337 complications (in Ireland, France, Poland, Japan, and the US) [31, 33, 39, 49, 58, 70] and

concerns with vaccine effectiveness were barriers to uptake (in France, Japan, and the US) [33, 58, 70] among other factors.

3.2.3.Vaccine and vaccine-specific issues

Direct cost of vaccine/vaccination

Subsidy or free pneumococcal vaccinations were enablers of vaccination in European countries and Japan [73, 77], while high cost and out-of-pocket payment were reported as barriers by older adults in Poland [39], Japan [58], and Malta [63].

Role of healthcare professionals

Healthcare providers played an important role in vaccine uptake in older adults in several studies. Receiving information [47], recommendation [39, 45, 49, 52, 58, 68, 73, 77] and prescription [56] of pneumococcal vaccine from a healthcare provider, including primary care or specialist physicians, and physician assistants were identified as enablers of vaccination in 9 studies in Japan, France, Poland, Canada and the US and a systematic literature review of studies in European countries among older adults, including those with chronic medical conditions. Likewise, a lack of healthcare provider recommendation was a barrier to uptake in older adults in France, Japan, Malta and other European countries [33, 58, 63, 73].

3.3. Predictors from providers' perspective

Few studies from the providers' perspectives identified the predictors of pneumococcal vaccination (Table 3). One study in the US [60] and three studies in Europe (Germany, the

Netherlands, and Italy) were on perspectives of providers [74-76], while one study from Japan included both older adults' and providers' perspectives [77].

The enablers and barriers of pneumococcal vaccination identified in the studies are summarized in Table 3. Patient's age and/or comorbidity was both an enabler and a barrier; an enabler in the Netherlands and Japan, and a barrier in Japan. Notably, a lack of knowledge on pneumococcal vaccine or difficulty in understanding the recommendation were barriers to recommendation in four studies in the US, Germany, Italy, and Japan [60, 74, 76, 77]. Direct financial barrier was reported in studies among providers in the US, Germany and Japan [60, 74, 77].

3.4. Institutional predictors

Three US studies focused on institutional-level predictors of pneumococcal vaccination; one study in acute care hospitals [78], one in skilled nursing facilities [79] and the other in long-term care facilities [80]. Hospitals having a higher (>30%) rate of intensive care unit (ICU) admission for adults aged ≥65 years with pneumonia were less likely to provide pneumococcal vaccination to the ICU pneumonia patient during hospital stay; thus the high ICU patient admission load was a barrier for pneumococcal vaccination [78]. In the skilled nursing facilities, nursing home characteristics such as higher quality (overall rating) and government and non-profit ownership were promoters of pneumococcal vaccination, while urban facilities and facilities located in the US South and the West were barriers [79]. In the long-term care setting, facilities with a higher proportion of Black residents had lower rates of vaccine uptake than facilities with a higher proportion of White residents [80]. Additionally, White residents had higher vaccination rates

than Black residents regardless of the facility's racial composition. The authors suggested that the lower vaccination rates in Black residents could be attributed to the community and facility-level characteristics, including the location of the facilities and the population they served.

3.5. Gaps in literature

Some themes within the Vaccine Hesitancy Determinants Matrix conceptual framework were not identified in the literature. Notably, there were no studies that examined barriers and enablers of pneumococcal vaccine uptake that related to public health communication and the media environment. Only three qualitative studies in older adults, including a mixed methods study in older Black adults, explored older adults' perspective on pneumococcal vaccine uptake. Only three studies, all in the US, sought to identify the predictors of vaccine uptake from the institutional perspective.

4. Discussion

In this scoping review, we summarized the key findings from the literature on the predictors of pneumococcal vaccination among older adults from the perspectives of older adults, healthcare providers and institutions in high-income settings. Studies frequently identified socio-economic factors as predictors of vaccine uptake in older adults, though with some mixed findings in terms of directionality. Receiving influenza vaccination was also positively associated with pneumococcal vaccine uptake in several studies. Healthcare providers' role in terms of recommending, prescribing, or providing information on pneumococcal vaccination was identified as an enabler consistently across different study designs; while financial cost of pneumococcal vaccine was noted as a barrier. Several factors, including a lack of knowledge,

financial and logistical issues, and concerns with vaccine safety and effectiveness were reported barriers for the healthcare providers to vaccinate or recommend pneumococcal vaccination. We also identified gaps in literature which may help inform future research directions.

