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Vaccination coverage among migrants: A systematic review and meta-analysis

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Abstract
Background: Migrants, a population vulnerable to communicable diseases, face multiple barriers in access to immunization programs. Individual studies suggest that they suffer immunization inequity compared to non-migrants, but the gap in vaccination has not been quantified. This systematic review assessed quantitatively the level of vaccination coverage among migrants, in comparison with non-migrants, collating the published literature.
Methods: Review protocol was prospectively registered (PROSPERO CRD42021228061). A literature search without language restrictions was conducted in PubMed, Scopus and Web of Science, from database inception to February 2021. This review included observational studies that provided the vaccination rates among migrant and non-migrant groups. Study quality was assessed using Newcastle-Ottawa scale. Data were synthesized pooling data from individual studies to generate summary odds ratio (OR) with 95% confidence interval (CI) using random effects model, assessing heterogeneity with I^2 statistic and publication bias with funnel asymmetry analysis.
Findings: There were 44 relevant studies (7,937,996 participants). Overall risk of bias was low in 13 (30%), moderate in 22 (50%) and high in 9 (20%) studies. Point estimates of individual ORs showed lower vaccination coverage among migrants in 36 of 39 meta-analyzable studies. Overall, the odds of vaccination coverage among migrants were lower compared to non-migrants (7,375,184 participants; summary OR 0.50; 95% CI 0.37–0.66; I^2 99.9%). There was no funnel asymmetry.
Interpretation: Migrants are half as often vaccinated compared to non-migrants. Public health prevention programs need to prioritize vaccination equity, not just to protect migrants but also to protect the host communities.

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PALABRAS CLAVE
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Cobertura de vacunación entre migrantes: una revisión sistemática y metaanálisis

Resumen

Antecedentes: Los migrantes, una población vulnerable a enfermedades transmisibles, se enfrentan a múltiples barreras en el acceso a los programas de inmunización. Estudios individuales sugieren que este colectivo poblacional sufre desigualdad en la cobertura de inmunización, en comparación con población no migrante; sin embargo, hasta el momento no se ha cuantificado la brecha en la cobertura de vacunación. Esta revisión sistemática evaluó cuantitativamente el nivel de cobertura de vacunación entre los migrantes, en comparación con los no migrantes, recopilando la literatura publicada.

Métodos: El protocolo de revisión fue registrado prospectivamente (PROSPERO CRD42021228061). Se realizó una búsqueda de literatura sin restricciones de idioma en PubMed, Scopus y Web of Science, desde el inicio de las bases de datos hasta febrero de 2021. Esta revisión incluyó estudios observacionales que proporcionaran coberturas de vacunación entre grupos de migrantes y no migrantes. La calidad de los estudios se evaluó mediante la escala Newcastle-Ottawa. Los datos se sintetizaron y se extrajeron los valores de *odds ratio* (OR) e intervalo de confianza (IC) del 95%, utilizando un modelo de efectos aleatorios para cada uno de los estudios incluidos. Finalmente, se evaluó la heterogeneidad de los mismos con la prueba estadística de I^2 y, el sesgo de publicación con el análisis de asimetría de embudo.

Resultados: Hubo 44 estudios relevantes (7.937.996 participantes). El riesgo de sesgo fue bajo en 13 (30%), moderado en 22 (50%) y alto en nueve (20%) estudios. Las estimaciones puntuales de las OR individuales mostraron una menor cobertura de vacunación entre los migrantes en 36 de 39 estudios metaanalizables. En general, las probabilidades de cobertura de vacunación entre los migrantes fueron menores, en comparación con los no migrantes (7.375.184 participantes; OR resumen 0,50; IC 95%: 0,37-0,66; I^2 99,9%). No hubo asimetría de embudo.

Interpretación: Los migrantes se vacunan la mitad de veces que los no migrantes. Los programas de prevención en salud pública deben priorizar la equidad en la vacunación, no solo para proteger a los migrantes, sino también a las comunidades nativas de acogida.

