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Review

Hepatitis B vaccination initiation and vaccination series completion: An in-depth systematic evidence review, with meta-analysis of associations with individual socioeconomic and health-related factors.

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A B S T R A C T

Background: Associations between hepatitis B vaccination and individual socioeconomic/health-related factors have not been summarised.
Methods: We conducted a systematic review with meta-analysis (PROSPERO: CRD42023445721) wherein we grouped study populations into a paediatric population (<18-year-olds), community-dwelling adults (≥18-year-olds of average risk), persons at a higher risk of exposure, and persons with a chronic condition(s). We pooled appropriate multivariable-adjusted results using an inverse variance random-effects model, with the pooled results expressed as odds ratios and associated 95% confidence intervals.
Results: We included 83 cross-sectional studies. Thirty-nine studies reported on vaccination initiation, and 51 reported on vaccination series completion. In the paediatric population, being a child of an Asian versus White mother increased the odds of vaccination initiation, whereas a low versus high mother's socioeconomic status and birth in a health facility versus home birth increased the odds of vaccination series completion. In community-dwelling adults, there were increased odds of vaccination initiation with being younger, a White versus Black/Hispanic person, a health professional, higher education, HIV/hepatitis B screening, influenza vaccination in the past year, health insurance, and health care utilisation. There were increased odds of vaccination series completion with factors like initiation. In persons at a higher risk of exposure, older age, higher education, HIV/hepatitis B screening, influenza vaccination in the past year, being married/cohabiting, and training on infection increased the odds of vaccination initiation. In contrast, drug use, HIV/hepatitis B screening, being married/cohabiting, being female, being a current/former smoker, and having more health worker experience increased the odds of vaccination series completion. In persons with chronic condition(s), younger age was associated with increased odds of vaccination initiation, whereas higher education and being a health professional increased the odds of vaccination series completion.
Conclusions: Several individual socioeconomic and health-related factors may influence hepatitis B vaccination, particularly in community-dwelling adults and persons at higher risk of exposure. Our findings may inform targeted messaging to optimise hepatitis B vaccination.

1. Introduction

The hepatitis B virus, a deoxyribonucleic acid (DNA) virus from the *Hepadnavirdiae* virus family, targets the liver in humans [1]. Infections with this virus can be acute and severe. They may become chronic, putting infected persons at a higher risk of severe morbidity and mortality from liver cirrhosis and hepatocellular carcinoma (primary liver cancer) [1,2]. The very young (≤5-year-olds) and immunocompromised persons are at a higher risk of chronic hepatitis B and becoming carriers [3,4].

Hepatitis B infection occurs mostly via contact with infected body fluids, including through blood transfusion, sharing of injection drugs paraphernalia like needles, tattooing, needlestick injury, and piercings, unprotected sex, especially in persons with multiple sexual partners, bite wounds with broken skin, and perinatal transmission (mother to baby transmission at birth), especially in highly endemic areas. The incubation period of the hepatitis B virus ranges from 28 to 180 days [5–7]. Estimates suggest that over 200 million people were living with chronic hepatitis B infection in 2022 [8], with over a million new infections each year, and about a million deaths in 2022 alone [7]. There is no specific

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treatment for acute infection of hepatitis B, and it is estimated that infections in early childhood lead to chronic hepatitis in about 95 % of cases. In contrast, infections in adulthood lead to chronic hepatitis in about 5 % of cases [7,9–11]. Prevention of hepatitis B infection is crucial, and early prevention is necessary for global health security.

Hepatitis B is preventable with hepatitis B vaccines, which are widely available and have been proven safe and effective, providing protection against infections for at least 20 years and potentially lifelong if administered as recommended [12–14]. Several paediatric and adult hepatitis B vaccines are available on the market, including the hepatitis B vaccine in combination with other recommended childhood vaccines, such as hepatitis A, diphtheria and tetanus toxoids, acellular pertussis, inactivated poliomyelitis, and conjugated *Haemophilus influenzae* type b vaccine [15]. However, the availability and recommendation of these vaccines differ across jurisdictions mostly according to the approach for children and adult vaccinations (whether routine-vaccine-based or risk-based approach). Public funding of hepatitis B vaccination also varies across jurisdictions. Nevertheless, irrespective of the differences in vaccine availability and jurisdictional recommendations and approaches to vaccination, it is advocated that babies are vaccinated as soon as possible after birth, followed by two to three additional doses of the vaccine at least four weeks apart [15–17]. In jurisdictions where the hepatitis B vaccine is not provided at birth/infancy, it is advocated that children at increased risk are vaccinated as soon as a risk is identified and that adolescents who have missed vaccination on the routine schedule are also vaccinated, with emphasis on migrants from areas where the disease is highly prevalent [15–17]. Further, vaccination is also advocated for persons who are at a higher risk of exposure or complications from hepatitis B infection, such as sex workers, injection drug users, healthcare workers, certain social workers, and persons with chronic conditions, including immunosuppression and immunodeficiency [15–17]. Booster vaccination is not usually required after two/three vaccinations.

While globally, hepatitis B vaccination coverage for infants has increased substantially over the past three decades, vaccination coverage among adults remains very low, even in the higher-risk subpopulations [16,17]. Although health and religious beliefs may influence vaccine acceptance, certain individual socioeconomic and health-related factors may facilitate or hinder vaccine acceptance and/or access. Despite this, there is a paucity of published evidence reviews of the potential influence of these factors on hepatitis B vaccination (vaccination initiation and vaccination series completion).

We sought to systematically identify, critically appraise, and summarise published evidence on associations between individual socioeconomic and health-related factors and hepatitis B vaccination initiation (receipt of at least one vaccine dose) and vaccination series completion (receipt of two/three or more vaccine doses depending on health status and recommendation) for evidence-based insights to optimise hepatitis B vaccination programmes.

2. Methods

We developed and registered a systematic review protocol in the International Prospective Register of Systematic Reviews (PROSPERO: CRD42023445721). Following the Cochrane Handbook for Systematic Reviews of Interventions guidelines, we then conducted a systematic evidence review [18]. Herein, we report findings following the Meta-analyses Of Observational Studies in Epidemiology (MOOSE) guidelines [19].

2.1. Literature search and study selection

A health librarian developed a literature search strategy for MEDLINE (Ovid) to identify studies of associations between individual socioeconomic and health-related factors and initiation and/or completion of hepatitis B vaccination, irrespective of vaccine type. An independent health librarian peer-reviewed this search strategy using the Peer Review of Electronic Search Strategies (PRESS) Checklist [20], following which appropriate revisions were made to the search strategy by the first librarian and the revised document was then adapted for Embase (Ovid), CINAHL with Full Text (EBSCOhost), the Cochrane Library (Wiley), Web of Science Core Collection (Clarivate), and Scopus (Elsevier) bibliographic databases (**Appendix 1**). These search strategies were implemented on December 19, 2022, and limited to items published since 1981 (inclusive) due to when the hepatitis B vaccine became approved and available on the market. The Scopus Search and Web of Science search included additional restrictions to remove items included in MEDLINE and Embase to minimise duplication of results (see Appendix 1). The retrieved literature citations from each database were imported into and de-duplicated in EndNote (X9.2) software [21]. We searched for new publications since the implementation of the search strategies in the bibliographic databases by searching Google Scholar on April 1, 2024, using the following search terms: hepatitis B, HBV, vaccination, determinants, OR factors, OR characteristics, OR associations, OR correlations "vaccine".

The de-duplicated citations were double-screened by independent reviewers, who first reviewed the titles/abstracts and then the full-text articles of eligible literature. We documented the number of ineligible citations at the title/abstract screening stage and the number and reasons for ineligibility at the full-text article screening stage. Further, we scanned the reference lists of the included full-text articles for any further relevant studies. Any differences in the reviewers' decisions were discussed and resolved between paired reviewers or by involving a third reviewer.

We included only peer-reviewed full-text publications of observational studies of cohort, case-control, and cross-sectional types that reported on associations between individual socioeconomic and/or health-related factors and hepatitis B vaccination initiation and/or the vaccination series completion, irrespective of vaccine type and the population of study. We excluded published but not peer-reviewed articles, such as preprint articles, theses/dissertations, and grey literature. We also excluded modelling studies, case reports, case series, and reviews. Vaccination initiation was defined as the receipt of at least one hepatitis B vaccine dose, and vaccination series completion was defined as a receipt of the recommended two or three doses of hepatitis B vaccine, irrespective of the timing of the vaccinations. Further, for inclusion, a study must have reported complete multivariable-adjusted results, including the point effect estimate and the associated 95 % confidence interval (CI).

2.2. Data extraction

Using five studies, we piloted data extraction on a data extraction spreadsheet designed in MS Excel (Microsoft Corporation, Redmond, WA, U.S.). We corrected identified errors and implemented required revisions before data extraction from all the included studies. One reviewer extracted data from the studies, and the extracted data were checked independently for errors. Any errors or omissions were discussed and corrected. We extracted the name of the first author of an article, the year of publication, and the study design; for example, cross-sectional, case-control, or cohort, and study period, country, funder, and sample size, and study population characteristics such as the population group, age group, sex, and mean/median age of study participants. Study population groups were regrouped into paediatric population (<18-year-olds), community-dwelling adults (non-hospitalised ≥18-year-olds of average risk of exposure to hepatitis B infection), persons at a higher risk of exposure to hepatitis B infection (drug users, sex workers, gay men, prisoners, and social safety and healthcare workers), and persons with a chronic medical condition (for example, diabetic, cancer, immunodeficient, and autoimmune disease patients). We also extracted vaccination information such as vaccine type, number of vaccine doses received, how vaccination status was determined, i.e.,

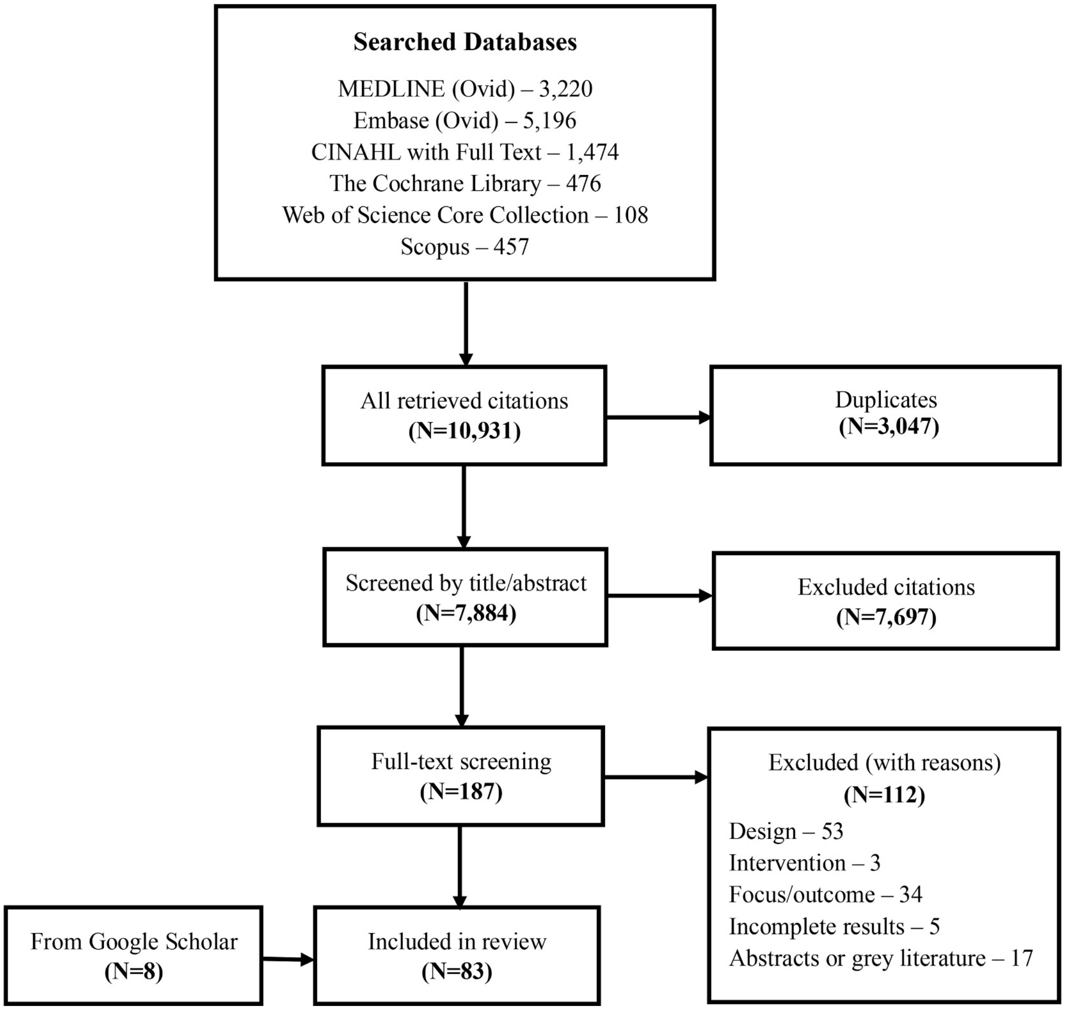

Fig. 1. Summary of literature search and citation screening (Modified PRISMA flow chart).