Most of the quantitative studies with multivariable analyses included in our review identified contextual influences, primarily socio-demographic factors, sex and geographic location likely because of the ease of collection or availability of these information. Some of these predictors were identified as being enablers in some studies or barriers in others; this was the case for increasing age, being Black or Hispanic, lower income, lower education, being female and having disability. Plausible explanation for the higher and/or lower odds of vaccination for these predictors was limited in most studies. The study in Taiwan suspected that household responsibilities precluded female older adults from receiving free PPV23 [34]. A study in the US that observed reverse disparities (i.e., black and/or Hispanic more likely to be vaccinated) hypothesized that recent emphasis on health equity through better access and care coordination may have contributed to this finding [46]. It is possible that differences in study population, study design, the profile of study participants in different stratum of one or more determinants, and national recommendations and/or payment mechanism may have led to the different directions of association between these predictors and pneumococcal vaccination in these studies. Comparing participant characteristics by each identified enabler or barrier in the studies could provide a better understanding of the possible reasons behind the observed results. Further exploration for these contrasting roles is warranted in future studies, including interactions with differing context and potential interrelations to other factors [82].

Only one study in the US assessed pharmacy visit as a determinant of pneumococcal vaccine uptake in older adults. Given that pneumococcal vaccines are widely available in pharmacies and other settings such as community health clinics, health departments, and other community locations and accessed easily, future studies should specifically assess access to pneumococcal vaccines as a determinant of pneumococcal vaccine uptake in older adults beyond access to healthcare or healthcare seeking behaviour/utilization.

Receipt of influenza vaccine was identified as an enabler of pneumococcal vaccine uptake in ten studies. Actions taken to increase influenza vaccine uptake could, thus, indirectly increase pneumococcal vaccine uptake. Thus, influenza vaccination in a pneumococcal vaccine eligible but non-recipient older adult would be considered a missed opportunity for vaccination. Most of the determinants of seasonal influenza vaccination in older adults [22, 83] are similar to the contextual influence predictors identified in our study. However, the contrasting role of some of the socio-economic predictors in our study (i.e., race/ethnicity, lower income, lower education, and having disability) has not been observed in relation to seasonal influenza vaccination [23]. Of note, receipt of hepatitis B vaccination was an enabler among older adult Medicare fee-for-service beneficiaries. In addition to routinely covered influenza and pneumococcal vaccines, hepatitis B vaccine is covered for individuals belonging to medium- and high-risk groups. Therefore, hepatitis B vaccination may increase the likelihood of receiving pneumococcal vaccine because of spillover effects of being categorized by providers as being at-risk.

Healthcare providers' recommendation, prescription and patient education was commonly found to facilitate vaccine uptake. A prompt from a healthcare provider was reportedly the most

common driver for pneumonia vaccination among European older adults [21]. Only 25% of Canadian adults reported receiving information from healthcare providers on vaccines in general [29]. Doctors not mentioning pneumococcal vaccine was one of the top three reported reasons for not receiving a pneumococcal vaccine among Canadian older adults in a recent national vaccination coverage survey not included in our review [17]. However, it may be worthwhile to examine in future studies if and to what extent healthcare providers' recommendation facilitates vaccine uptake in older adults having low perceived importance of the pneumococcal vaccine and with concerns about vaccine safety and effectiveness.

Our findings suggest that healthcare providers were not often aware of the recommendations, vaccine safety and effectiveness or encountered financial or logistical issues and difficulty in determining patients' vaccination status. Similar barriers were faced by Canadian healthcare providers in relation to adult vaccination in general [84] and by Western European healthcare providers [27]. Measures to improve healthcare providers' knowledge on vaccines and address the financial and logistical barriers could be used to leverage the provider-patient interface to aid vaccine uptake in older adults.