Introduction

The migratory phenomenon has increased considerably with approximately 272 million people residing outside their country of birth.[1] Migrants may be relatively healthy upon arrival in a new country,[2,3] but they tend to become vulnerable with a higher risk of contracting infectious diseases.[4] Thus, they are considered a priority group for prevention and control.[5–7] Access to health services is one of the challenges faced by migrants in their host countries.[8–10] This is a particular issue with respect to immunization programs.[1] In their countries of origin vaccination coverage may have been affected by factors such as interruption of immunization services,[11] low socioeconomic status, and poor level of knowledge and awareness.[10,12] Providing vaccination services to this vulnerable population is crucial, not just to protect migrants but also to protect the host communities.[13]

Previous systematic reviews have suggested that migrant groups generally experience lower immunization rates,[13–15] but they have several limitations according to evidence synthesis quality assessment tools.[16] One of the reviews[14] applied language restrictions, risking overlooking relevant publications. Other reviews had geographical limitations, in one focusing on Europe[13] and in another on three low-income and middle-income countries.[15] A comprehensive systematic review of the worldwide literature is required.

Given the above background, the objective of this systematic review was to quantitatively determine the level of vaccination coverage among migrants compared to non-migrants, collating the published observational studies.

Methods

The protocol of the systematic review was prospectively registered (registration number CRD42021228061; www.crd.york.ac.uk/PROSPERO). We followed MOOSE reporting guideline.[17]

Search strategy and study selection

Bibliographic searches were carried out in PubMed, Scopus and Web of Science databases, without language or publication date restrictions from inception to February 2021. The search term combination was: ((vaccin*) OR (immuniz*) OR (immunis*)) AND ((coverage) OR (uptake) OR (access) OR (accept) OR (choice) OR (agreed)) AND ((migrant) OR (immigrant) OR (refugee) OR (asylum seeker*) OR (foreign

born) OR (newcomer) OR (newcomer)) AND ((non-migrant) OR (indigenous) OR (native)) OR (locally born)). Reference lists of previous reviews were collated. All citations found were exported to Mendeley, where duplicates were removed.

Initially, the titles and abstracts of the articles were examined and those that met the following requirements were included: comparison of migrants with non-migrants, vaccination coverage for both groups, and observational study design. Studies without quantitative results were excluded. To address citations and articles published in languages other than English and Spanish we used translation by online means. One reviewer screened the titles and abstracts, and evaluated the full text of the articles to select studies to be included in the review. All study eligibility decisions were double checked by another reviewer and any disputes resolved by discussion or arbitration by the third reviewer.

Data extraction and study quality assessment

Data were extracted and the quality of the selected articles was assessed. The information extraction was recorded in Microsoft Excel, including the following parameters: Author, publication year, study year, location, study design, sample size, population and vaccine. Migrants were people who had moved from their country of birth to another country. Non-migrants were native or indigenous people of the host country. Some studies reported findings for several migrant groups. To assess risk of bias, quality of the studies was assessed with a modified Newcastle-Ottawa scale.[18] The following quality aspects were evaluated: Selection (representativeness of the sample, sample size, non-respondents or losses and ascertainment of the exposure); comparability (control for potential confounders); and, outcome (assessment of outcome and statistical testing). Overall score was calculated ranging from 0 to10 points and classified for risk of bias as follows: low 7–10 points; moderate 5–6 points; and high 0–4 points. Studies were not excluded from the review on the basis of quality.

Data synthesis

From the numerical data reported, we constructed 2 $\times$ 2 tables of vaccine coverage among migrants and non-migrants for each vaccine individually per study. The point estimates of all the crude odds ratios (OR) were plotted. From each study a single 2 $\times$ 2 table with the largest total sample, the largest number of doses, and the smallest difference in vaccine coverage was selected for meta-analysis to maximize precision and to produce the most conservative estimate of the association. Where data for more than one type of migrant groups were reported in a study, we used the most vulnerable group for comparison with non-migrants. We assessed heterogeneity using I^2 statistic and applied random effects model for pooling results to generate summary OR with 95% confidence interval (CI).[19] We assessed for publication and related biases using funnel asymmetry analysis.[20]

Results

The search yielded 401 citations. After removal of duplicates, 298 citations remained for title and abstract screening. We excluded 170 citations that did not meet the selection criteria, leaving 128 studies for review of full-text articles. Forty-four studies with 7,937,996 participants were eligible (Fig. 1).

Study characteristics and quality

The study characteristics are given in Table 1. Of the 44 studies, 16 (36%) were from the USA, 8 (18%) from Spain, 3 (7%) from the UK, 3 (7%) from Denmark, 2 (5%) from Germany and the rest were conducted in Australia, Israel, Italy, Lebanon, Mayotte Island, New Zealand, Portugal, Norway, Republic of Korea, France, Greece and European Union. Thirty-eight studies (87%) were cross-sectional, five (11%) were cohort and one (2%) was a case-control in design. Sample sizes ranged from 70 to 5,245,238 participants. Fig. 2 and Appendix 1 show study quality details. Overall risk of bias was low in 13 (30%), moderate in 22 (50%) and high in 9 (20%) studies.

