Journal of Public Health
https://doi.org/10.1007/s10389-023-02103-z

REVIEW ARTICLE

Health-related impacts of climate change and air pollution on older adult, child, and adolescent immigrants and refugees globally: a scoping review

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Received: 12 June 2023 / Accepted: 13 September 2023

Abstract

Aim Climate change and air pollution exposures are global issues impacting human health. This scoping review aims to synthesize evidence on the health-related impacts of climate change and air pollution exposures on immigrant and refugee populations younger than 18 and 65 years and older, and to determine if the impacts are influenced by age, immigrant category, gender, and/or geographical location.

Subject and methods Databases were searched from inception to July 2022 and included PROSPERO, OVID Medline, OVID EMBASE, Wiley Cochrane Library (CDSR and Central), Proquest Dissertations and Theses Global and SCOPUS. All time frames, languages, and geographic locations were included. Types of evidence sources included were reviews (e.g. scoping, systematic, clinical), books, and descriptive (e.g., ecological) and analytical (e.g. case–control, cross-sectional and cohort) studies.

Results Three studies fit the criteria. All used secondary data sources, different study designs and analysis approaches and defined immigrants, refugees, and exposures differently. Only climate change exposures (excessive temperatures) were explored, with mortality and respiratory syncytial virus outcomes. Two articles found that foreign-born and non-US citizens 65 years and older were similarly or less susceptible compared to native-born, but younger individuals were more susceptible. The other found that higher temperatures were associated with higher respiratory syncytial virus incidence in refugee children younger than 5 years old. If stratification was done, only sex, age, race, ethnicity, and place of birth were examined.

Conclusions Immigrants and refugees are understudied in the literature and often excluded. Additional research is needed to determine other exposures and health outcomes for immigrant and refugee populations.

Keywords Immigrant · Refugee · Climate change · Air pollution · Older adult · Adolescent

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Introduction

Climate change and air pollution are interrelated exposures that can directly or indirectly affect human health, including respiratory and cardiovascular diseases (D'Amato et al. 2014; Orru et al. 2017; Peters and Schneider 2021; Dominski et al. 2021). The World Health Organization has called climate change the biggest threat to humanity (World Health Organization 2021). The acceleration of climate change and ambient air pollution is the result of natural emissions and anthropogenic activities, including fossil fuel consumption (Warren and Lemmen 2014). More research is being done on the effects of climate change and air pollution on human health.

Certain populations, including immigrants, may be more susceptible to the effects of these exposures than others (Hathaway and Maibach 2018). The Intergovernmental

Published online: 14 October 2023

Panel on Climate Change defines vulnerability as "the propensity or predisposition to be adversely affected" (Smith et al. 2014). Vulnerability can result from low income, structural and racial inequities, lack of education, poor health, and/or a lack of access to high-quality healthcare (Smith et al. 2014). Upon relocation, immigrants experience social and cultural changes, adjustments to a new language, have a different diet, and are exposed to different values and ways of life (Beiser 2005). Refugees adjust to these same changes but also deal with the added stress of fleeing their home country due to fear for their safety, and the negative effect that migrating has on their mental health (Beiser 2005; Lebano et al. 2020). As a result, refugees have worse health than immigrants and are more vulnerable to certain health outcomes, such as infectious diseases (Beiser 2005). Overall, these factors can increase levels of vulnerability among the immigrant and refugee populations, and can exacerbate the effects of climate change and air pollution exposures. Immigrants have also been found to be exposed to higher levels of fine particulate matter ($PM_{2.5}$), as they tend to settle in urban areas and specifically in areas with higher levels of exposure (Pinault et al. 2017; Erickson et al. 2020). Certain age ranges, including those younger than 18 and older than 65 years old may be more susceptible to certain health outcomes due to physiological reasons (Carnes et al. 2014; Stanberry et al. 2018; Yu and Weitzman 2021). Adolescents and children may experience additional vulnerability due to factors related to immunity, physiology, and cognitive development (Stanberry et al. 2018). Older adults have an increased risk of pre-existing medical conditions (e.g. hypertension, diabetes, etc.), decreased immune systems, often live alone, and have decreased mobility which can affect how their body deals with these exposures, making them more susceptible to health-related impacts (Balbus and Malina 2009; Smith et al. 2014; Kriebel-Gasparro 2022).