whether self-reported or via medical records, the assessed individual socioeconomic and health-related factors, the data analysis type, and the adjusted covariates. Race was extracted as a single self-defined race reporting in studies. Further, we extracted the effect estimate type, such as odds ratio, prevalence ratio, relative risk, and hazard ratio, and the results (point effect estimate with associated 95 % CI).

2.3. Study quality assessment

We assessed the quality of the included studies using the National Institutes of Health (NIH) quality assessment tool for observational cohort and cross-sectional studies [22]. One reviewer conducted the quality assessments, and the judgments were independently checked and corrected for errors. The quality assessment tool assesses 14 study quality domains: clarity of research question/objectives, appropriateness of population and participants selection process, sample size justification, measurements, and data analysis. A study was judged to be of high quality if all assessed parameters were satisfactory, good quality if all but one parameter were satisfactory, moderate quality if all but two to four parameters were satisfactory, and poor quality if more than four parameters were unsatisfactory.

2.4. Data synthesis/analysis

We presented relevant characteristics and quality assessments of the included studies in a tabular form and summarised them descriptively. We anticipated that most of the included studies in this review would likely have reported adjusted odds ratios (ORs). We converted reported adjusted prevalence ratios or relative risks to ORs if enough information for conversion was available, and if not, we pooled them with the odds ratios and then conducted a sensitivity analysis excluding the studies and reported our findings on the sensitivity analysis only if it differed significantly from the overall analysis.

If most of the studies that contributed to a meta-analysis compared factor A against factor B, and a few studies compared factor B against factor A, results from the few studies were inverted (1/OR and (95 % CI: 1/upper CI to 1/lower CI)) for consistency of comparison with the majority. If a study reported results for more than one comparison on the same factor, for example, a comparison of 40–50-year-olds and 25–39-year-olds with 18–24-year-olds, we first meta-analysed results for the two comparisons to represent older compared with younger using a fixed effects model before we then meta-analysed the pooled estimated result with results of similar comparisons from other studies with different populations using a random effects model. We applied the same approach to the other factors.

To minimise the variance of a weighted average (the pooled estimate), we first converted the individual study results and their associated 95 % CIs to their natural logs before conducting a meta-analysis using an inverse variance random-effects model (DerSimonian and Laird method) [23]. We expressed the pooled estimates as ORs with associated 95 % CIs and assessed statistical heterogeneity using the I^2 statistic [24]. Only if at least ten results contributed to a meta-analysis and the results are as reported in studies and not derived by collapsing results from strata of a categorised factor did we assess for publication

Table 1
Summary of relevant characteristics of the 39 studies that reported on hepatitis B vaccination initiation.

Study (Country [Region])	Study period (Population type) [Funder]	Age group (Sample size - [Mean age])	Vaccination status (% male) [Assessed factors]	Effect measure (Adjusted factors)
Acikgoz 2021[27] (Turkey [7 universities from seven geographical regions])	February 4, 2019, to December 27, 2019 (Community-dwelling adults) [NA]	17–64 years (5104 - [21.1 (2.3) years])	Self-reported (31.3) [Age, sex, and family's socioeconomic status]	Odds Ratio (Age, sex, school, perceived family economic status, and childhood residence)
Adjei Gyimah 2021 [28] (Ghana [3 Universities in Kumasi, Accra, and Koforidua])	Not reported (Community-dwelling adults) [Not funded]	≥18 years (2712 - [Not reported])	Self-reported (46.8) [Age, and area of residence]	Odds Ratio (Not reported)
Afolabi 2022 [29] (Uganda [Lubaga Hospital, Kampala])	September to October 2020 (Community-dwelling adults) [NA]	≥18 years (385 - [Not reported])	Self-reported (0) [Age, educational attainment, employment status, and marital status]	Odds Ratio (Not reported)
Ayana Hordofa 2021 [32] (Ethiopia [Akaki Kality Subcity of Addis Ababa])	May 15 to June 15, 2020 (Higher risk of exposure) [Not reported]	≥18 years (505 - [29 (NR) years])	Self-reported (42.8) [Age, educational attainment, religion, profession, and years of service/work experience]	Odds Ratio (Not reported)
Aytaman 2016 [33] (U.S. [National (National Health Interview Survey)])	2000 to 2013 (Persons with chronic conditions) [Brooklyn Health Disparities Center National Institutes of Health grant]	19–60 years (36,489 - [45.7 (NR) years])	Self-reported (50) [Age, sex, race, native-born, marital status, educational attainment, alcohol consumption, health insurance, and chronic disease status]	Odds Ratio (Not reported)
Berman 2017 [35] (U.S. [Massachusetts])	2011–2013 (Higher risk of exposure) [The Physician Training Award in Cancer Prevention, The American Cancer Society, and Centers for Disease Control and Prevention, U.S.]	9–26 years (2269 - [Not reported])	Medical record (54) [Age, and sex]	Odds Ratio (Age group, Refugee Health Assessment Program site, Hepatitis B virus surface antigen status, and anti-Hepatitis B virus surface antibody status)
Brandl 2020 [37] (Europe [38 countries])	June 6 to 31 August 2010 (Higher risk of exposure) [The European MSM Internet Survey Network]	Not reported (163,987 - [Not reported])	Self-reported (100) [Age, and educational attainment]	Odds Ratio (Not reported)
Chan 2009 [38] (China [Hong Kong])	2008 (Community-dwelling adults) [Not reported]	≥21 years (1404 - [31.2 (4.3) years])	Self-reported (0) [Age, marital status, educational attainment, native-born, income, and medical check-up]	Odds Ratio (Age, marital status, highest educational attainment, occupation, place of birth, residency, monthly family incomes, premarital checkup, routine medical checkup, obstetric characteristics, and place of delivery)
Deerin 2021 [41] (U.S. [U.S. Department of Defense's Military Health System])	January 2014 to December 2018 (Children) [Not reported]	Infants (168,198 - [Not reported])	Medical record (Not reported) [Mother's age, and mother's race]	Odds Ratio (Correlation within hospital and provider, birth year, maternal race, maternal age, birth order, infant bed days, and sponsor's military branch)
Dufour 1999 [44] (Canada [Montreal])	1997 (Higher risk of exposure) [National Health Research and Development Program, Health Canada]	16–73 years (626 - [34 (NR) years])	Self-reported (100) [Area of residence, and drug use]	Odds Ratio (Age, college degree, annual income, history of sexually transmitted disease, lifetime risk behaviours, number of casual partners, trip to endemic countries, prostitution for drugs, gave goods or services for sex, and risky behaviour during the past 6 months)
Frew 2014 [47] (U.S. [Atlanta, Georgia])	2010 (Community-dwelling adults) [The Atlanta Clinical and Translational Science Institute]	≥18 years (316 - [Not reported])	Self-reported (43) [Age, sex, educational attainment, income, and health insurance]	Odds Ratio (Not clear)
Grytdal 2009 [49] (U.S. [National (CDC and Racial and Ethnic Approaches to Community Health (REACH) 2010 Risk Factor Survey)])	2006 (Community-dwelling adults) [Not funded]	≥18 years (2049 - [48.8 (NR) years])	Self-reported (50.7) [Age, sex, native-born, marital status, educational attainment, visit to a healthcare provider/ hospitalisation in past year, influenza vaccination in past year, and pneumococcal vaccination]	Odds Ratio (Not reported)
Hibbert 2023 [52] (United Kingdom [England])	2015–2019 (Higher risk of exposure) [The National Institute for Health	Not reported (10,681 - [Not clear])	Self-reported (0) [Race, and native-born]	Odds Ratio (Not reported)

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Table 1 (*continued*)

Study (Country [Region])	Study period (Population type) [Funder]	Age group (Sample size - [Mean age])	Vaccination status (% male) [Assessed factors]	Effect measure (Adjusted factors)
	Research in partnership with the UK Health Security Agency]			
Hussein 2022 [54] (Somalia [Bosaso, Puntland])	September to November 2020 (Higher risk of exposure) [Not reported]	Not reported (232 - [Not reported])	Self-reported (43.2) [Age, income, profession, and years of service/work experience]	Odds Ratio (Age group, occupation, monthly income, and work experience)
Jain 2004 [57] (U.S. [National (National Health Interview Survey)])	2000 (Higher risk of exposure) [Not reported]	18–49 years ((498 (men) and 538 (women)) - [Not reported])	Self-reported (Not clear) [Age, marital status, having a place of routine health care, visit to a healthcare provider/hospitalisation in past year, influenza vaccination in past year, pneumococcal vaccination, and hepatitis B or HIV screening]	Prevalence ratio (Not clear)
Juon 2022 [60] (U.S. [Washington Metropolitan Region])	2018–2020 (Children) [Office of Minority Health, U.S. Department of Health and Human Services]	Newborns (40,269 - [Not reported])	Medical record (Not reported) [Mother's race, medical facility type, and health insurance]	Odds Ratio (Not reported)
Kisangau 2019 [61] (Kenya [Makueni County])	May to June 6, 2017 (Higher risk of exposure) [The US President's Emergency Plan for AIDS Relief, Centers for Disease Control and Prevention, Division of Global HIV & TB and the Global Health Security Agenda]	19–67 years (312 - [Not reported])	Self-reported (34) [Profession, and medical facility type]	Odds Ratio (Not clear)
Kisic-Tepavcevic 2017 [62] (Serbia [Belgrade])	December 2015 (Higher risk of exposure) [The Ministry of Education, Science and Technological Development of the Republic of Serbia]	Not reported (352 - [Not reported])	Self-reported (24.4) [Profession, years of service/work experience, and influenza vaccination in past year]	Odds Ratio (Age, occupation, work site, duration of work experience, blood exposure in past year, influenza vaccination, use of seat belt, and hepatitis B related knowledge)
Liang 2021 [64] (China [Beijing])	July 2019 to June 2020 (Community-dwelling adults) [The Development Center for Medical Science & Technology National Health Commission of the People's Republic of China, and the Aids and Viral Hepatitis Infectious Diseases Prevention and Control Science and Technology Major Project]	Not reported (36,007 - [Not reported])	Self-reported (37.9) [Age, sex, educational attainment, employment status, and marital status]	Odds Ratio (Suggestively, age, education, occupation, marital status, and household registration)
Lu 2011 [66] (U.S. [National (National Health Interview Survey)])	2009 (Community-dwelling adults) [Centers for Disease Control and Prevention, U.S.]	18–49 years (15,136 - [Not reported])	Self-reported (49.7) [Age, sex, race, employment status, socioeconomic status, visit to a healthcare provider/hospitalisation in past year, having a place of routine health care, health insurance, hepatitis B or HIV screening, hepatitis A vaccination, and being a health professional]	Prevalence ratio (Age, sex, race/ethnicity, marital status, education, employment status, poverty level, physician contacts in past year, hospitalisation in past year, place of routine health care, health insurance, ever tested for HIV, health care personnel, influenza vaccination, and ever received hepatitis A vaccination)
Lu 2018 [69] (U.S. [National (National Health Interview Survey)])	2015 (Community-dwelling adults) [Centers for Disease Control and Prevention, U.S.]	≥18 years (Population 1 (11,079) & population 2 (21,875) - [Not reported])	Self-reported (50.5 for population 1 & 46.9 for population 2) [Age, sex, race, marital status, educational attainment, employment status, socioeconomic status, U.S. region, native-born, visit to a healthcare provider/hospitalisation in past year, having a place of routine health care, health insurance, hepatitis B or HIV screening, being a health professional, and chronic disease status]	Prevalence ratio (Age, sex, race/ethnicity, marital status, educational level, employment status, poverty level, region of residence, U.S.-born status, number of physician contacts in the past 12 months, hospitalisation in the past 12 months, usual place for health care, health insurance status, ever being tested for HIV, healthcare personnel (HCP) status, ever being lived with someone who had hepatitis diseases, ever having chronic liver disease, and diabetes status)
Mungandi 2017 [73] (Zambia [Lusaka District])	October 2015 to March 2016 (Higher risk of exposure) [Ministry of Health, Zambia]	Not reported (331 - [35 (0.5) years])	Self-reported (46.2) [Age, sex, profession, medical facility type, and training on infections]	Odds Ratio (Not clear)