Quantitative data synthesis

Five articles did not have enough information to construct the 2 $\times$ 2 table (Fig. 1). Appendix 2 contains the details of the data tables. The meta-analysis was based on 39 studies. Together these studies comprised data on a total of 7,375,184 participants of whom 6,449,102 (87%) were non-migrants and 926,082 (13%) were migrants. Point estimates of individual ORs showed lower vaccination coverage among migrants in 36 studies as shown in the forest plot in Fig. 3. The meta-analysis produced a summary OR of 0.50 (95% CI: 0.37–0.66). There was a high level of heterogeneity with an I^2 value of 99.9% (chi-square test for heterogeneity $X^2 = 22.96$, df = 1, $P < 0.0001$). Appendix 4 shows the funnel plot, where there was no funnel asymmetry (Egger's test $P = 0.0511$).

Discussion

This meta-analysis, the first of its kind to our knowledge, quantified the relationship between vaccination coverage and migration status. The quality of the included studies was diverse, predominantly moderate. A wide range of vaccinations were covered in the included studies. High level of heterogeneity was found in the pooled results, though the majority of the studies showed lower vaccination coverage among migrants. This is probably related to the different vaccination policies among the countries included in the review. Our findings showed that migrants were half as often vaccinated compared to non-migrants, so vaccination coverage related to migrant status should be an important public health issue. This is crucial for the current vaccination campaign in the coronavirus pandemic era worldwide.

This systematic review and meta-analysis followed a robust methodology so as to attempt to reduce the

Table 1 Characteristics of studies included in the review of vaccination coverage among migrants.

No.	Author, publication year	Year of study	Location	Study design[a]	Sample size	Population	Vaccine[b]
1	Adjei et al., 2019	2014–2017	United States	Cross-sectional	14,056	Men aged 18 to 34 years	HPV[b]
2	Agénor et al., 2018	2011–2015	United States	Cross-sectional[a]	15,502	Aged 18–65 years	HPV[b]
3	Astray et al., 2016	2011–2014	Spain	Cross-sectional[a]	43,849	≥16 years	Influenza
4	Borràs et al., 2007	2003–2004	Spain	Cross-sectional	630	<3 years	DTP[b]/OPV [b]/Hib[b]/ MenC[b]/MMR[b]
5	Charania et al., 2018	2006–2015	New Zealand	Cohort	692,919	<5 years	MMR[b]/PCV[b]/RV[b]/ Pneumococcal
6	Dallo et al., 2015a	2000–2011	United States	Cross-sectional[a]	91,636	Non-hispanic White men ≥18 years	Pneumonia/Flu
7	Dallo et al., 2015b	2000–2011	United States	Cross-sectional[a]	117,893	Non-hispanic White women ≥18 years	Pneumonia/Flu
8	De et al., 2017	2013	United States	Cross-sectional	34,557	<26 years	HPV[b]
9	Fabiani et al., 2016	2012–2013	Italy	Cross-sectional	42,048	Residents (≥18 years) at risk for influenza-related complications and with free access to vaccination	Influenza
10	Fernández et al., 2016	2012–2013	Denmark	Cohort	274,154	Women aged 19–28 years	HPV[b]
11	Guthmann et al., 2013	2005–2010	France	Cross-sectional	425	Aged 0–5 years	BCG[b]
12	Healy et al., 2018	2012–2014	United States	Cross-sectional[a]	58,090	Aged 13–17 years	DTP[b]/MenACWY[b]/ HPV [b]/MMR[b]/ Hep B[b]/VAR[b]
13	Hertzum-Larsen et al., 2020	Not clear	Denmark	Cohort	260,251	Girls born from 1996 to 2003	HPV[b]
14	Jain et al., 2018	2013–2015	United Kingdom	Cohort	35,333	Aged 70–79 years	Zoster
15	Jiménez et al., 2008a	2004–2005	Spain	Cross-sectional	7341	≥16 years	Influenza
16	Jiménez et al., 2008b	2003–2006	Spain	Cross-sectional[a]	38,329	≥6months	Influenza
17	Jiménez et al., 2014a	2011–2012	Spain	Cross-sectional	5,245,238	All residents ≥15 years registered in the public health system	Influenza