Since immigrants and refugees have different experiences than the native-born population, which can impact their health, it is important to include and focus on this population (Erickson et al. 2020). Immigrants and refugees are understudied, particularly recent immigrants, and tend to be excluded in climate change research such as in large cohort studies focusing on air pollution exposures (Erickson et al. 2020). This could be due to numerous factors such as a lack of information on prior exposures, reduced access to the health system, and moving within the new country (Erickson et al. 2020; Ravichandiran et al. 2022). Research can also be more complicated due to a lack of previous known exposures and immigrants and refugees not being captured in databases if they recently immigrated (Erickson et al. 2020). Additionally, they primarily move to urban areas, which have higher temperatures and levels of air pollution compared to rural areas (Erickson et al. 2020). This scoping review aims to examine the literature to determine the health impacts of these exposures on immigrants and refugees, and how it varies among different groups (e.g., age, immigrant category, gender, and/or geographical location). A scoping review was chosen as the field of research on this topic was unknown. While there are studies that focus on the health impacts of climate change and air pollution, it was unclear how or if immigrants have been included in this research topic.

Materials and methods

For this scoping review, framework outlined by the Joanna Briggs Institute Reviewer's Manual was followed (The Joanna Briggs Institute 2015). This framework was first proposed in 2005 by Arksey and O'Malley, and was further refined in 2010 by Levac, Colquhoun and O'Brien (Arksey and O'Malley 2005; Levac et al. 2010; Daudt et al. 2013). The PRISMA-S Checklist for scoping reviews was followed (Tricco et al. 2018).

Research questions

For this study, we aimed to explore previous research on the health-related impacts of air pollution (e.g., NO_2, O_3 and $PM_{2.5}$) and extreme weather (e.g., wildfires, extreme temperatures and floods) exposures on immigrant and refugee populations. We also examined whether studies explored effects by age group (children and adolescents less than 18 or adults 65 years and older), immigrant category (refugee, economic immigrant, immigrant sponsored by family, other), gender (woman vs man or other) or geographical location (rural vs urban locations). Economic immigrants are those that move for economic opportunities, such as a new job (Statistics Canada 2022). We define children and adolescents as those younger than 18, and older adults as those 65 years and older. The protocol was filed on open science framework (https://osf.io/wrfah/?view_only=8366393dbefa45e09d6e22d54ef2ba0c).

For this review, only immigrants and refugees were included. An immigrant was defined as a person who has chosen to leave their country of origin and is or has been a landed immigrant, permanent resident, or citizen through naturalization (Government of Canada 2019; Statistics Canada 2023). A refugee was defined as a person who left their country for safety (Government of Canada 2019). Weather extremes could include several types of exposures such as wildfires, extreme temperatures, and floods. Ambient air pollution is defined as a mixture of air pollutants from vehicles, industries, and households that people are exposed to outdoors (World Health Organization 2022). Air pollution exposures could include NO_2, O_3, and $PM_{2.5}$, among others (World Health Organization 2022). Climate change and air pollution exposures were chosen, as complex

relationships between them can have an impact on human health independently and synergistically. It is important to look at both exposures, as they may particularly impact immigrant and refugee populations globally. Children, adolescents, and older adults are focused on in this scoping review, as immigrants are not a uniform group; some age groups may be more vulnerable to certain health outcomes.

Search methods

A health librarian from the University of Alberta completed a search on six databases using controlled vocabulary (e.g., MeSH, Emtree, etc.) and text word searching. Databases included PROSPERO, OVID Medline, OVID EMBASE, Wiley Cochrane Library (CDSR and Central), Proquest Dissertations and Theses Global, and SCOPUS. Words representing key concepts including "climate change", "air pollution", and "immigrants" were searched (Campbell 2020, Campbell 2021a, b, Campbell 2022a, b, c, d, e, f, g; Dennett and Campbell 2022). Searches were restricted to adults 65 years and older, and children and adolescents younger than 18. Databases were searched from inception to July 2022. Records (2378) were exported to Covidence systematic review software, where duplicates (934) were removed, leaving 1444 for level 1 screening (Veritas Health Innovation 2023). Detailed search strategies are available via Online Resource 1.