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Table 1 (*continued*)

Study (Country [Region])	Study period (Population type) [Funder]	Age group (Sample size - [Mean age])	Vaccination status (% male) [Assessed factors]	Effect measure (Adjusted factors)
Olakunde 2022 [76] (Nigeria [National (Nigerian Demographic and Health Survey)])	2018 (Children) [Not funded]	12–23 months (6143 - [Not reported])	Mixed (52.3) [Sex, place of delivery, area of residence, mother's age, mother's socioeconomic status, mother's religion, parent's educational attainment, and parent's marital status]	Odds Ratio (Place of delivery, sex, birth order, birth attendant, and mother's age, educational attainment, wealth index, marital status, religion, place of residence, and region of residence)
Omotowo 2018 [77] (Nigeria [University of Nigeria Teaching Hospital, Enugu])	July and August 2016 (Higher risk of exposure) [Not funded]	18–75 years (3132 (main analysis limited to 872 persons who were hepatitis B negative) - [39.4 (9.6) years])	Self-reported (30.4) [Age, sex, marital status, educational attainment, profession, and years of service/work experience]	Odds Ratio (Age, sex, marital status, level of education, and professional categories)
Park 2012 [79] (South Korea [National (Korean National Cancer Screening Survey)])	2005–2008 (Community-dwelling adults) [Grant-in-Aid for Cancer Research and Control from the National Cancer Center, Korea]	30–79 years (4350 - [Not reported])	Self-reported (0) [Age, marital status, income, employment status, and private insurance for cancer]	Odds Ratio (Age, area of residence, private insurance for cancer, equivalised household income, duration of education, occupation, self-reported health status, marital status, type of health insurance, smoking and drinking status, and survey year)
Park 2013 [78] (South Korea [National (Korean National Cancer Screening Survey)])	2006–2008 (Community-dwelling adults) [Grant-in-Aid for Cancer Research and Control from the National Cancer Center, Korea]	40–80 years (2174 - [Not reported])	Self-reported (100) [Age, marital status, income, employment status, and private insurance for cancer]	Odds Ratio (Age, area of residence, private insurance for cancer, equivalised household income, duration of education, occupation, self-reported health status, marital status, type of health insurance, smoking and drinking status, and survey year)
Rachiotis 2005 [84] (Greece [Athens])	September to December 2001 (Higher risk of exposure) [Not reported]	20–63 years (175 - [36.4 (7.68) years])	Self-reported (37.1) [Age, sex, profession, and years of service/work experience]	Odds Ratio (Suggestively, age, sex, duration of employment, knowledge of transmission routes, and use of gloves)
Ranjan 2019 [85] (Canada [Vancouver])	2010 to February 2017 (Higher risk of exposure) [The U.S. National Institutes of Health, Canadian Institutes of Health Research, and Mac AIDS]	Not reported (855 - [Not reported])	Self-reported (0) [Age, native-born, drug use, and hepatitis B or HIV screening]	Odds Ratio (Not clear)
Rhodes 2001 [88] (U.S. [Internet-based but U. S.-focused])	Not reported (Higher risk of exposure) [Not reported]	18–78 years (336 - [38 (11) years])	Self-reported (100) [Age]	Prevalence ratio (Age, number of sex partners in the last 30 days, sharing of needles, knowledge and perceived knowledge of hepatitis B and its vaccine, communication with health care provider, information access, and number of sources of information)
Rhodes 2002 [89] (U.S. [Birmingham, Alabama])	September 2001 (Higher risk of exposure) [The W. K. Kellogg Foundation]	18–50 years (170 - [26.3 (6.5) years])	Self-reported (100) [Age, educational attainment, and visit to a healthcare provider/ hospitalisation in past year]	Odds Ratio (Age, education, estimated income per year, number of sex partners in the last 30 days, sex with women in past years, HIV seropositive status, recent visit to healthcare provider, health insurance, information sources, and number of information sources)
Saindou 2013 [90] (Mayotte Island [Island-wide])	September 15, 2008, to September 27, 2009 (Community-dwelling adults) [The Conseil General de Mayotte]	Not reported (327 - [Not reported])	Self-reported (0) [Age, and employment status]	Odds Ratio (Site, marital status, employment status, educational attainment, birthplace, and age of first sexual intercourse)
Soomar 2021 [92] (Pakistan [Sindh])	Not reported (Higher risk of exposure) [Not funded]	Not reported (252 - [36.2 (9.3) years])	Self-reported (20.2) [Sex]	Odds Ratio (Not clear)
Stroffolini 2008 [95] (Italy [Public hospitals (5 in North, 7 in Centre & 3 in South/islands regions)])	2016 (Higher risk of exposure) [Not reported]	Not reported (1632 - [Not reported])	Self-reported (Not reported) [Age, sex, profession, and years of service/work experience]	Odds Ratio (Not cleat)
Stroffolini 2021 [96] (Italy [8 tertiary centres (3 in North, 1 in Centre, 3 in South & 1 in Sardinia Island)])	July to December 2019 (Persons with chronic conditions) [Not funded]	25–89 years (731 - [65.6 (12.2) years])	Self-reported (64.7) [Age, and sex]	Odds Ratio (Sex, age, area of residence, years of education, country of birth, aetiology of cirrhosis, and grade of Child)

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Table 1 (*continued*)

Study (Country [Region])	Study period (Population type) [Funder]	Age group (Sample size - [Mean age])	Vaccination status (% male) [Assessed factors]	Effect measure (Adjusted factors)
Strong 2012 [97] (U.S. [Maryland])	2009–2010 (Community-dwelling adults) [National Cancer Institute, U.S.]	≥18 years (810 - [45 (NR) years])	Self-reported (41.5) [Age, sex, educational attainment, health insurance, and having a place of routine health care]	Odds Ratio (Not clear)
Tian 2019 [99] (U.S. [National (National Health Interview Surveys)])	2016–2017 (Community-dwelling adults) [The Kunshan Special Fund for Social Development and Science & Technology and the Suzhou "Kejiaoxingwei" Youth Science Project]	≥18 years (19,123 - [Not reported])	Self-reported (47.7) [Age, sex, race, native-born, U.S. region, sexual orientation, marital status, profession, educational attainment, health insurance, alcohol consumption, smoking status, chronic disease status, influenza vaccination in past year, and visit to a healthcare provider/ hospitalisation in past year]	Odds Ratio (Chronic liver diseases, ever lived with someone with hepatitis, sexual orientation, sex, born in the U.S., age, religion, race, Hispanic ethnicity, marital status, class of worker, computer use, education, health insurance, ratio of family income to the poverty threshold, drinking, smoking, light/moderate activity, influenza vaccination, and number of physician visits in the past year)
Tsiligianni 2023 [101] (Greece [Macedonia, Thrace, Thessaly, Central Greece, Crete, & Peloponnese])	March to July 2019 (Community-dwelling adults) [Not funded]	≥18 years (18–94 years) (1571 - [60 (15) years])	Self-reported (39) [Age, sex, marital status, employment status, educational attainment, area of residence, smoking status, and chronic disease status]	Odds Ratio (Age, gender, rural vs urban areas, body mass index (BMI), smoking status, education level, and comorbidities)
Vrachnaki 2020 [103] (Greece [Crete])	2018 (Higher risk of exposure) [The Special Account for Research Funds of University of Crete]	21–67 years (2181 - [Not reported])	Self-reported (24.3 (based on 1825 participants)) [Age, and profession]	Odds Ratio (Age, sex, profession, and workplace)
Yuan 2019 [108] (China [Fujian, Jiangxi, & Gansu Provinces])	Not reported (Higher risk of exposure) [Peking University Health Science Center and the National Key Science and Technology Research on Infections Diseases]	25–60 years (3104 - [Not reported])	Self-reported (34) [Age, sex, profession, training on infections, medical facility type, and years of service/work experience]	Odds Ratio (Not clear)

U.S. = United States of America; U.K. = United Kingdom.

bias using Egger's regression test [25]. We conducted data management and analysis using STATA software (version 16; StataCorp LP, Texas, U. S.).

3. Results

We included 83 cross-sectional studies (Fig. 1) [26–108]. Thirty-nine (39) studies reported on vaccination initiation, 51 reported on vaccination series completion, and seven reported on both vaccination initiation and series completion. Relevant characteristics of the studies on vaccination initiation are presented in Table 1, and those for the studies on vaccination series completion are presented in Table 2.

Of the 39 studies that reported on vaccination initiation, one-third (13 studies) was from the U.S. [33,35,41,47,49,57,60,66,69,88,89,97,99], three studies each were from China [38,64,108], and Greece [84,101,103], two studies each were from Canada [44,85], Italy [95,96], Nigeria [76,77], and South Korea [78,79], and one study each was from a group of European countries [37], Ghana [28], Ethiopia [32], Kenya [61], Mayotte Island [90], Pakistan [92], Somalia [54], Serbia [62], Turkey [27], Uganda [29], U.K. [52], and Zambia [73]. The study sample sizes ranged from 170 persons to 168,198 persons. Vaccination status was self-reported in 35 studies, confirmed from medical records in three studies [35,41,60], and self-reported/confirmed from medical records in one study [76]. Further, 35 studies reported odds ratios and four reported prevalence ratios [57,66,69,88]. Thirty-one studies (79 %) did not report calculation and justification of sample size; hence, they were judged to be of good quality, while the rest (n = 8, 21 %) were of high quality (**Appendix 2**).