Notably, none of the studies included in this review examined older adults' access to information on pneumococcal vaccination and the use and influence of mass media in influencing the decision to get vaccinated. Evidence suggests that mass media coverage on influenza coverage influenced vaccine uptake in older adults [85]; contrarily, fear conveyed by mass media were reported obstacles to influenza vaccination [72]. Future studies could examine the sources and access to information and mass media and their role as predictors of

pneumococcal vaccination. A handful of qualitative studies in our review explored older adults' perspective on pneumococcal vaccination. Only one study explored the reasons for vaccine refusal and barriers among older adults who identified as Black. Racial disparities have been observed not only for pneumococcal vaccination [86] but also for influenza vaccination [87] among older adults in the US. However, in Canada, individuals who identified as White or Black were found to be less likely to get influenza vaccination than individuals belonging to other ethnic groups [88]. Thus, more qualitative studies are warranted among different racial or ethnic groups to better understand vaccine hesitancy from their perspectives.

We identified only three studies from the US on institutional characteristics as predictors in three different settings. In the US, several regulatory initiatives are in place to improve pneumococcal vaccination status in nursing homes such as standing order programs, immunization standard and infection control guidelines; nevertheless, some of the previously reported barriers such as post-acute care/long-term care practitioners' skepticism about the benefits of pneumococcal vaccines, difficulty in obtaining an accurate vaccination history, issues with reimbursement from Medicare and the complexity of vaccine recommendations [89] were similar to the barriers faced by the healthcare providers in other health care settings identified in our study. Further studies are needed to identify predictors beyond the facility-level characteristics we identified in the published literature. This will help to better understand the predictors from regulatory and implementation standpoints in other high-income settings. Hospitalization and living in communal settings such as long-term care facilities, assisted living or nursing homes could provide an important opportunity to identify unvaccinated individuals and offer pneumococcal vaccination with necessary regulatory and logistical measures in place.

Our findings suggest that direct financial cost is a common impediment to pneumococcal vaccination across all three stakeholders. However, this barrier needs to be contextualized, particularly in light of presence or absence of a national recommendation for vaccination of older adults together with whether the vaccines are offered free of cost or subsidized regardless of the funding mechanism (public funding, insurance or subsidy scheme) or requires out-of-pocket payment. Older adults in some high-income countries, for example, France, the Netherlands, and Malta need to pay out-of-pocket [90, 91]; older adults who do not belong to the high-risk groups need to pay out-of-pocket in Singapore [62]. Imposing some costs of accessing vaccines onto individuals may also hinder healthcare providers' and healthcare facilities' ability or commitment towards vaccinating older adults even in presence of national recommendations and/or institutional regulatory measures.

Some of the recommended actions in context of COVID-19 vaccination, such as gaining insights on key drivers and barriers to vaccination through carefully designed qualitative and quantitative research, and social media listening could be useful in addressing pneumococcal vaccine hesitancy in this population [92]. National online news media could also provide additional understanding of public perceptions around vaccinations in older adults that could be leveraged to plan measures to promote vaccine uptake [93].

4.1 Limitations

This review included studies published in English alone, and thus likely resulted in selection or publication bias by excluding relevant publications in other languages from high-income

settings, including European countries having a universal health care system. However, we finalized our search strategy following consultation from a librarian to better capture relevant English literature and we included 20 studies from Europe and six studies from Asia. We did not evaluate the quality of the studies or quantify the magnitude of the predictors because our objective was to understand the current landscape of literature on pneumococcal vaccine uptake and to identify the gaps in knowledge. Thus, all predictors identified in the included studies may not be useful if the evidence generated was biased because of issues related to study quality. The Vaccine Hesitancy Determinant Matrix that we followed included certain demographic factors (e.g., age, sex and marital status), access to healthcare and health status under socio-economic category. We faced some difficulty in assigning some predictors within the existing categories and subcategories of the Vaccine Hesitancy Determinants Matrix, and included such factors where deemed appropriate. Two new higher valent PCV vaccines, PCV15 and PCV20, have recently been authorized and recommended for use in older adults in the US [94]; PCV15 has been authorized in Canada [95], while PCV20 has been authorized in the European Unions [96]. These new vaccines may have an influence on the uptake in older adults long-term as other jurisdictions approve, recommend and offer them in the future.