Screening

The titles and abstracts of articles were screened using predetermined questions and completed by two independent reviewers. Articles that completely or partly met the inclusion criteria (answered yes or maybe) proceeded to level 2 screening. The complete articles were then screened based on inclusion and exclusion criteria and were completed by two independent reviewers. Any article that completely met the inclusion criteria (answered yes) was included in the results. If any exclusion criteria were identified, it was rejected. Google Translate was used to translate non-English titles and abstracts for screening. The reference lists of relevant articles were analysed by browsing for articles that met the inclusion criteria The types of evidence sources included were reviews (e.g., scoping, systematic, clinical), books, and descriptive (e.g., ecological) and analytical (e.g., case–control, cross-sectional and cohort) studies. All time frames, languages, and geographic locations were included. The studies that focused on any population were considered, as long as immigrants and/or refugees (children and adolescents less than 18 or adults 65 years and older) were also included.

Data extraction and presentation

Data was extracted from each article using Covidence 2.0 data extraction software (Veritas Health Innovation 2023). Fields recommended by JBI for extraction were used and expanded upon (Peters et al. 2020). The full list used for data extraction is provided in Online Resource 2. Data was analysed narratively.

Results

Of the 1444 studies screened at the first stage, 1353 were excluded, leaving 91 for level two full-text screening. Three articles were included in the results (Fig. 1). Table 1 summarizes the characteristics of the three final included articles. Mercereau et al. analysed the difference in temperature mortality between those native to France and foreign-born (Mercereau et al. 2017). Taylor et al. had a similar objective, and explored the risk of heat-related deaths among non-US citizens compared to US citizens (Taylor et al. 2018). Nyoka et al. looked at the relationship between the incidence of respiratory syncytial virus infections and weather, including temperature in refugee children (Nyoka et al. 2017). All the articles were published within a 2-year period, two published in 2017 and one in 2018. Two articles had similar study length periods, both 10 years, with some overlapping years (Mercereau et al. 2017; Taylor et al. 2018). The shortest study period was 5 years (Nyoka et al. 2017). No air pollution studies were included in the results.

While all studies focused on populations of different ages, two of the articles specifically included those aged 65 and older. Mercereau et al. looked at those aged 65 to 85 and those older than 85, and Taylor et al. those 65 years and older (Mercereau et al. 2017; Taylor et al. 2018). Each study defined immigrants and refugees differently, and none included the length of residence in the adopted country. Taylor et al. used the place of residence to define citizenship, as the citizenship status was not available through the National Vital Statistics System (Taylor et al. 2018). If a death occurred in the United States, but the residence was recorded as outside of the country, they recorded them as a non-US citizen (Taylor et al. 2018). It was not specified who was included in the non-US citizen population (e.g., immigrant, refugee). Mercereau et al. used the birthplace of each person to distinguish between those native to France and those foreign-born, obtained from death certificates from the French Epidemiology Center on Medical Causes of Death (Mercereau et al. 2017). Nyoka et al. focused on a refugee population, and recruited from among children who underwent surveillance for viral respiratory illnesses (Nyoka

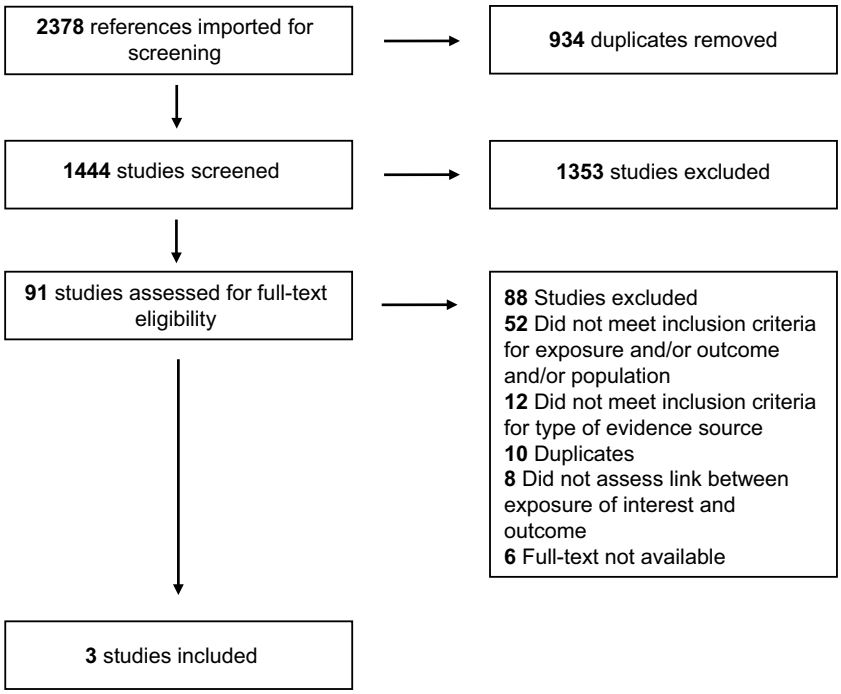

Fig. 1 PRISMA flow diagram

et al. 2017). Data was obtained from surveillance done in the Dadaab refugee camp in Kenya (Nyoka et al. 2017).