Of the 51 studies that reported on vaccination series completion, about a fifth (11 studies) was from the U.S. [36,55,56,58,66–69,87,99,100], four studies each were from Brazil [31,39,45,83], and Ethiopia [26,30,48,50], three studies each were from China [53,105,108], South Korea [59,78,79], and Uganda [93,94,104], two studies each were from Australia [70,71], Netherlands [42,86], U.K. [81,98], and a group of three African countries [34,106], and one study each was from Cameroon [43], Canada [44], Colombia [40], France [82], Gabon [72], Ghana [102], Mexico [46], Nigeria [75], Pakistan [107], Senegal [80], Somalia [51], Taiwan [65], Turkey [63], Vietnam [74], and a group of 16 European and four non-European countries [91]. The study sample sizes ranged from 232 persons to 10,911,530 persons. Vaccination status was self-reported in 35 studies, confirmed from medical records in 15 studies [34,36,40,43,53,55,56,70–72,80,86,87,100,105], and self-reported/ confirmed from medical records in one study [58]. Further, 44 studies reported odds ratios, six studies reported prevalence ratios [39,66,68,69,94,104], and one study reported relative risk [82]. Forty-six studies (90 %) did not report calculation and justification of sample size; hence, they were judged to be of good quality, while the rest (n = 5, 10 %) were of high quality (**Appendix 3**).

4. Meta-analysis of the association between hepatitis B vaccination initiation and vaccination series completion and individual socioeconomic and health-related factors in paediatric population

4.1. Vaccination initiation

Race was the only factor found to be associated with vaccination initiation, with significantly increased odds of vaccination initiation observed among children of Asian mothers compared with those of White mothers [OR: 1.50 (1.31–1.72, I^2 64.9 %, two studies, 208,467 persons)] (Table 3). Forest plots for the assessed factors are presented in **Appendix 4**.

Table 2
Summary of relevant characteristics of the 51 studies that reported on hepatitis B vaccination series completion.

Study (Country [Region])	Study period (Population type) [Funder]	Age group (Sample size [Mean age])	Vaccination status (% male) [Assessed factors]	Effect measure (Adjusted factors)
Abebaw 2017 [26] (Ethiopia [Shashemene])	March 16 to 31, 2015 (Higher risk of exposure) [Debre Markos University, Ethiopia]	18–59 years (410 [29.42 (6.65) years])	Self-reported (40) [Age, sex, religion, marital status, medical facility type, and years of service/work experience]	Odds Ratio (Age, sex, marital status, work experience, type of institution and rated price, specifically between those who rated price of vaccine as affordable and those who didn't know the price)
Akibu 2018 [30] (Ethiopia [Adama General Hospital and Medical College, Adama])	December 2016 to February 2017 (Higher risk of exposure) [Not reported]	21–64 years (386 [28.45 (3.2) years])	Self-reported (51.2) [Sex, profession, years of service/ work experience, and work unit]	Odds Ratio (Not reported)
Arrelias 2016 [31] (Brazil [Sao Paulo])	July to December 2014 (Persons with chronic conditions) [Not reported]	≥18 years (255 - [Not reported])	Self-reported (33.3) [Age, sex, educational attainment, and being a health professional]	Odds Ratio (Age, sex, education, length of time with diabetes mellitus, insulin use, blood glucose monitoring, and whether a health professional)
Bekondi 2015 [34] (Cameroon, Central African Republic and Senegal [Yaounde (Cameroon), Bangui (Central African Republic), and Dakar (Senegal)])	April 2009 to May 2010 (Children) [Actions Concertées du Réseau International des Instituts Pasteur, France]	3 months to 6 years (1783 - [Not reported])	Medical record (56) [Age, and parent's educational attainment]	Odds Ratio (Age, nutritional status, mother's education, and toilet system type)
Bowman 2014 [36] (U.S. [Hartford and Bridgeport in Connecticut and Chicago in Illinois])	May 2003 to March 2006 (Higher risk of exposure) [National Institute on Drug Abuse, U.S.]	≥18 years (430 - [Not reported])	Medical record (0) [Age]	Odds Ratio (Not reported)
da Costa 2013 [39] (Brazil [Montes Claros])	August to December 2010 (Higher risk of exposure) [Not reported]	Not reported (761 - [Not reported])	Self-reported (20.1) [Age, educational attainment, and alcohol consumption]	Prevalence ratio (Not clear)
de la Hoz 2005 [40] (Colombia [Colombian Amazon: Leticia, Puerto Narino, Aracaura and Puerto Santander])	Not reported (Children) [Pan American Health Organization]	1-11 years (3044 - [Not reported])	Medical record (53) [Age]	Odds Ratio (Age, number of siblings, birth order, and certain ecological factors)
Den Daas 2020 [42] (Netherlands [National (Men and Sexuality survey)])	February to June 2018 (Higher risk of exposure) [Not funded]	≥16 years (4270 - [35.7 (14.5) years])	Self-reported (100) [Age, educational attainment, native-born, having a bloodborne disease/sexually transmitted disease, and hepatitis B or HIV screening]	Odds Ratio (Age, education, place of residence, urbanisation level, migration background, sexual orientation (homosexuality versus bisexuality/ other), and several sexual health and behaviours)
Dionne-Odom 2018 [43] (Cameroon [National (Demographic Health Survey in Cameroon)])	2011 (Children) [NIH/NICHD]	12–60 months (4594 - [Not reported])	Medical record (Not reported) [Area of residence, socioeconomic status, mother's age, parent's educational attainment, mother's religion, parent's marital status, and visit to a healthcare provider/ hospitalisation in past year]	Odds Ratio (Not clear)
Dufour 1999 [44] (Canada [Montreal])	1997 (Higher risk of exposure) [National Health Research and Development Program, Health Canada]	16–73 years (626 - [34 (NR) years])	Self-reported (100) [Age, educational attainment, income, and having a bloodborne disease/sexually transmitted disease]	Odds Ratio (Age, college degree, annual income, history of sexually transmitted disease, lifetime risk behaviours, number of casual partners, trip to endemic countries, prostitution for drugs, gave goods or services for sex, and risky behaviour during the past 6 months)
Ferreira 2012 [45] (Brazil [Montes Claros, Minas Gerais])	2007–2008 (Higher risk of exposure) [Not reported]	≥23 years (283 - [36.9 (9.6) years])	Self-reported (47.9) [Smoking status, and alcohol consumption]	Odds Ratio (Not clear)
Flores-Sanchez 2014 [46] (Mexico [Acapulco, State of Guerrero])	July to August 2010 (Higher risk of exposure) [Not reported]	Not reported (834 - [Not reported])	Self-reported (33.1) [Educational attainment]	Odds Ratio (Not reported)
Getnet 2020 [48] (Ethiopia [Gondar, Central Gondar Zone of the Amhara National Regional State])	May 19 to June 15, 2018 (Higher risk of exposure) [Not funded]	Not reported (260 - [Not reported])	Self-reported (48.8) [Educational attainment, income, and years of service/work experience]	Odds Ratio (Not clear)
Haile 2021 [50] (Ethiopia [Wolkite University, Southwest Ethiopia])	November to December 2020 (Community-dwelling adults) [Not funded]	20–33 years (417 - [22.7 (1.7) years])	Self-reported (60.2)	Odds Ratio (Sex, residence, academic year, department, attitude, practice)

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Table 2 (*continued*)

Study (Country [Region])	Study period (Population type) [Funder]	Age group (Sample size [Mean age])	Vaccination status (% male) [Assessed factors]	Effect measure (Adjusted factors)
			[Sex, area of residence, and medical training]	
Hassan 2023 [51] (Somalia [Mogadishu])	August to October 2022 (Community-dwelling adults) [Not reported]	Not reported (569 - [21.4 (2.45) years])	Self-reported (29.5) [Age, sex, and medical training]	Odds Ratio (Not reported)
Hu 2018 [53] (China [Zhejiang Province, East China])	July 1, 2018 (Children) [Not funded]	<18 years (10,911,530 - [Not reported])	Medical record (50.6) [Place of delivery, parent's employment status, parent's educational attainment, and socioeconomic level of school or residential area]	Odds Ratio (Sex, delivery place (hospital or home), immigration status, maternal occupation, maternal education, economic development level of residence area, and frequency of vaccination service)
Hwang 2010 [55] (U.S. [Houston, Texas])	February 2004 to October 2007 (Higher risk of exposure) [Not reported]	≥18 years (1260 - [Not reported])	Medical record (77) [Age, race, and alcohol consumption]	Odds Ratio (Interventions; age; race; housing status; use of speedball, alcohol, crack cocaine, or methamphetamine; injection drug use; and trading sex for money or drugs)
Jain 2009 [56] (U.S. [National (National Immunization Survey–Teen)])	2006 (Children) [Centers for Disease Control and Prevention]	13–17 years (Overall including 13–17 years (2882) - [Not reported])	Medical record (Not reported) [Race, area of residence, U.S. region, parent's marital status, parent's educational attainment, socioeconomic status, and health insurance]	Odds Ratio (Age, sex, race/ethnicity, maternal marital status, maternal education, federal poverty level, metropolitan statistical, census region, health insurance status, and parental report)
Jenkins 2000 [58] (U.S. [The metropolitan areas of Houston and Dallas, Texas, and Washington, DC])	Spring of 1998 (Children) [The Centers for Disease Control and Prevention]	3–18 years (1508 (study results were based on 1292) - [9.8 (NR)])	Mixed (50.3) [Parent's marital status]	Odds Ratio (Not clear)
Juon 2009 [59] (South Korea [National (Korea National Cancer Screening Survey)])	2005 (Community-dwelling adults) [Cancer Research and Control from the National Cancer Center, Korea]	40–90 years (1786 (934 for vaccination status and main analysis) - [51.8 (8.8) years])	Self-reported (46.2) [Age, sex, area of residence, educational attainment, employment status, income, private insurance for cancer, and medical check-up]	Odds Ratio (Age, sex, education, employment, residence, monthly income, self-reported health, belief in cancer screening, alcohol use, exercise, having private cancer insurance, and regular health check-up)
Kumbul 2023 [63] (Turkey [Isparta Province])	February to July 2020 (Higher risk of exposure) [Not funded]	Not reported (378 - [36.7 (8.6) years])	Self-reported (41.1) [Sex, and chronic disease status]	Odds Ratio (Age, gender, educational status, monthly income, presence of a chronic disease, perception of health, smoking status, profession, considering vaccination necessary in their profession, risk perception towards their profession, shift work schedule, current information source usage status, awareness of the unit for healthcare personnel immunization)
Lin 2010 [65] (Taiwan [National])	Not reported (Children) [The Bureau of Health Promotion, Department of Health, Executive Yuan, Republic of China (Taiwan)]	3–24 years (488 - [16.1 (3.29) years])	Self-reported (59.1) [Age, mother's age, and mother's income]	Odds Ratio (Caregiver's relation with child/ adolescent child and caregiver's age)
Lu 2011 [66] (U.S. [National (National Health Interview Survey)])	2009 (Community-dwelling adults) [Centers for Disease Control and Prevention, U.S.]	18–49 years (15,136 - [Not reported])	Self-reported (49.7) [Age, race, marital status, educational attainment, socioeconomic status, being a health professional, visit to a healthcare provider/ hospitalisation in past year, having a place of routine health care, health insurance, hepatitis B or HIV screening, influenza vaccination in past year, and hepatitis A vaccination]	Prevalence ratio (Age, sex, race/ethnicity, marital status, education, employment status, poverty level, physician contacts in past year, hospitalisation in past year, place of routine health care, health insurance, ever tested for HIV, health care personnel, influenza vaccination, and ever received hepatitis A vaccination)
Lu 2011 [67] (U.S. [National (National Health Interview Survey)])	2007 (Higher risk of exposure) [Centers for Disease Control and Prevention, U.S.]	18–49 years (232 - [Not reported])	Self-reported (Not reported) [Age, sex, educational attainment, marital status, and health insurance]	Odds Ratio (Age group, sex, race/ethnicity, education, marital status, household income, and medical insurance status)
Lu 2018 [69] (U.S. [National (National Health Interview Survey)])	2015 (Community-dwelling adults) [Centers for Disease Control and Prevention, U.S.]	≥18 years (Population 1 (11,079) & population 2	Self-reported (50.5 for population 1 & 46.9 for population 2) [Age, sex, race, marital status,	Prevalence ratio (Age, sex, race/ethnicity, marital status, educational level, employment status, poverty level, region of