Table 1 (*Continued*)

No.	Author, publication year	Year of study	Location	Study design[a]	Sample size	Population	Vaccine[b]
18	Jiménez et al., 2014b	2008–2012	Spain	Cross-sectional	43,072	≥16 years	Influenza
19	Joseph et al., 2012	2008–2009	United States	Cross-sectional[a]	70	Girls aged 11–17 years	HPV[b]
20	Kamimura et al., 2015	2014	United States	Cross-sectional	389	Female aged 23–65 years	HPV[b]
21	Karki et al., 2016	2012–2013	Australia	Cross-sectional[a]	76,040	≥49 years	Influenza
22	Kyrka et al., 2009	2006–2007	Greece	Cross-sectional	1383	Aged 0–14 years	Hep A[b]
23	Levy et al., 2010	2001–2004	United States	Cross-sectional	1502	Men aged 18–35 years	Hep B[b]
24	Lu et al., 2014	2012	United States	Cross-sectional[a]	34,525	≥18 years	Influenza/ Pneumococcal/Tetanus/ Hep A[b]/Hep B[b]/Herpes/HPV[b]
25	Mansour et al., 2019	2016	Lebanon	Cross-sectional[a]	9315	Aged 12–59 months	Hep B[b]/IPV[b]/DTP[b]/Hib[b]/MCV[b]/RCV[b]
26	McElfish et al., 2020	2014	United States	Cross-sectional	4879	Aged 18–26 years	HPV[b]
27	Mikolajczyk et al., 2008	2004–2005	Germany	Cross-sectional[a]	1481	Pre-school children	MMR[b]/Hep B[b]
28	Moller et al., 2016	1996–2012	Denmark	Cohort	116,907	Children	MMR[b]/DTP[b]/IPV[b]
29	Moran et al., 2017	2012–2013	United States	Cross-sectional[a]	1565	Hispanic female aged 21–50 years	Influenza
30	Pascal et al., 2021	2019	Mayotte Island	Cross-sectional[a]	162	No description	Mandatory
31	Pérez et al., 2018	2011–2015	United States	Cross-sectional[a]	39,761	Men aged 18 to 32 years and women aged 18–35 years	HPV[b]
32	Perry et al., 2020	2014–2017	United Kingdom	Cross-sectional[a]	56,861	Children aged 5–16 years	MCV[b]/Tetanus/Men C[b]

Table 1 (*Continued*)

No.	Author, publication year	Year of study	Location	Study design[a]	Sample size	Population	Vaccine[b]
33	Poethko-Muller et al., 2009	2003–2006	Germany	Cross-sectional[a]	14,826	Aged 0–17 years	Measles
34	Riise et al., 2015	2010–2012	Norway	Cross-sectional[a]	63,382	Aged <2 years	Complete series
35	Rodríguez et al., 2011	2005–2010	Spain	Cross-sectional	51,666	≥16 years	Influenza
36	Rosano et al., 2017	2008, 2011–2014	European Union	Cross-sectional[a]	151,311	≥65 years	Flu
37	Shaaban et al., 2019	2014	Portugal	Cross-sectional	18,165	≥15 years	Flu/Tetanus
38	Song et al., 2015	2012	Republic of Korea	Case control	1878	≥19 years	Influenza
39	Taylor et al., 2019	2013–2015	United Kingdom	Cross-sectional	346	>16 years	Hep B[b]
40	Varan et al., 2017	2010–2012	United States	Cross-sectional[a]	52,441	Aged 19–35 months	DTP[b]/IPV[b]/Hep A[b]/ Hep B[b]/ Hib[b]/MCV[b]/MMR[b]/ PCV[b]/RV[b]/VAR[b]
41	Vilajeliu et al., 2015	2008–2013	Spain	Cross-sectional	22,681	Pregnant women	Rubella
42	Wershof et al., 2013	2004–2009	Israel	Cross-sectional	136,944	≥65 years	Pneumococcal/ Influenza
43	Williams et al., 2016	2014	United States	Cross-sectional[a]	32,296	≥19 years	Influenza/ Pneumococcal/Tetanus/Tetanus + pertussis Hep A[b]/Hep B[b]/Herpes zoster/HPV[b]
44	Williams et al., 2017	2015	United States	Cross-sectional[a]	31,897	≥19 years	Influenza/ Pneumococcal/Tetanus/Tetanus + pertussis/Hep A[b]/ Hep B[b]/Herpes zoster/HPV[b]

[a] Studies without reporting of specific design; design assigned by reviewers.