All articles used secondary data sources, but each employed a different study design and analysis approach. Nyoka et al. conducted a non-Gaussian time-series with generalized linear and additive models, and Mercereau et al. used a matched-pairs design based on birth date, sex, and the place of death with a generalized additive model (Nyoka et al. 2017; Mercereau et al. 2017). Taylor et al. did not specify the type of study design, but completed descriptive analysis (Taylor et al. 2018). Despite these differences, two of the articles examined mortality as the health outcome, while Nyoka et al. focused on monthly respiratory syncytial virus (RSV) incidence rate (Nyoka et al. 2017; Mercereau et al. 2017; Taylor et al. 2018). Additionally, two articles stratified by age, with Taylor et al. also stratifying risk ratios for heat-related deaths by sex (male vs female) race (white vs other) and ethnicity (Hispanic vs non-Hispanic) (Mercereau et al. 2017; Taylor et al. 2018). Mercereau et al. studied the relationship between temperature and mortality, and stratified by birth region and age (Mercereau et al. 2017). Nyoka et al. investigated the association between RSV incidence and climate, but did not present any stratified results (Nyoka et al. 2017). All articles neglected to stratify by immigrant category.

All three studies examined temperature exposures, but each defined them differently. Mercereau et al. defined a heat wave and a cold spell as "at least the 4th day above the 99th or below the 1st percentile of the local temperature distribution" (Mercereau et al. 2017). Taylor et al. did not formally define excessive heat, but used an ICD-10 code (X30) indicative of mortality due to excessive natural heat (Taylor et al. 2018). Nyoka et al. included the daily mean, minimum, and maximum temperatures (Nyoka et al. 2017).

Study findings

Nyoka et al. focused on refugee children younger than 5 years old in the Dadaab refugee camp (Nyoka et al. 2017), and found that higher temperatures were associated with higher RSV incidence (Nyoka et al. 2017). The other two articles focused on older population ages (Mercereau et al. 2017; Taylor et al. 2018). Mercereau et al. was specifically interested in adaptation to temperature, and hypothesized that if there was little difference in mortality among foreign-born and native-born, this would be indicative of adaptation (Mercereau et al. 2017). They found that between those aged 65 to 85 and those older than 85, there was little difference in the attributable fraction of deaths with exposure to cold and hot temperatures for native-born and foreign-born populations (Mercereau et al. 2017). Additionally, for both native-born and foreign-born populations, those older than 85 years were found to be more sensitive to temperatures compared to those ages 65 to 85 (Mercereau et al. 2017). The only significant difference found was the attributable fraction of death due to cold between those 65 to 85 who were Southern European-born and their matched native-born counterparts in the continental region of France (Mercereau et al. 2017). The authors reported an estimated mortality rate of 8.8% among those who were Southern European-born,

Table 1 Characteristics of the final studies included

Authors	Years of study	Country	Population (type, sample size, age categories)	Gender	Study design	Comparison group	Primary exposure variables	Health outcomes	Main findings
(Nyoka et al. 2017)	September 2007–August 2011	Kenya	Refugee, sample size not specified, ages < 5 years old	Gender not specified	Non-Gaussian time-series	No comparison group	Temperature (daily mean, minimum and maximum temperature)	Monthly RSV incidence rate	Higher temperatures associated with higher RSV incidence
(Mercereau et al. 2017)	2000–2009	France	Population type not specified (foreign-born), sample size 573,384, all ages, 0–65 (unclear if this category includes those aged 65), 65–85 and > 85	Gender not specified	Matched pairs design	Native-born	Heat and cold (Heat wave: at least the 4th day above the 99th percentile of the local temperature distribution, Cold spell: at least the 4th day below the 1st percentile of the local temperature distribution)	Mortality	Similar attributable fraction of deaths in cold/hot temperatures for native-born and foreign-born for ages 65–85 and > 85. Foreign and native-born > 85 found to be more sensitive to temperatures
(Taylor et al. 2018)	2005–2014	United States	Population type not specified (non-US citizens), sample size 999, ages < 5, 5–17, 18–24, 25–44, 45–64 and ≥ 65	Men and women	Not specified	US citizens	Excessive heat (defined heat -related deaths with ICD-10 code X30 [exposure to excessive natural heat] as underlying cause of death)	Mortality	Non-US citizens ≥ 65 years old had a lower risk of mortality compared to US citizens of the same age. Non-US citizens ages 5–17 had a higher risk compared to US citizens of the same age