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Table 2 (*continued*)

Study (Country [Region])	Study period (Population type) [Funder]	Age group (Sample size [Mean age])	Vaccination status (% male) [Assessed factors]	Effect measure (Adjusted factors)
		(21,875) - [Not reported])	educational attainment, employment status, socioeconomic status, U.S. region, native-born, visit to a healthcare provider/hospitalisation in past year, having a place of routine health care, health insurance, hepatitis B or HIV screening, being a health professional, and chronic disease status]	residence, U.S.-born status, number of physician contacts in the past 12 months, hospitalisation in the past 12 months, usual place for health care, health insurance status, ever being tested for HIV, healthcare personnel (HCP) status, ever being lived with someone who had hepatitis diseases, ever having chronic liver disease, and diabetes status)
Lu 2021 [68] (U.S. [National (National Health Interview Survey)])	2018 (Persons with chronic conditions) [Centers for Disease Control and Prevention, U.S.]	$\geq$ 18 years (Not clear - [Not reported])	Self-reported (Not reported) [Age, sex, race, marital status, educational attainment, employment status, socioeconomic status, U.S. region, native-born, visit to a healthcare provider/hospitalisation in past year, having a place of routine health care, health insurance, hepatitis B or HIV screening, being a health professional, influenza vaccination in past year, and chronic disease status]	Prevalence ratio (Age, sex, race/ethnicity, marital status, educational level, employment status, poverty level, region of residence, U.S.-born status, number of physician contacts in the past 12 months, hospitalisation in the past 12 months, usual place for health care, health insurance status, ever being tested for HIV, healthcare personnel (HCP) status, ever being lived with someone who had hepatitis diseases, status of receiving influenza vaccination in the past 12 months, and ever having chronic liver disease)
Macdonald 2007 [70] (Australia [Kings Cross, Sydney])	January 1992 to June 2003 (Community-dwelling adults) [Not reported]	Not reported (2085 - [27 (7.6) years])	Medical record (38.6) [Drug use]	Odds Ratio (Intravenous drug use, intention to deliver accelerated schedule and length of contact with service)
Mak 2013 [71] (Australia [Western region])	2009–2010 (Community-dwelling adults) [Not reported]	Not reported (46,046 - [11.8 (0.5) years])	Medical record (51.8) [Area of residence, school types, and socioeconomic level of school or residential area]	Odds Ratio (Not reported)
Minto'O 2022 [72] (Gabon [Libreville])	April to December 2019 (Children) [Not funded]	4 months to 5 years (500 - [Not reported])	Medical record (48.6) [Parent's employment status]	Odds Ratio (Not reported)
Nguyen 2023 [74] (Vietnam [Tra Vinh University])	April to June 2022 (Community-dwelling adults) [Not funded]	Not reported (459 - [21.5 (1.9) years])	Self-reported (34.2) [Age, and medical training]	Odds Ratio (Not reported)
Ochu 2017 [75] (Nigeria [Kaduna State])	June 17 to July 22, 2015 (Higher risk of exposure) [Not funded]	$\geq$18 years (327 (main data analysis included only 309) - [Not reported])	Self-reported (79.5) [Age, sex, years of service/work experience]	Odds Ratio (Age, sex, duration of service, Cadre, knowledge and risk perception for occupational exposure to hepatitis B virus)
Park 2012 [79] (South Korea [National (Korean National Cancer Screening Survey)])	2005–2008 (Community-dwelling adults) [Grant-in-Aid for Cancer Research and Control from the National Cancer Center, Korea]	30–79 years (4350 - [Not reported])	Self-reported (0) [Age, area of residence, income, employment status, marital status, and private insurance for cancer]	Odds Ratio (Age, area of residence, private insurance for cancer, equivalised household income, duration of education, occupation, self-reported health status, marital status, type of health insurance, smoking and drinking status, and survey year)
Park 2013 [78] (South Korea [National (Korean National Cancer Screening Survey)])	2006–2008 (Community-dwelling adults) [Grant-in-Aid for Cancer Research and Control from the National Cancer Center, Korea]	40–80 years (2174 - [Not reported])	Self-reported (100) [Age, area of residence, income, employment status, marital status, and private insurance for cancer]	Odds Ratio (Age, area of residence, private insurance for cancer, equivalised household income, duration of education, occupation, self-reported health status, marital status, type of health insurance, smoking and drinking status, and survey year)
Perieres 2021 [80] (Senegal [Niakhar])	October 2018 to May 2019 (Children) [The French National Agency for AIDS and Viral Hepatitis Research]	Not clear (241 - [Not reported])	Medical record (45.5) [Place of delivery]	Odds Ratio (Not clear)
Plugge 2007 [81] (United Kingdom [England])	2004 (Higher risk of exposure) [The King's Fund]	21–39 years (487 - [Not reported])	Self-reported (0) [Drug use, having a place of routine health care, and having a bloodborne disease/sexually transmitted disease]	Odds Ratio (Time spent in prison in last 10 years, injected drug use, registered with a general practitioner in the community, contact with drug/alcohol services in the community, receipt of treatment for sexually transmitted infections, and exchange of money or goods for sex)

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Table 2 (*continued*)

Study (Country [Region])	Study period (Population type) [Funder]	Age group (Sample size [Mean age])	Vaccination status (% male) [Assessed factors]	Effect measure (Adjusted factors)
Pulcini 2013 [82] (France [National])	June to December 2010 (Higher risk of exposure) [The Direction de la Recherche, des Etudes, de l'Evaluation etdes Statistiques (DREES) – Ministère du travail, des relations sociales, de la famille, de la solidarité et de la ville, Ministèrede la santé et des sports]	Not reported (1431 (1240 contributed to the main analysis) - [Not reported])	Self-reported (72.7) [Training on infections]	Relative Risk (General practitioner's socio-demographic characteristics, practice characteristics and region of practice)
Queiroz 2019 [83] (Brazil [National])	November 2016 to February 2017 (Higher risk of exposure) [Coordination for the Improvement of Higher Education Personnel]	≥18 years (1855 - [25.7 (7.8) years])	Self-reported (100) [Educational attainment, being a health professional, and having a bloodborne/sexually transmitted disease]	Odds Ratio (Not clear)
Raven 2018 [86] (Netherlands [National (data for behavioural risk groups from the register of the national vaccination program)])	2002–2011 (Higher risk of exposure) [Not reported]	Not reported (18,054 (only 11,891 included in the main analysis) - [37.3 (10) years])	Medical record (83.2) [Sex, and drug use]	Odds Ratio (Age, sex, vaccination period, intravenous drug use, commercial sex work, difference in location of vaccine delivery, and organization of vaccine delivery)
Rhee Kim 2001 [87] (U.S. [The Albany Park neighbourhood in Chicago])	February to October 1998 (Children) [Not reported]	2–5 years (Not reported, but there were 116 mothers - [3.67 (1) years])	Medical record (Not reported) [Age]	Odds Ratio (Not clear)
Segalo 2023 [91] (16 European & 4 non-European countries [Multinational])	November 2020 to February 2021 (Higher risk of exposure) [Not reported]	20–63 years (640 - [44 years])	Self-reported (21.6) [Age]	Odds Ratio (Not reported)
Ssekamatte 2020 [94] (Uganda [Wakiso district])	43,282 (Higher risk of exposure) [Not funded]	Not reported (306 - [29.5 (7.7) years])	Self-reported (32.7) [Sex, medical facility type, and hepatitis B or HIV screening]	Prevalence ratio (Sex, healthcare level, type of facility, location, marital status, ever been screened for, and perceived risk of hepatitis B and safety of the vaccine, increase in infection risk due to job, and use of guidelines)
Ssekamatte 2022 [93] (Uganda [Kampala])	June to July 2019 (Higher risk of exposure) [Not funded]	18–24 years (768 - [21.5 (2.1) years])	Self-reported (78.5) [Age, sex, educational attainment, marital status, income, and hepatitis B or HIV screening]	Odds Ratio (Sex, level of education, marital status, average monthly income, knowledge of the recommended vaccine dose, and the duration of vaccine protection, ever screened for hepatitis B, and attitude towards effectiveness of hepatitis B vaccine)
Taylor 2019 [98] (United Kingdom [London, England])	August 2013 to June 2015 (Higher risk of exposure) [National Institute for Health Research Policy Research Programme]	19–69 years (346 (283 for the main analysis) - [Not reported])	Self-reported (76.3) [Age, sex, native-born, smoking status, drug use, chronic disease status, and having a bloodborne disease/sexually transmitted disease]	Odds Ratio (Not clear)
Tian 2019 [99] (U.S. [National (National Health Interview Surveys)])	2016–2017 (Community-dwelling adults) [The Kunshan Special Fund for Social Development and Science & Technology and the Suzhou "Kejiaoxingwei" Youth Science Project]	≥18 years (19,123 - [Not reported])	Self-reported (47.7) [Age, sex, race, educational attainment, native-born, U.S. region, marital status, sexual orientation, profession, chronic disease status, health insurance, alcohol consumption, smoking status, influenza vaccination in past year, and visit to a healthcare provider/hospitalisation in past year]	Odds Ratio (Chronic liver diseases, ever lived with someone with hepatitis, sexual orientation, sex, born in the U.S., age, religion, race, Hispanic ethnicity, marital status, class of worker, computer use, education, health insurance, ratio of family income to the poverty threshold, drinking, smoking, light/moderate activity, influenza vaccination, and number of physician visits in the past year)
Tressler 2020 [100] (U.S. [West Virginia (hepatitis B Vaccination Pilot Project)])	2013–2015 (Higher risk of exposure) [The National Institutes of Health]	≥18 years (1201 - [Not reported])	Medical record (54.5) [Age, and sex]	Odds Ratio (Age, sex, and race)
Vivian Efua 2024 [102] (Ghana [Five districts within the Greater Accra Region])	Not reported (Higher risk of exposure) [Not funded]	≥20 years (340 - [34.5 (7.7) years])	Self-reported (25.9) [Age, sex, educational attainment, profession, and medical facility type]	Odds Ratio (Not reported)
Wibabara 2019 [104] (Uganda [Makerere University College of Health Sciences])	March to April 2018 (Community-dwelling adults) [Not funded]	18–49 years (760 - [Not reported])	Self-reported (65.1) [Sex]	Prevalence ratio (Not clear)

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Table 2 (*continued*)

Study (Country [Region])	Study period (Population type) [Funder]	Age group (Sample size [Mean age])	Vaccination status (% male) [Assessed factors]	Effect measure (Adjusted factors)
Wu 2015 [105] (China [Fujian Province (using data from the Chinese National Hepatitis Serosurvey, a national cross-sectional survey conducted by the Chinese Centres for Disease Control and Prevention)])	September to October 2006 (Children) [Not reported]	Suggestively up to 12 years (1443 - [Not reported])	Medical record (Not clear) [Sex, area of residence, and place of delivery]	Odds Ratio (Child's age, sex, ethnicity (Han vs She), residential area, and place of delivery (county level or above hospital, township hospital, home or another place))
Yendewa 2023 [106] (Sierra Leone, Liberia, and Guinea [National (Demographic and Health Surveys)])	2019 (Children) [The National Institutes of Health/ AIDS Clinical Trials Group, the Roe Green Center for Travel Medicine and Global Health/University Hospitals Cleveland Medical Center]	4–35 months (4846 - [Not reported])	Self-reported (50) [Sex, area of residence, mother's age, mother's religion, mother's socioeconomic status, parent's educational attainment, and place of delivery]	Odds Ratio (Child's sex, mother's age, educational level, and religion, household wealth index quintiles, number of antenatal visits, place of delivery, big problem, and region)
Yousafzai 2014 [107] (Pakistan [Tehsil Swabi, Khyber Pakhtonkhwa])	July to October 2010 (Higher risk of exposure) [Not reported]	Not reported (485 - [38 (10.4) years])	Self-reported (Not reported) [Medical facility type]	Odds Ratio (Type of healthcare worker, and facility, perceptions about hepatitis B and its vaccination, and job experience)
Yuan 2019 [108] (China [Fujian, Jiangxi, and Gansu Provinces])	Not reported (Higher risk of exposure) [Peking University Health Science Center and the National Key Science and Technology Research on Infections Diseases]	25–60 years (3104 - [Not reported])	Self-reported (34) [Age, sex, profession, training on infections, years of service/work experience, and medical facility type]	Odds Ratio (Not clear)

U.S. = United States of America; U.K. = United Kingdom.