4.2 Conclusions

To our knowledge, this is the first scoping review on the predictors of pneumococcal vaccination in older adults from the perspective of three different stakeholders (e.g., older adults, healthcare providers and institutions) in high-income countries. Our findings suggest that several contextual, individual and social group, and vaccine and vaccination-specific determinants influence older adults' decision to receive pneumococcal vaccine; socio-economic factors,

influenza and other vaccine uptake and healthcare providers' recommendations are important predictors. A lack of knowledge and financial factors preclude healthcare providers vaccinating or recommending pneumococcal vaccines. Future studies are warranted to address the gaps we identified in current literature, such as examining the role of media and other communication strategies. This will further enhance our understanding of the enablers and barriers of pneumococcal vaccine uptake in older adults.

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All authors attest they meet the ICMJE criteria for authorship.

Author contributions: SA, ML and AK conceived of the study design. All authors provided methodological input. SN, GBG, AK, MT, and ML contributed to study selection, review of papers and data extraction. SN analyzed the data and drafted the manuscript. All authors interpreted the results, critically reviewed the manuscript, and have approved the final version for publication.

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Tables

Table 1: Summary study characteristics

Characteristic	Number of studies N= 52	Nationally recommended PPV23 and/or PCV13	Funding / payment scheme for vaccines	Scoping review study citation
Publication type				
Full text research article	46			[30, 32, 34-52, 54-58, 60-68, 70, 71, 73-81]
Brief communication	1			[69]
Correspondence	1			[72]
Letter to the Editor	1			[33]
Abstract	3			[31, 53, 59]
Study design				
Quantitative				
Cross-sectional	45			[30, 31, 33-36, 38-69, 74-77, 79-81]
Longitudinal (prospective/retrospective)	3			[32, 37, 78]
Systematic review	1			[73]
Qualitative	2			[71, 72]
Mixed method	1			[70]
Region/Country				
North America				
US	22	Yes	Funded / reimbursed by federal health insurance Medicare	[32, 35, 37, 41, 42, 46, 48, 50, 51, 53, 59, 60, 64, 66-70, 78-81]
Canada	2	Yes	Publicly funded, free	[30, 45]

Europe				
Europe	1	Differs by country	Differs by country	[73]
France	6	Only for specific high-risk groups	Out-of-pocket	[33, 47, 49, 56, 57, 72]
Spain	4	PPV23 (≥65 years); PCV13 for specific high-risk individuals	Publicly funded, free	[38, 40, 44, 61]
Germany	3	PPV23 (≥60 years)	Funded / reimbursed by statutory health insurance	[36, 55, 74]
Italy	2	Yes (≥60 years)	Funded / reimbursed	[54, 76]
Ireland	1	PPV23 (≥65 years) [15, 97]	Funded / reimbursed	[31]
Netherlands	1	PPV23 (≥60 years)	Out-of-pocket	[75]
Poland	1	Only PCV for ≥50 years [97]	Not funded by the National Health system [90]	[39]
Malta	1	PPV23 (≥65 years) [91]	Out-of-pocket	[63]
Australia	2	PCV13 for all non-indigenous adults (≥70 years), additional PPV23 for at-risk older adults; PCV13 and	Free through the National Immunisation Program	[43, 65]

		PPV23 for all indigenous adults (≥50 years) [98]		
Asia				
Japan	3	PPV23 (≥65 years)	Public subsidy to partially cover vaccination cost, remaining cost out-of-pocket	[52, 58, 77]
Singapore	1	PPV23 (≥65 years)	Out-of-pocket for individual not at high-risk; funded / reimbursed by Medisave, a compulsory national health-care savings scheme for high-risk groups	[62]
Hong Kong	1	PCV13/PPV23 (≥65 years)	Funded / reimbursed through government's Elderly Vaccination Subsidy Scheme, with additional cost coverage available through Elderly Health Care Voucher Scheme	[71]

Taiwan	1	PPV23 (≥75 years)	Free (financial support from a nongovernmental organization)	[34]
Study population				
Older adults				
General seniors (no specific group)	17			[32, 34, 35, 38, 42, 44, 46, 50, 51, 53, 55, 58, 62, 64, 66, 73, 81]
High-risk patients/patients with chronic medical conditions	14			[30, 31, 33, 36, 37, 39-41, 45, 47, 49, 56, 57, 72]
Women	1			[65]
Specific race/ethnicity				
African-American	1			[68]
African-American or Latino	1			[48]
Black patients	1			[70]
Latinos and non-Hispanic Whites	1			[69]
Agricultural workers	1			[54]
Community clinic patients	1			[59]
Hospitalized patients	1			[61]
Inpatients and outpatients in a hospital	1			[43]
Patients receiving community-based and hospital-based healthcare services	1			[63]
Nursing home residents	1			[67]
Residents of senior citizens' centers	1			[71]
Elderly club members	1			[52]
Providers				
General practitioners	2			[75, 76]
General practitioners and physician assistants	1			[74]
Primary care physicians	1			[60]
Older adults and providers				