and 5.3% among the native-born populations. It was also found that overall, there was a higher percentage of deaths attributable to cold compared to heat, with those older than 85 affected more than those ages 65 to 85 (Mercereau et al. 2017). Taylor et al. also investigated if non-US citizens had higher heat-related mortality rates compared to US citizens (Taylor et al. 2018). Non-US citizens ages 65 years and older had a lower risk of heat-related deaths compared to US citizens of the same age [RR = 0.2 (0.1, 0.4)] (Taylor et al. 2018). It was also found that non-US citizens aged 5 to 17 had a higher risk of heat-related deaths compared to US citizens of the same age (15.6 times more likely). White [RR = 6.2 (5.8, 6.7)] and Hispanic [RR = 3.6 (3.2, 3.9)] non-US citizens were found to be at a higher risk for heat-related death compared to US citizens (Taylor et al. 2018).

Discussion

Health impacts of climate change exposures in immigrant populations

Three articles were included in the results, among two of the articles, it was found that for older foreign-born and non-US citizens (65 and older and 65 to 85) there was little difference or lower risk of mortality when compared to native-born (Mercereau et al. 2017; Taylor et al. 2018). Conversely, mortality from excessive heat exposure among younger non-US citizens ages 18 to 24 was found to be higher (Taylor et al. 2018). This may be due to younger non-US citizens having higher risk jobs such as farming, compared to older non-US citizens (Taylor et al. 2018). This is supported by the fact that 19.8% of non-US citizens' place of death was recorded as a farm (Taylor et al. 2018). It was not certain what led to the difference in older immigrants, with certain factors such as health, and occupation or cultural differences, hypothesized as having a role (Taylor et al. 2018). A study in France hypothesized that individuals become adapted to weather conditions in their adopted countries, which could also help explain these results (Mercereau et al. 2017). This is contradicted by one significant finding, the attributable fraction of death due to cold in those aged 65 to 85 in the continental region of France was higher in Southern European-born compared to the native-born population (Mercereau et al. 2017). Southern Europe includes countries with warmer climates, such as Greece, Italy, and Spain, which all have mild winters. Comparatively, France has a temperate climate and can have cold winters. This does not support the adaptation of individuals to weather conditions in their adopted countries, it suggests that those born in Southern Europe may not become adapted to colder weather. This suggests that those who move from hot to cold climates may not have the same adaptation to weather conditions as those who move from cold to hot, or from a similar climate. This was not observed for those ages 65 to 85 born in Maghreb (Mercereau et al. 2017). It was also found that overall more deaths were attributed to cold compared to heat (Mercereau et al. 2017). This may be due to factors such as a lack of education about cold winters resulting in unsuitable winter clothing (Shor and Roelfs 2019). It has even been suggested that vitamin D deficiency may also be an issue for those moving from warm to cold climates (Shor and Roelfs 2019). Mercereau et al. found that those older than 85 were more affected by cold temperatures than those aged 65 to 85 (Mercereau et al. 2017). This is expected, as older adults may be more susceptible to cold temperatures (Young and Lee 1997). Additionally, generally older adults have worse health compared to those who are younger, due to pre-existing medical conditions (e.g., hypertension, diabetes etc.), decreased immune systems, and decreased mobility, which can all increase susceptibility to certain diseases (Balbus and Malina 2009; Smith et al. 2014; Kriebel-Gasparro 2022). Differences were found among study designs, analysis approaches, and in terms of how results were stratified. These differences may be due to the different data sets used, with each article obtaining population data from different sources. If immigrant data is available, it seems that certain factors of interest are not, which limits what can be studied, resulting in a lack of stratified data.