4.2. Vaccination series completion

Mother's socioeconomic status and a child's place of delivery were the only factors found to be associated with vaccination series completion (Table 3), with a significantly increased odds of vaccination series completion observed among those whose mother was of a low compared with a high socioeconomic status [OR 1.22 (1.06–1.39, I^2 0 %, three studies, 11,181 persons)], and among those delivered in a health facility compared with those delivered at home [OR 2.00 (1.41–2.78, I^2 72.9 %, six studies, 10,924,395 persons)]. Forest plots for the assessed factors are presented in **Appendix 4**.

5. Meta-analysis of the association between hepatitis B vaccination initiation and vaccination series completion, and individual socioeconomic and health-related factors in community-dwelling adults

5.1. Vaccination initiation

There was a significantly increased odds of vaccination initiation with reducing age [OR: 1.04 (1.02–1.06, I^2 0 %, two studies, 1887 persons)], being a health professional [OR: 2.02 (1.61–2.54, I^2 97.3 %, two studies, 34,490 persons)], having higher educational attainment [OR: 1.41 (1.29–1.53, I^2 66,8 %, nine studies, 94,619 persons)], having ever been screened for hepatitis B virus or HIV infection [OR: 1.32 (1.10–1.59, I^2 93 %, two studies, 48,090 persons)], influenza vaccination in the past year [OR: 1.59 (1.07–2.39, I^2 87.2 %, two studies, 21,172 persons)], having private insurance for cancer [OR: 1.39 (1.15–1.67, I^2 0 %, two studies, 6524 persons)], and having visited a healthcare provider/hospitalisation in the past year [OR: 1.15 (1.08–1.22, I^2 65.4 %, four studies, 69,262 persons)] (Table 4). Further, compared with Black and Asian adults, White adults had significantly increased odds of vaccination initiation; [OR: 1.15 (1.07–1.23, I^2 0 %, two studies, 52,077 persons)] and [OR: 1.14 (1.06–1.22, I^2 0 %, two studies, 48,090 persons)], respectively. Furthermore, compared with living in the Northeast of the U.S., living in the Midwest significantly increased the odds of vaccination initiation [OR: 1.13 (1.04–1.22, I^2 0 %, two studies, 52,077 persons)]. Forest plots for the assessed factors are presented in **Appendix 4**.

5.2. Vaccination series completion

Being a health professional [OR: 2.18 (1.67–2.84, I^2 96.5 %, two studies, 48,090 persons)], having a higher educational attainment [OR: 1.42 (1.31–1.55, I^2 61.9 %, four studies, 68,147 persons)], having a place of routine health care [OR: 1.08 (1.02–1.14, I^2 0 %, two studies, 48,090 persons)], having ever been screened for hepatitis B virus or HIV infection [OR: 1.33 (1.09–1.61, I^2 92.7 %, two studies, 48,090 persons)], and having visited a healthcare provider/hospitalisation in the past year [OR: 1.17 (1.09–1.27, I^2 80.9 %, three studies, 67,213 persons)] significantly increased the odds of vaccination series completion (Table 4). Further, compared with Black and Asian adults, White adults had significantly increased odds of vaccination series completion; [OR: 1.16 (1.06–1.25, I^2 0 %, two studies, 52,077 persons)] and [OR: 1.23 (1.14–1.33, I^2 0 %, two studies, 48,090 persons)], respectively. Furthermore, compared with living in the Northeast of the U.S., living in the Midwest significantly increased the odds of completing the vaccination series [OR: 1.15 (1.02–1.30, I^2 38.1 %, two studies, 52,077 persons)]. Forest plots for the assessed factors are presented in **Appendix 4**.

6. Meta-analysis of the association between hepatitis B vaccination initiation and vaccination series completion and individual socioeconomic and health-related factors in persons at a higher risk of exposure

6.1. Vaccination initiation

There was significantly increased odds of vaccination initiation among older persons [OR: 1.36 (1.02–1.80, I^2 95.5 %, 10 studies, 175,993 persons)], and with having higher educational attainment [OR: 1.97 (1.36–2.87, I^2 48.6 %, four studies, 165,534 persons)], having ever been screened for hepatitis B virus or HIV infection [OR: 1.68 (1.26–2.24, I^2 0 %, two studies, 1891 persons)], influenza vaccination in the past year [OR: 1.81 (1.02–3.20, I^2 0 %, two studies, 1388 persons)], being married/cohabiting compared with being single, separated, divorced, or widowed [OR: 1.44 (1.21–1.72, I^2 0 %, two studies, 1908

Table 3
Meta-analysis of association between individual socioeconomic and health-related characteristics, and hepatitis B vaccination initiation and vaccination series completion in paediatric population.

Individual characteristics	Comparison	Vaccination initiation				Completion of vaccination series			
		No. of studies	Total Sample	Adjusted odds ratio with 95 % CI (Pooled*)	I^2 statistic (%)	No. of studies	Total Sample	Adjusted odds ratio with 95 % CI (Pooled*)	I^2 statistic (%)
Age	Older vs. younger	–	–	–	–	3	5315	0.53 (0.11–2.62)*	98.1 %
	Increase in age as a continuous variable	–	–	–	–	1	NR	0.64 (0.36–1.15)	–
Area of residence	Urban vs. rural	1	6143	0.86 (0.69–1.06)	–	5	15,254	0.84 (0.64–1.10)*	60 %
Health insurance	Insured vs. uninsured	–	–	–	–	1	2882	0.58 (0.33–0.87)	–
	Public vs. private	1	40,269	1.17 (1.08–1.26)	–	1	2882	0.95 (0.65–1.38)	–
Medical facility type	Tertiary vs. secondary/primary level	1	40,269	1.05 (0.98–1.11)	–	–	–	–	–
Mother's age	Older vs. younger	2	174,341	1.00 (0.59–1.69)*	95.7 %	3	9928	1.13 (0.66–1.94)*	89.3 %
Mother's race	Black vs. White	2	208,467	1.03 (0.58–1.81)*	99.3 %	–	–	–	–
	Asian vs. White	2	208,467	**1.50 (1.31–1.72)***	64.9 %	–	–	–	–
	Hispanic vs. White	1	40,269	1.22 (1.09–1.37)	–	–	–	–	–
Mother's income	High vs. low	–	–	–	–	1	488	3.04 (2.01–4.59)	–
Mother's socioeconomic status	High vs. low	1	6143	1.78 (1.51–2.09)	–	3	11,181	**0.82 (0.72–0.94)***	0 %
Mother's religion	Muslim vs. Christian mother	1	6143	0.72 (0.56–0.93)	–	4	15,775	0.89 (0.55–1.46)*	89.2 %
Parent's educational attainment	Higher vs. lower	1	6143	2.26 (1.94–2.64)	–	7	10,931,970	1.16 (0.88–1.52)*	85.7 %
Parent's employment status	Employed vs. unemployed	–	–	–	–	2	10,912,030	0.83 (0.55–1.27)*	68 %
Parent's marital status	Married/cohabiting vs. single/separated/divorced/widowed	1	6143	0.84 (0.52–1.37)	–	3	8768	1.23 (0.67–2.27)*	88.2 %
	Single vs. separated/divorced/widowed	1	6143	0.77 (0.39–1.52)	–	–	–	–	–
Place of delivery	Home vs. a health facility	1	6143	0.53 (0.42–0.66)	–	6	10,924,395	**0.50 (0.36–0.71)***	72.9 %
	Private vs. public health facility	1	6143	0.77 (0.59–99)	–	–	–	–	–
Race	Black vs. White	–	–	–	–	1	2882	0.90 (0.57–1.43)	–
	Hispanic vs. White	–	–	–	–	1	2882	1.14 (0.70–1.85)	–
School types	Private vs. public	–	–	–	–	1	46,046	1.11 (1.03–1.20)	–
Sex	Female vs. male	1	6143	0.99 (0.86–114)	–	3	9077	0.89 (0.65–1.23)*	82.2 %
Socioeconomic level of school or residential area	High vs. low	–	–	–	–	2	10,957,576	1.83 (0.74–4.53)*	97.5 %
	High vs. low	–	–	–	–	1	4594	1.46 (1.21–1.76)	–
Socioeconomic status	At or above vs. below federal poverty level	–	–	–	–	1	2882	1.08 (0.69–1.69)	–
U.S. region of residence	Midwest vs. Northeast	–	–	–	–	1	2882	0.33 (0.20–0.55)	–
	South vs. Northeast	–	–	–	–	1	2882	0.32 (0.20–0.51)	–
	West vs. Northeast	–	–	–	–	1	2882	0.38 (0.22–0.65)	–
Visited a healthcare provider/hospitalisation in past year	Visited/hospitalised vs. not	–	–	–	–	1	4594	1.37 (1.15–1.63)	–

U.S. = United States of America; CI = confidence interval; No = number; Bold = statistically significant.

persons)], other clinical staff (for example, nurses, laboratory workers, and morticians) compared with physicians/dentists [OR: 1.49 (1.06–2.11, I^2 74.4 %, two studies, 8918 persons)], and having been trained on infections [OR: 1.99 (1.64–2.42, I^2 0 %, two studies, 3435 persons)] (Table 5). Forest plots for the assessed factors are presented in **Appendix 4**.

6.2. Vaccination series completion

Having a history of drug use [OR: 2.53 (1.60–3.99, I^2 63.6 %, three studies, 12,661 persons)], having ever been screened for hepatitis B virus or HIV infection [OR: 2.27 (1.29–3.99, I^2 68.7 %, three studies, 5344 persons)], being married/cohabiting compared with being single, separated, divorced, or widowed [OR: 2.18 (1.25–3.81, I^2 0 %, three studies, 1410 persons)], other clinical staff compared with physicians/dentists [OR: 1.24 (1.10–1.39, I^2 0 %, three studies, 3830 persons)], being female [OR: 1.33 (1.10–1.62, I^2 70.6 %, 12 studies, 19,608 persons)], being a current or former smoker [OR: 2.42 (1.19–4.93, I^2 0 %, two studies, 566 persons)], and having longer years of service or work experience [OR: 2.52 (1.06–6.04, I^2 92 %, five studies, 4469 persons)] significantly increased the odds of vaccination series completion (Table 5). Forest plots for the assessed factors are presented in **Appendix 4**.

7. Meta-analysis of the association between hepatitis B vaccination initiation and vaccination series completion, and individual socioeconomic and health-related factors in persons with chronic medical condition(s)

7.1. Vaccination initiation

Age was the only factor associated with vaccination initiation, with significantly increased odds of vaccination initiation seen with being

Table 4
Meta-analysis of association between individual socioeconomic and health-related characteristics, and hepatitis B vaccination initiation and vaccination series completion in community-dwelling adults.