Patients with chronic medical conditions and clinicians	1	[77]
Institutional		
Hospital	1	[78]
Long-term care facility	1	[80]
Medicaid and Medicare skilled nursing facilities	1	[79]
Study funding		
Funding information unavailable		
Abstract	3	[31, 53, 59]
No conflict of interest	7	[40, 43, 49, 54, 58, 72]
Conflict of interest not available	2	[68, 69]
Disclosure related to pneumococcal vaccine producer	2	[33, 47]
No funding/no specific funding		[36, 64]
No conflict of interest	6	[46, 52, 56, 62, 65, 79]
Disclosure related to pneumococcal vaccine producer	2	[36, 64]
Non-pharmaceutical funding		
No conflict of interest	20	[30, 32, 34, 35, 37-39, 44, 48, 55, 60, 61, 67, 70, 71, 73-76, 78]
Conflict of interest not available	3	[45, 66, 80]
Non-pharmaceutical related conflict of interest	1	[50]
Unspecified pharmaceutical related conflict of interest	1	[41]
Pneumococcal vaccine producer		
Funding and conflict of interest	3	[51, 77, 81]
Funded publication of article	1	[42]
Supported data collection, conflict of interest not available	1	[57]

922 Table 2: Predictors of pneumococcal vaccination in older adults identified according to study designs

			Quantitative studies				Systematic review		Mixed method and qualitative studies	
	Category	Subcategory	Studies in older adults with chronic medical conditions		Other studies in older adults					
			Enabler	Barrier	Enabler	Barrier	Enabler	Barrier	Enabler	Barrier
Contextual influences	Communication and media environment	Access to information								
		Mass Media (use and influence)								
	Influential leaders and individuals	Influential leaders and individuals								
	Historical influences	Historical influences								
	Socio-economic factors	Age	[30, 36, 40, 47]	[41]	[38, 42, 44, 53, 66]	[35, 59]				
		Race/Ethnicity			[32, 46, 53]	[35, 42, 67, 81]				
		Birthplace			[66]					
		Income/SES			[46, 62]	[35, 48, 81]				
		Marital status	[41]		[46, 53]	[35]				
		Education			[42, 46, 62]	[35, 66, 81]				
		Employment status	[30]		[42]	[35, 46]				
		Language Proficiency								
		Family decision making								
		Access to healthcare	[30, 50]		[35, 42, 48, 53, 59, 61, 62, 64, 66, 69]	[64]				
		Health status	[30, 39-41, 47]	[56]	[32, 35, 38, 44, 46, 48, 51, 53, 59, 66]	[34, 44, 46, 61, 64], [58]*				
		Family size								
	Religion / Culture / Gender	Religious affiliation								
		Cultural								
		Gender/sex	[30, 33]		[42]	[34, 35, 46, 64]				
	Politics / Policies (e.g., Mandates)	Politics								
		Policies							[72]	
	Geographic barriers	Place of residence	[41]		[44, 46, 55, 64]	[44, 64, 81]				