This review identified one study that associated higher RSV incidence in children younger than 5 years old with higher temperatures (Nyoka et al. 2017). It is important to note that overcrowding may also have played a role (Ahmed et al. 2012; Somo et al. 2021). Crowding issues have led to camps being set up on the perimeters of Dadaab (Somo et al. 2021). Other studies have pointed to the detrimental impact of refugee camps on child health, Colosia et al. found that overcrowding was associated with a higher risk of RSV hospitalization for infants and children due to a higher chance of being exposed to the virus through droplets or secretions (Colosia et al. 2012). Crowded conditions can also lead to other disease outbreaks, as in 2015 when the Dadaab refugee camp experienced a cholera outbreak (Golicha et al. 2018). Another potential factor is that individuals in refugee camps may experience poor living conditions, malnutrition, and lack of access to appropriate care, which can also increase the incidence of disease (Ahmed et al. 2012).

No articles analysing the health-related impacts of air pollution exposures (e.g., NO_2, O_3, and $PM_{2.5}$) on immigrants were included in the results of this scoping review, but still are an important exposure. This may, in part, be due to a lack of pre-immigration exposure data or other missing data, particularly if they recently immigrated (Taylor et al. 2018; Erickson et al. 2020). A number of studies have looked at air pollution and immigrant health, which showed that immigrants were found to be exposed to higher levels

of $PM_{2.5}$ but had lower mortality rates compared to non-immigrants (Brauer et al. 2019; Pappin et al. 2019; Christidis et al. 2019). This may be due in part to the screening process that is conducted prior to admission to Canada (healthy immigrant effect) (Brauer et al. 2019; Pappin et al. 2019; Christidis et al. 2019). Due to the vulnerability of children, adolescents, and older adults, further research is required to examine the impacts of air pollution on these age-specific migrant populations.

Limitations

While a comprehensive search was conducted, any articles that did not include the chosen keywords could have been missed. We also did not complete a quality assessment of the evidence, and instead focused on an exploration of the available research focused on climate change, air pollution and older adult, child and adolescent immigrant, and refugee health. Two independent reviewers completed the screening process, though only one completed the data extraction. However, the data extraction table was discussed and vetted by the other authors. While library databases were used to access articles for full-text screening, six full-text studies were not found. Additionally, as populations in low-income countries develop chronic diseases earlier than high-income countries, a broader definition of older adults (e.g., 50 or over) could be warranted. Lastly, there were papers that met most of the screening criteria but were excluded as age ranges were grouped.

Conclusions and gaps in the literature

This scoping review highlighted potential differences in health impacts related to climate change exposures in immigrant and refugee populations. However, there is a lack of research in this area. As a result of this study, several gaps in the literature were identified, including the lack of stratified results. If results were stratified by age, for example, they tended to be grouped into large age ranges, and key information such as the length of residence was not provided or considered. Data sources might have limited the availability of these factors in these analyses. Immigrant populations are heterogeneous and grouped results might obscure important differences. Vulnerability to climate change and air pollution exposures is probably different in populations 65 years and older and under 18 years old, and should be studied separately (Balbus and Malina 2009; Stanberry et al. 2018). Geographical gaps were also found. As exposures vary by geographical region, this is an important gap. Immigrants and refugees were often not the focus of the study, but a subgroup analysis. Many studies that included immigrants also excluded recent immigrants who had been in the country for less than 10 years. Studies tended to focus on temperature-related exposures. Other climate change-related exposures such as floods or wildfires did not appear as frequently in the literature, and none were included in this review. Additionally, given that each paper defined temperature exposures differently, it would be beneficial to establish a standardized definition. No air pollution studies met our inclusion criteria. The health outcomes examined were narrow and focused on mortality. A focus on other health outcomes is needed. These gaps highlight the need for further focused research on immigrant and refugee populations, particularly children, adolescents, and older adults.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10389-023-02103-z.

Author contributions Brooke T. Sidney had the idea for the article, and Shelby S. Yamamoto helped refine the research question. Sandra M. Campbell performed the literature search. Brooke T. Sidney and Shubham Chandras completed the screening process. Brooke T. Sidney completed the data extraction and drafted the scoping review. Brooke T. Sidney, Shelby S. Yamamoto, Jordana Salma, Shubham Chandras, and Sandra M. Campbell critically revised the work.

Funding Provided by the Public Health Agency of Canada: Enhanced Surveillance for Chronic Disease Program (2021-HQ-000108).

Data availability Not applicable.

Code availability Not applicable.

Declarations

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests All authors have no competing interests to declare.

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