Individual characteristics	Comparison	Vaccination initiation				Completion of vaccination series			
		No. of studies	Total Population	Adjusted odds ratio with 95 % CI (Pooled*)	I^2 statistic (%)	No. of studies	Total Population	Adjusted odds ratio with 95 % CI (Pooled*)	I^2 statistic (%)
Age	Older vs. younger	13	122,535	0.76 (0.49–1.19)*	99.4 %	7	74,765	0.87 (0.48–1.58)*	99.6 %
	Increase in age as a continuous variable	2	1887	**0.96 (0.94–0.98)***	0 %	1	934	1.01 (0.98–1.04)	–
Alcohol consumption	History vs. no history of drinking	1	19,123	0.89 (0.80–1.00)	–	1	19,123	0.90 (0.79–1.01)	–
Area of residence	Urban vs. rural	2	4283	0.81 (0.49–1.32)*	46.1 %	5	53,921	1.28 (0.99–1.65)*	83.3 %
Being a health professional	Health professional vs. not	2	34,490	**2.02 (1.61–2.54)***	97.3 %	2	48,090	**2.18 (1.67–2.84)***	96.5 %
Chronic disease	Having vs. not	3	53,648	1.06 (0.77–1.47)*	53.5 %	2	52,077	1.04 (0.94–1.15)*	0 %
Drug use	History vs. no history of drug use	–	–	–	–	1	2085	0.94 (0.74–1.19)	–
Educational attainment	Higher vs. lower	9	94,619	**1.41 (1.29–1.53)***	66.8 %	4	68,147	**1.42 (1.31–1.55)***	61.9 %
Employment status	Employed vs. unemployed	8	92,904	1.24 (0.95–1.62)*	96.1 %	4	40,412	1.03 (0.96–1.09)*	0 %
Family's socioeconomic status	High vs. low	1	5104	1.50 (1.16–1.94)	–	–	–	–	–
Having a place of routine health care	Having vs. not	3	48,900	1.03 (0.97–1.10)*	22.7 %	2	48,090	**1.08 (1.02–1.14)***	0 %
Health insurance	Insured vs. uninsured	5	68,339	1.09 (1.00–1.19)*	35.3 %	3	67,213	1.06 (0.97–1.17)*	41.7 %
Hepatitis A vaccination	Vaccinated vs. unvaccinated	1	15,136	2.60 (2.50–2.70)	–	1	15,136	2.70 (2.56–2.85)	–
Hepatitis B or HIV screening	Ever screened vs. never screened	2	48,090	**1.32 (1.10–1.59)***	93 %	2	48,090	**1.33 (1.09–1.61)***	92.7 %
Income	High vs. low	4	8244	1.08 (0.82–1.42)*	85.9 %	3	7458	0.74 (0.67–0.81)*	0 %
Influenza vaccination in past year	Vaccination vs. unvaccinated	2	21,172	**1.59 (1.07–2.39)***	87.2 %	2	34,259	1.57 (0.93–2.65)*	98.4 %
Marital status	Married/cohabiting vs. single/separated/divorced/widowed	9	100,017	1.01 (0.94–1.09)*	32 %	5	73,737	1.00 (0.92–1.08)*	39.7 %
	Single vs. separated/divorced/widowed	2	52,077	0.99 (0.91–1.09)*	25.4 %	3	67,213	0.99 (0.93–1.06)*	0 %
Medical check-up	Regular check-up vs. not	1	1404	1.79 (1.35–2.38)	–	1	934	2.70 (1.57–4.67)	–
Medical training	Medicine vs. nursing/midwifery	–	–	–	–	2	876	1.32 (0.07–24.49)*	85.6 %
	Public health vs. nursing/midwifery	–	–	–	–	2	876	1.79 (0.83–3.88)*	0 %
	Nursing vs. midwifery	–	–	–	–	1	417	2.30 (0.50–9.30)	–
	Nursing/midwifery vs. medical laboratory sciences	–	–	–	–	2	986	1.31 (0.63–2.73)*	29.7 %
Native-born	No vs. Yes	4	55,530	1.23 (0.92–1.64)*	90.2 %	–	–	–	–
Pneumococcal vaccination	Vaccinated vs. unvaccinated	1	2049	1.72 (1.25–2.36)	–	–	–	–	–
Private insurance for cancer	Insured vs. uninsured	2	6524	**1.39 (1.15–1.67)***	0 %	3	7458	1.06 (0.64–1.75)*	89.5 %
Employment	Government vs. private employees	1	1,9123	1.45 (1.30–1.61)	–	1	19,123	1.49 (1.32–1.68)	–
Race	Black vs. White	2	52,077	**0.87 (0.81–0.93)***	0 %	2	52,077	**0.86 (0.80–0.94)***	0 %
	Asian vs. White	1	32,954	1.10 (1.00–1.21)	–	1	32,954	1.09 (0.97–1.22)	–
	Hispanic vs. White	2	48,090	**0.88 (0.82–0.94)***	0 %	2	48,090	**0.81 (0.75–0.88)***	0 %
	Asian vs. Black	1	19,123	0.96 (0.78–1.18)	–	1	19,123	0.97 (0.78–1.21)	–
Sex	Female vs. male	9	113,070	1.07 (0.96–1.19)*	88.3 %	6	54,757	1.09 (0.83–1.43)*	93.6 %
Sexual orientation	Gay/lesbian/bisexual vs. not	1	19,123	1.30 (1.04–1.63)	–	1	19,123	1.30 (1.00–1.68)	–
Smoking status	Current/former vs. non-smokers	2	20,694	0.96 (0.74–1.24)*	11.3 %	1	19,123	0.98 (0.89–1.08)	–
	At or above vs. below federal poverty level	2	48,090	0.99 (0.93–1.05)*	0 %	2	48,090	1.01 (0.93–1.10)*	0 %
U.S. region of residence	Midwest vs. Northeast	2	52,077	**1.13 (1.04–1.22)***	0 %	2	52,077	**1.15 (1.02–1.30)***	38.1 %
	South vs. Northeast	2	52,077	1.02 (0.95–1.09)*	0 %	2	52,077	1.01 (0.90–1.12)*	35.8 %
	West vs. Northeast	2	52,077	1.19 (1.00–1.41)*	75.5 %	2	52,077	1.26 (0.98–1.63)*	81.7 %

(*continued on next page*)

Table 4 (*continued*)

Individual characteristics	Comparison	Vaccination initiation				Completion of vaccination series			
		No. of studies	Total Population	Adjusted odds ratio with 95 % CI (Pooled*)	I^2 statistic (%)	No. of studies	Total Population	Adjusted odds ratio with 95 % CI (Pooled*)	I^2 statistic (%)
Visited a healthcare provider/ hospitalisation in past year	Visited/hospitalised vs. not	4	69,262	**1.15 (1.08–1.22)***	65.4 %	3	67,213	**1.17 (1.09–1.27)***	80.9 %

U.S. = United States of America; CI = confidence interval; No = number; Bold = statistically significant.

younger [OR: 2.94 (1.49–5.88, I^2 84.4 %, two studies, 37,220 persons)] (Table 6). Forest plots for the assessed factors are presented in **Appendix 4.**

7.2. Vaccination series completion

Being a health professional [OR 2.09 (1.68–2.61, I^2 0 %, two studies, unclear number of persons)] and having higher educational attainment [OR 1.37 (1.17–1.61, I^2 27.4 %, two studies, unclear number of persons)] significantly increased the odds of vaccination series completion (Table 6). Forest plots for the assessed factors are presented in **Appendix 4.**

8. Discussion

This systematic review with meta-analysis provides a detailed summary of published peer-reviewed evidence of multivariable-adjusted associations between individual socioeconomic and health-related factors and hepatitis B vaccination initiation and vaccination series completion in population subgroups of public health importance. While there was a small but considerable amount of published evidence on community-dwelling adults and persons at a higher risk of exposure to hepatitis B infection, there was a paucity of published evidence on paediatric populations and persons with chronic disease(s). Nevertheless, generally, age, race, sex, marital status, socioeconomic status, educational attainment, drug use, smoking, health profession, health experience and training, health insurance, and contact with the health system appeared to influence hepatitis B vaccination.

A lack of published similar systematic reviews with meta-analyses on the topic means there are no prior findings from systematic reviews against which to compare our findings. Nevertheless, our previous evaluations of socioeconomic and health-related factors associated with influenza vaccination in older adults (≥65-year-olds), pregnant women, and cancer patients [109–112], and with human papillomavirus vaccination initiation and vaccination series completion in paediatric and adult males and females [113–115], revealed mostly similar associations as found in this present systematic review, thus, suggesting that most of the identified factors may impact on vaccination appetite and decision-making across populations irrespective of vaccine type. Therefore, understanding these factors and how they may influence each other may be the key to designing more potent interventions to increase the uptake of vaccines across populations; in particular, education, employment/income, and healthcare utilisation are among the strongest influencing factors, irrespective of vaccine type. Further, similar to our findings, a systematic review and meta-analysis of evidence on healthcare workers in Africa found that those with ten or more years of experience (OR: 2.2, (95 % CI: 1.5–3.3)) were more likely to complete hepatitis B vaccination series and that doctors were more likely than nurses (OR: 2.6 (95 % CI: 1.8–3.7)) to complete the vaccination series [116]. Similarly, a systematic review with meta-analysis of evidence on healthcare workers in Ethiopia alone found that being female, having a higher educational attainment, more work experience, and training on infection increased the likelihood of vaccination series completion [117]. However, it was unclear if the pooled estimates from the included studies were all multivariable-adjusted estimates and whether the outcome across the studies was actual receipt of vaccine or willingness to complete the vaccination series.

Whereas being of the White race increased the odds of vaccination initiation among community-dwelling adults, we observed the opposite among the paediatric population with mother's race, particularly with mother being of Asian race. Trust in medicaments and health systems impacts utilisation of preventive care services by race, as previous studies have found [118,119]. However, this may not fully explain our findings, and it may be challenging to explain with certainty, especially considering that little is known regarding the determinants of uptake of hepatitis B vaccination. We observed an interesting and potentially difficult-to-explain mixed effect of age, with being younger associated with increased odds of vaccination initiation among community-dwelling adults and the opposite observed among persons at a higher risk of exposure. However, persons at a higher risk of exposure are a composite group of diverse subgroups; therefore, the effect of age may vary across the subpopulations.

Studies have shown that increased contact with health systems improves access to and receipt of preventive care [120–122]. This may explain the observed increased odds of vaccination initiation and vaccination series completion with having ever been screened for hepatitis B virus or HIV infection, having received influenza vaccination in the past year, having visited a healthcare provider/hospitalisation in the past year, and having a place of routine health care among community-dwelling adults and persons at a higher risk of exposure to hepatitis B virus infection. Further, having health insurance [123,124], a person's educational attainment [125,126], and income/socioeconomic status [127,128], have all been demonstrated to positively influence receipt of preventive care just as we observed irrespective of the review population. While these findings are helpful insights, they also suggest health inequality in hepatitis B vaccination [129], which is quite concerning. Nevertheless, the vaccination decision is a multifactorial process involving knowledge, attitudes, practices, religion [130–132], and availability and access to vaccines and vaccination services.