			Quantitative studies				Systematic review		Mixed method and qualitative studies	
	Category	Subcategory	Studies in older adults with chronic medical conditions		Other studies in older adults					
			Enabler	Barrier	Enabler	Barrier	Enabler	Barrier	Enabler	Barrier
	Perception of the pharmaceutical industry	Perception of the pharmaceutical industry								
Individual and social group influences	Experience with past vaccination	Past negative/positive experience or knowledge of someone's experience with vaccination (side effects)								[70]
	Beliefs, attitudes, perceptions and practice/behaviour about health and prevention	Attitude	[47, 57]		[54]					
		Beliefs								
		Receipt of influenza and other vaccines	[33, 40, 45, 49, 77]		[32, 52, 55, 61, 64]					
		Perceived health or responsibility			[48, 62, 66]	[62]				
		Life style or health behaviour			[46, 65]	[34, 46, 65]				[71]
		Perceived social support	[37]							
	Knowledge/awareness of why/where/what/when vaccines are needed	Knowledge/awareness - pneumococcal vaccination or recommendation		[31, 39]*	[55, 58, 68]	[43, 58]*		[73]		
		Knowledge/awareness - general vaccination	[56, 57]							
		Knowledge - General Health								
	Health system and providers - trust and personal experience	Trust/distrust in government/authorities				[54]			[72]	[70]
		System procedures, long or complex								
		Personal interactions								
	Risk/Benefits related to pneumococcal vaccine (perceived/heuristics)	Susceptibility to disease/recent disease experience	[77]				[73]	[73]	[72]	[70, 71]
		Disease severity			[52]					
		Perceived importance of vaccination		[31, 39, 49]*	[55]	[43, 58]*				
		Vaccine safety		[31, 33, 39, 49]*		[58]*				[70, 71]
		Vaccine efficacy/effectiveness		[33]*	[58]	[58]*	[73]			[70]

			Quantitative studies				Systematic review		Mixed method and qualitative studies	
	Category	Subcategory	Studies in older adults with chronic medical conditions		Other studies in older adults					
			Enabler	Barrier	Enabler	Barrier	Enabler	Barrier	Enabler	Barrier
	Immunisation as a social norm vs. not needed/harmful	Need for vaccine - peer group and social norms		[49]*						
Vaccine and vaccination-specific issues	Risk/benefit (scientific evidence)	Evidence of risk/benefit								
		History of safety issues								
	Introduction of a new vaccine or new formulation	Introduction of a new vaccine or new formulation								
	Mode of administration	Mode of administration, injections/shots								
	Design of vaccination program/Mode of delivery	Campaign, distance, hours	[77]			[58]*				[71]
	Vaccination schedule	Schedule (multiple dose or age of vaccination)								
	Reliability and/or source of vaccine supply	Supply								
	Costs	Financial	[77]	[39]*		[58, 63]*	[73]			
		Time				[58]*				
		Administrative								
		Access								
	Role of healthcare professionals on pneumococcal vaccination	Recommending or prescribing vaccine	[39, 45, 49, 56, 77]	[33]*	[52, 58, 68]	[58, 63]*	[73]	[73]	[72]	
		Patient communication - Providing information on vaccination	[47]	[49]*		[63]*				[71]

*Older adult-reported barrier

Table 3: Predictors of pneumococcal vaccination from providers' perspective

	Predictors
Enablers	**Patient characteristics:** Patient's age ≥50 years, ≥60 years or ≥65 years and/or comorbidity or chronic medical conditions [75, 77]
	Providers' attitude and vaccine uptake practice: Healthcare provider's positive attitude or receipt of other vaccines (e.g., varicella zoster vaccine, seasonal influenza vaccine) [76]
	Disease severity: Perceived severity of pneumococcal diseases [75]
Barriers	**Patient characteristics:** Pneumococcal vaccine not for patients aged 50–64 years [77]
	Health behaviour: Other prevention methods (e.g., hand washing, masking, gargling and oral care) were effective enough [77]
	Knowledge: Lack of knowledge on recommendation or vaccine [74, 76, 77]; difficulty in understanding recommended interval between PCV13 and PPV23 [60]
	Contact with patient and perceived responsibility: Less contact with older adult patients, did not feel responsible for vaccination [74]
	Ascertaining patients' vaccination status: Difficulty in determining patient's pneumococcal vaccination history [60]
	Vaccine availability: Lack of vaccine stock at practice
	Lack of interest: Not interested in pneumococcal vaccine, Did not want to spend time on vaccination [77]
	Perceived susceptibility and patient history: Low perceived risk to the patient and lack of a history of pneumonia [77]; pneumococcal disease harmless [74]
	Vaccine safety and efficacy/effectiveness: Concern with vaccine safety [74, 77] and vaccine efficacy/effectiveness [74, 76]
	Peer-group opinion: Other doctors opposed giving the vaccine [77]
	Reimbursement, cost and accounting: Reimbursement did not compensate the effort, accounting was too complicated [74]; Reimbursement of the cost for vaccine purchase not adequate and upfront cost of purchasing PCV13 [60]; pneumococcal vaccine expensive and lack of municipal subsidy [77]
	Insurance coverage: Vaccine not covered by private insurance, Medicaid, Medicare or not covered if appropriate time did not elapse since prior pneumococcal vaccination [60]
	Forgetfulness and patients' choice: Forgetting to advice [74] or deferring to patient's wishes [77]