[b] HPV: human papillomavirus vaccine. DPT: diphtheria–tetanus–pertussis vaccine. OPV: trivalent oral polio vaccine. Hib: hemophilus influenzae type b. Men C: meningococcal serogroup C vaccine. MMR: measles–mumps–rubella. PCV: pertussis-containing vaccine. RV: rotavirus vaccine. BCG: Bacillus Calmette–Guérin vaccine. MenACWY: quadrivalent meningococcal conjugate vaccine. Hep B: hepatitis B. VAR: varicella vaccine. Hep A: hepatitis A. IPV: poliovirus vaccine. MCV: measles vaccine. RCV: rubella-containing vaccine.

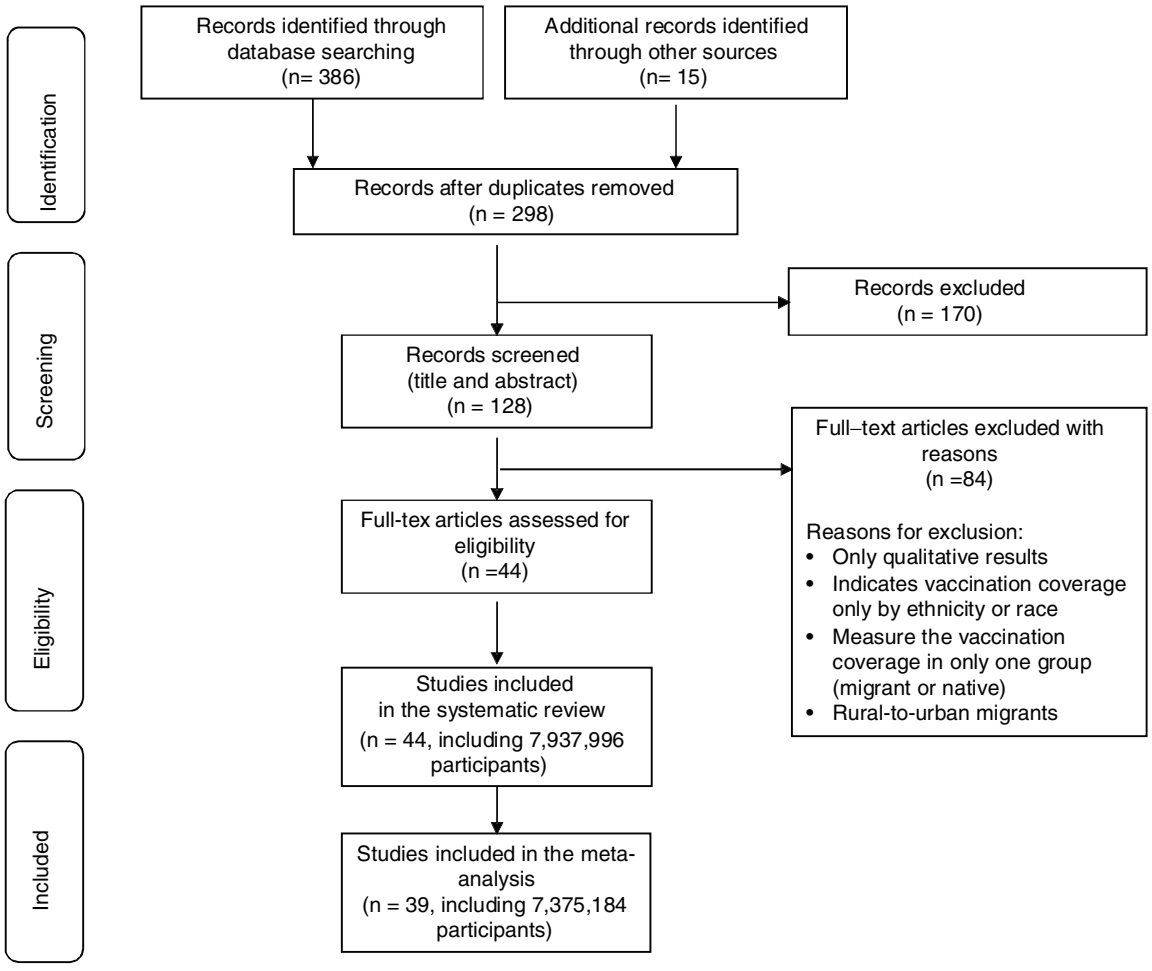

Figure 1 Flow chart of study selection in the review of vaccination coverage among migrants.