Figures:

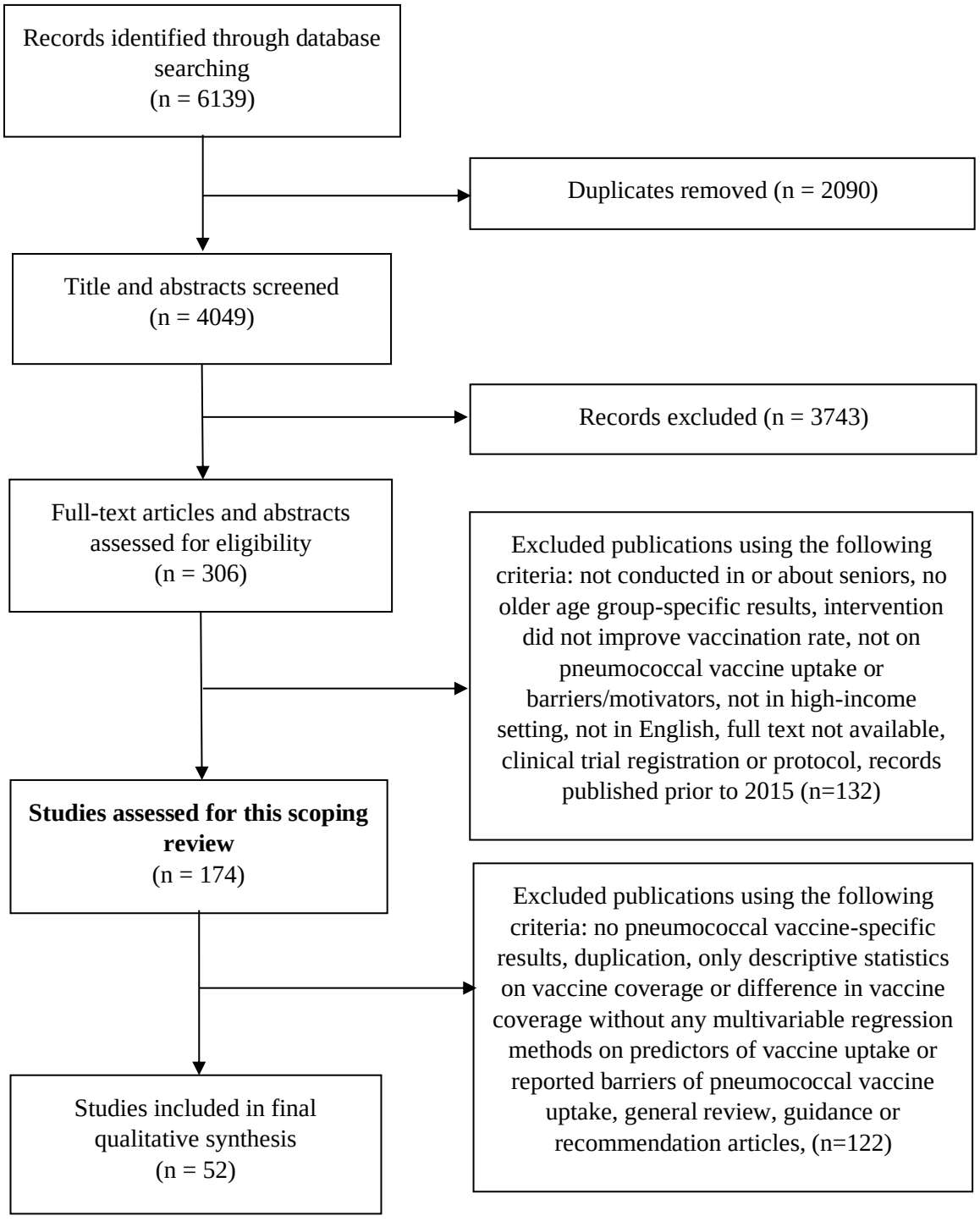

Figure 1. Flow diagram for literature search and study selection

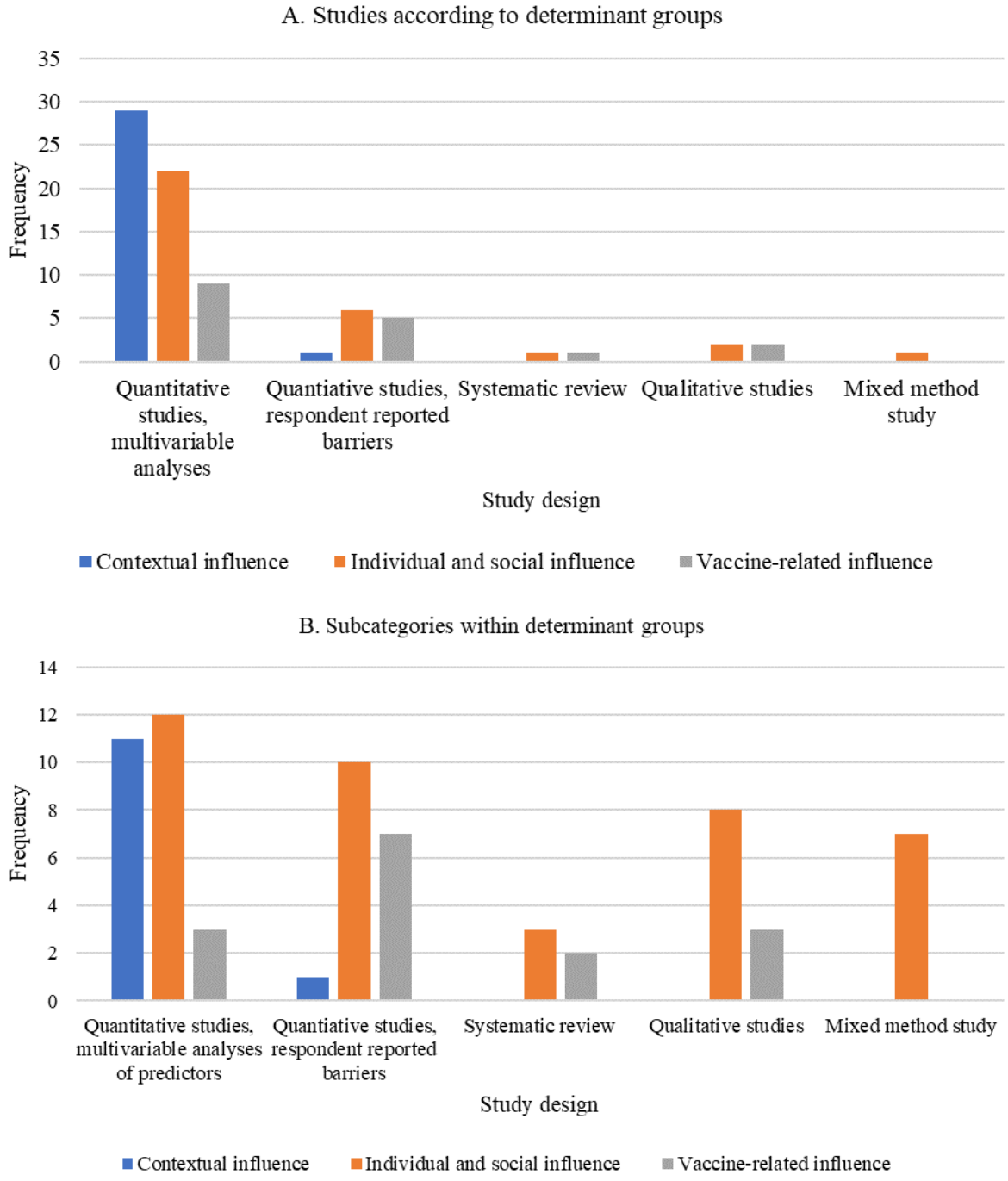

Figure 2A. Studies according to determinant groups 2B. Subcategories of predictors within determinant groups