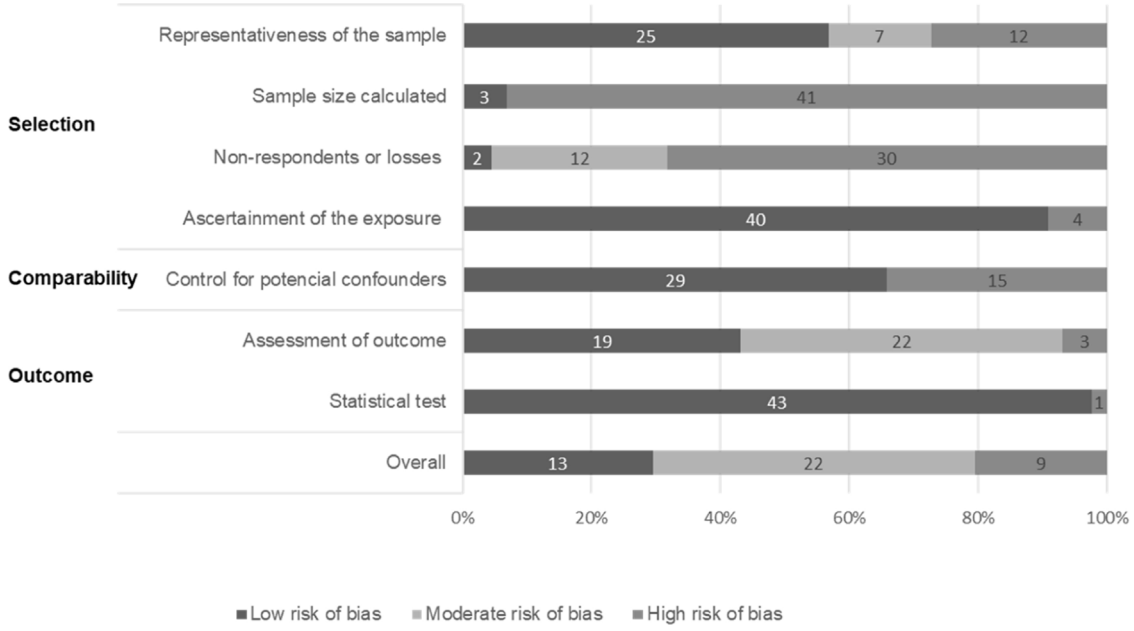

Figure 2 Quality assessment of the studies included in the review of vaccination coverage among migrants, using Newcastle-Ottawa scale (numbers in bars are numbers of studies).

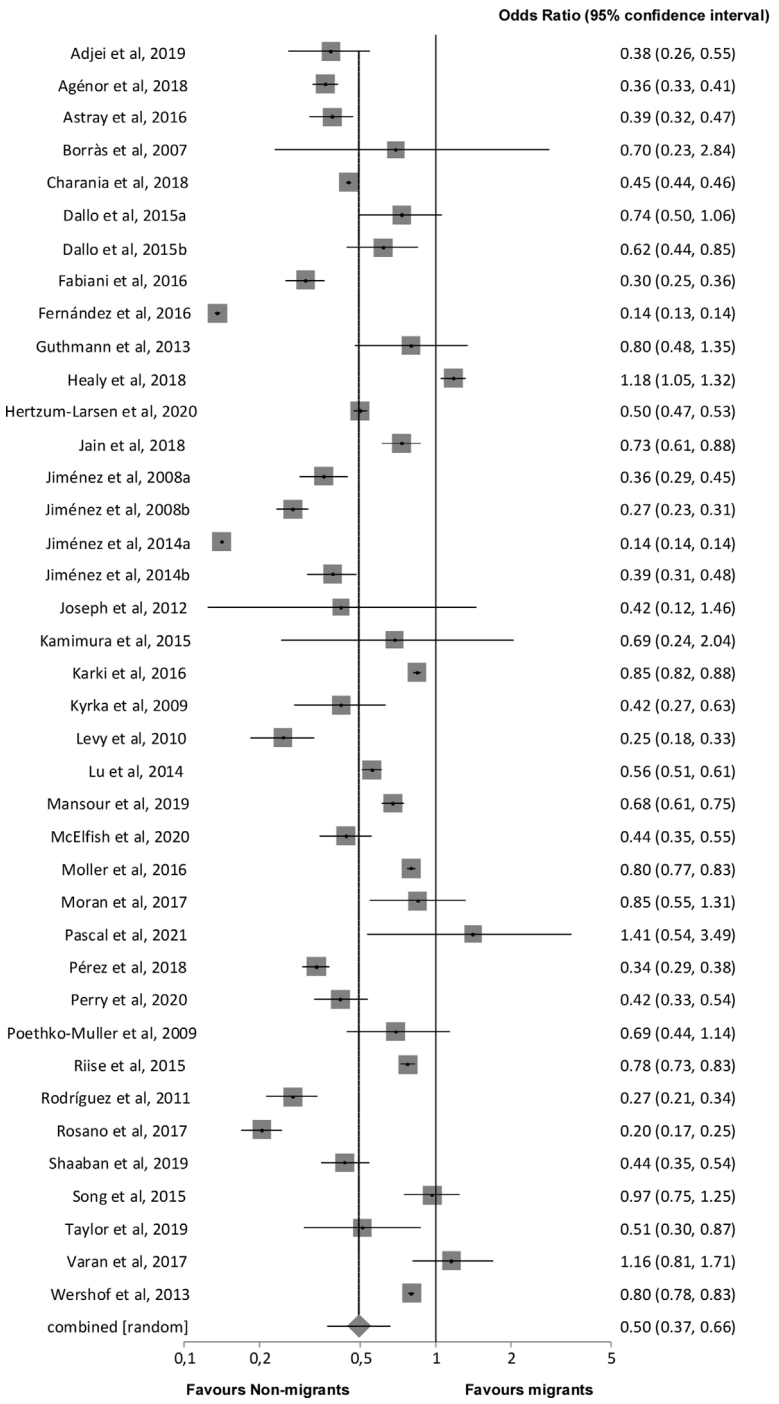

Figure 3 Random-effects meta-analysis of vaccination coverage among migrants compared to non-migrants.

possibility of various forms of errors and biases. The global search without language and date restrictions yielded sufficient numbers of studies with a high number of participants to facilitate precise estimation of the association. Although contact with authors or migrant organizations may have led to further information, the summary result was reliable with narrow confidence interval. However, one perceived limitation of this study may be related to the fact that there is no universally accepted definition of a migrant at the international level. The lack of clarity about this general term leaves the interpretation somewhat open, generating issues in generalizability of our findings. With respect to the observed heterogeneity, it's possible that legal migrants as well as some specific ethnic or racial groups may have been over-represented in the exposure group. However, the heterogeneity observed represented differences in size of the association with migratory status rather than differences in direction of the association. This type of heterogeneity may be unavoidable, and given the large size of association our observation merits careful

consideration. Regarding the designs included, the studies were largely cross-sectional self-report surveys, which may have been susceptible to nonresponse bias and recall bias.[22] There is no standardized way to measure the vaccination coverage, and medical records reviews may be more accurate. Self-reported coverage may overestimate the coverage of vaccination records,[23] and validity of the comparisons may be affected by sociodemographic variables such as age, gender or migratory status.[21] In case of differential reporting related to migratory status, there is a risk of bias in the observed findings. However, in our view, the size of the summary result obtained and its precision provides protection against a spurious conclusion.

The results of our meta-analysis are in accordance generally with the previously published narrative reviews.[13–15] Moreover, we were able to quantify the extent to which migrant groups experience lower immunization rates than native-born groups in the evidence collated without geographic restriction. Thus our review provides the current best quantitative evidence synthesis, and it underpins the needs for public health prevention programs to prioritize vaccination equity. In addition, health workers must develop skills and knowledge for the care of immigrants, in order to successfully face the cultural, language and medical differences of this population.[24] At this time as we vaccinate against coronavirus, immunization program planning needs to focus on vaccinating migrants, something that will be crucial for the benefit of the entire population.[13]

In conclusion, migrants are significantly less often vaccinated compared to non-migrants, and public health prevention programs need to prioritize vaccination equity.

Contributors

All authors contributed in the conception of the research question and designed the study. MR did the literature search, study selection and data extraction, and double checked by NC. MR and KK did the statistical analysis. The figures, tables and appendices were designed by MR and KK. All authors contributed to the drafts and final version of the manuscript.

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Conflict of interest

All other authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.semerg.2021.10.008

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