Our finding of an increased odds of vaccination series completion with longer years of service or work experience among healthcare workers suggests that academic detailing and regular training of healthcare workers on preventive care and vaccination services could increase hepatitis B vaccination among this important subpopulation who have a leading role to play and are vital advocates of preventive care and one of the primary sources of vaccination information for the public [133,134]. Noteworthy is that while the recommendation of hepatitis B vaccination to healthcare workers may be similar across jurisdictions, the provision of free-of-charge vaccination and a mandatory requirement for healthcare workers to be vaccinated varies across jurisdictions and could, therefore impact vaccination initiation and vaccination series completion in this population subgroup. Nevertheless, knowledge is an extremely important factor in any decision-making process. Hence, as our findings suggest, it may mean that irrespective of jurisdiction, impacting home birth attendants with adequate knowledge on childhood immunisations may not only help address misconceptions but also empower and help them to educate parents and increase uptake of hepatitis B vaccine and potentially other childhood

Table 5
Meta-analysis of association between individual socioeconomic and health-related characteristics, and hepatitis B vaccination initiation and vaccination series completion in persons at a higher risk of exposure.

Individual characteristics	Comparison	Vaccination initiation				Completion of vaccination series			
		No. of studies	Total Population	Adjusted odds ratio with 95 % CI (Pooled*)	I^2 statistic (%)	No. of studies	Total Population	Adjusted odds ratio with 95 % CI (Pooled*)	I^2 statistic (%)
Age	Older vs. younger	10	175,993	**1.36 (1.02–1.80)***	95.5 %	12	13,921	1.22 (0.93–1.60)*	87.7 %
	Increase in age as a continuous variable	4	1692	0.93 (0.84–1.04)*	87.9 %	2	713	0.97 (0.78–1.22)*	62.8 %
Alcohol consumption	History vs. no history of drinking	–	–	–	–	3	2304	1.28 (0.76–2.13)*	87.8 %
Area of residence	Urban vs. rural	1	626	2.50 (1.25–5.00)	–	–	–	–	–
Being a health professional	Health professional vs. not	4	4099	0.97 (0.41–2.31)*	77 %	3	5299	0.94 (0.39–1.49)*	89.7 %
Chronic disease	Having vs. not	–	–	–	–	2	661	1.10 (0.26–4.59)*	86.5 %
Drug use	History vs. no history of drug use	2	1481	0.93 (0.22–4.04)*	90.1 %	3	12,661	**2.53 (1.60–3.99)***	63.6 %
Educational attainment	Higher vs. lower	4	165,534	**1.97 (1.36–2.87)***	48.6 %	9	9946	1.16 (0.72–1.85)*	94.8 %
Having a bloodborne/sexually transmitted disease	Having vs. not	–	–	–	–	5	7521	1.06 (0.51–2.21)*	91 %
Having a place of routine health care	Having vs. not	1	1036	1.88 (1.33–2.66)	–	1	487	0.81 (0.46–1.42)	–
Health insurance	Insured vs. uninsured	–	–	–	–	1	232	1.80 (0.60–5.40)	–
Hepatitis B or HIV screening	Ever screened vs. never screened	2	1891	**1.68 (1.26–2.24)***	0 %	3	5344	**2.27 (1.29–3.99)***	68.7 %
Income	High vs. low	1	232	0.84 (0.39–1.81)	–	3	1654	1.80 (0.55–5.86)*	81.8 %
Influenza vaccination in past year	Vaccination vs. unvaccinated	2	1388	**1.81 (1.02–3.20)***	0 %	–	–	–	–
Marital status	Married/cohabiting vs. single/separated/divorced/widowed	2	1908	**1.44 (1.21–1.72)***	0 %	3	1410	**2.18 (1.25–3.81)***	0 %
Medical facility type	Tertiary vs. secondary/primary level	3	3747	1.46 (0.64–3.34)*	87.3 %	2	3444	0.90 (0.28–2.88)*	77.8 %
	Private vs. public	1	331	1.60 (0.50–2.70)	–	3	1201	1.59 (0.64–3.97)*	85.5 %
Native-born	No vs. Yes	2	11,536	0.73 (0.37–1.42)*	88.5 %	2	4553	0.96 (0.74–1.23)*	0 %
Pneumococcal vaccination	Vaccinated vs. unvaccinated	1	1036	1.72 (1.29–2.29)	–	–	–	–	–
Clinical department of work	Other clinical staff vs. physicians/dentists	7	8918	**1.49 (1.06–2.11)***	74.4 %	3	3830	**1.24 (1.10–1.39)***	0 %
	Other clinical unit staff vs. outpatient staff	2	2686	1.03 (0.37–2.86)*	79.2 %	1	386	1.07 (0.54–2.14)	–
	Other clinical staff vs. emergency department staff	1	505	1.40 (0.75–2.62)	–	–	–	–	–
Race	Black vs. White	1	10,681	0.83 (0.64–1.07)	–	1	1260	1.56 (1.04–2.34)	–
	Asian vs. White	1	10,681	0.63 (0.45–0.89)	–	–	–	–	–
Religion	Muslim vs. Orthodox Christian	1	505	1.47 (0.84–2.55)	–	1	410	0.67 (0.26–1.71)	–
	Protestant vs. Orthodox Christian	1	505	0.53 (0.31–0.91)	–	1	410	1.34 (0.62–2.92)	–
Sex	Female vs. male	7	8635	1.07 (0.96–1.20)*	0 %	12	19,608	**1.33 (1.10–1.62)***	70.6 %
Smoking status	Current/former vs. non-smokers	–	–	–	–	2	566	**2.42 (1.19–4.93)***	0 %
Training on infections	Training vs. no training	2	3435	**1.99 (1.64–2.42)***	0 %	2	4344	1.22 (0.84–1.78)*	92 %
Visited a healthcare provider/hospitalisation in past year	Visited/hospitalised vs. not	2	1206	2.09 (0.53–8.16)*	89.9 %	–	–	–	–
Work unit	Other clinical unit staff vs. outpatient staff	–	–	–	–	1	386	1.67 (0.87–3.21)	–
Years of service/work experience	Longer vs. shorter	7	6872	1.04 (0.86–1.27)*	88.5 %	5	4469	**2.52 (1.06–6.04)***	92 %

U.S. = United States of America; CI = confidence interval; No = number; Bold = statistically significant.

vaccines among home-delivered babies. Likewise, sustained and well-tailored public education on preventive care and vaccination services may not only help address misconceptions and vaccine hesitancy but may also encourage good healthcare-seeking behaviours, which could lead to more contact with healthcare providers and, conversely, the likelihood of being recommended and uptake of a necessary vaccination. To optimise the effectiveness of hepatitis B vaccination programmes, emphasis should be placed on effective approaches to engaging with

Table 6
Meta-analysis of association between individual socioeconomic and health-related characteristics, and hepatitis B vaccination initiation and vaccination series completion in persons with chronic medical condition(s).

Individual characteristics	Comparison	Vaccination initiation				Completion of vaccination series			
		No. of studies	Total Population	Adjusted odds ratio with 95 % CI (Pooled*)	I^2 statistic (%)	No. of studies	Total Population	Adjusted odds ratio with 95 % CI (Pooled*)	I^2 statistic (%)
Age	Older vs. younger	2	37,220	**0.34 (0.17–0.67)***	84.4 %	1	Unclear	1.43 (1.21–1.70)	–
	Increase in age as a continuous variable	–	–	–	–	1	255	0.97 (0.93–1.01)	–
Alcohol consumption	History vs. no history of drinking	1	36,489	1.34 (1.16–1.55)	–	–	–	–	–
Being a health professional	Health professional vs. not	–	–	–	–	2	Unclear	**2.09 (1.68–2.61)***	0
Educational attainment	Higher vs. lower	1	36,489	0.63 (0.53–0.74)	–	2	Unclear	**1.37 (1.17–1.61)***	27.4 %
Employment status	Employed vs. unemployed	–	–	–	–	1	Unclear	1.04 (0.84–1.29)	–
Having a place of routine health care	Having vs. not	–	–	–	–	1	Unclear	1.35 (0.82–2.23)	–
Health insurance	Insured vs. uninsured	1	36,489	1.19 (0.68–2.09)	–	1	Unclear	1.18 (0.84–1.65)	–
Hepatitis B or HIV screening	Ever screened vs. never screened	–	–	–	–	1	Unclear	1.57 (1.32–1.86)	–
Influenza vaccination in past year	Vaccination vs. unvaccinated	–	–	–	–	1	Unclear	1.07 (0.89–1.28)	–
Marital status	Married/cohabiting vs. single/separated/ divorced/widowed	1	36,489	1.21 (0.93–1.57)	–	1	Unclear	1.12 (0.97–1.30)	–
Native-born	No vs. Yes	1	36,489	1.33 (0.53–3.36)	–	1	Unclear	1.13 (0.84–1.52)	–
Race	Black vs. White	1	36,489	1.36 (1.10–1.68)	–	–	–	–	–
	Asian vs. White	1	36,489	1.36 (1.29–1.43)	–	–	–	–	–
	Hispanic vs. White	1	36,489	0.80 (0.26–2.42)	–	–	–	–	–
Sex	Female vs. male	2	37,220	1.15 (0.50–2.64)*	86.8 %	2	Unclear	0.95 (0.79–1.13)*	0 %
	At or above vs. below federal poverty level	–	–	–	–	1	Unclear	0.95 (0.74–1.22)	–
U.S. region of residence	Midwest vs. Northeast	–	–	–	–	1	Unclear	1.07 (0.81–1.41)	–
	South vs. Northeast	–	–	–	–	1	Unclear	0.86 (0.66–1.12)	–
	West vs. Northeast	–	–	–	–	1	Unclear	1.20 (0.90–1.59)	–
Visited a healthcare provider/ hospitalisation in past year	Visited/hospitalised vs. not	–	–	–	–	1	Unclear	1.06 (0.91–1.23)	–

U.S. = United States of America; CI = confidence interval; No = number; Bold = statistically significant.

different population subgroups utilising evidence-based targeted public health messaging and education. This would encourage hepatitis B vaccination among those who may not have had the opportunity to be vaccinated in infancy/adolescence, especially persons at a higher risk of infection for whom the vaccine is most advocated in adulthood.

We must note that we defined vaccination initiation as receiving at least one vaccine. This meant potentially including persons who may have completed the vaccination series. Nonetheless, any impact of such inclusion is unlikely detrimental considering that our focus was on factors that may influence receipt of vaccination irrespective of the number of vaccine doses received. We summarised the factors reported in the included studies. As such, this review may not be an exhaustive summary of all potentially relevant socioeconomic/health-related factors that could influence hepatitis B vaccination. While analysis by study region would have added value to this review given potential variations in hepatitis B trends and vaccination recommendations/programmes between regions (geographical regions and developed/developing countries), in most instances, such analysis was not feasible due to little available evidence. Where such analysis may be possible, the pooled estimates were considerably similar irrespective of study region/jurisdiction, thus suggesting that the influence of the evaluated factors on vaccination initiation/completion may be similar across jurisdictions.

Nevertheless, regional variations in the influence of some of the assessed factors may exist, and this, in part, may explain the observed high heterogeneity in some of the pooled estimations, in addition to the effect of differences in methods of estimations, the comparisons made on the individual factors across the studies, and our regrouping of some of the comparisons for uniformity of assessment [135]. Future studies with substantial data should aim to assess regional variations in the pooled analyses. Notwithstanding these potential limitations, this review represents the first of its kind, providing evidence-based insights that could aid optimisation of hepatitis B vaccination across jurisdictions.

9. Conclusions

Our findings suggest that many individual socioeconomic and health-related factors influence hepatitis B vaccination, particularly in community-dwelling adults and persons at a higher risk of exposure to hepatitis B infection. The findings may inform targeted messaging to optimise hepatitis B vaccination programmes globally, balancing the focus on infant and young children's vaccinations with the make-up opportunity for adult vaccination, particularly among those not so fortunate to have adolescent vaccination and those at a higher risk of infection.

Contributor and guarantor information

Conceptualisation (GN Okoli); Methodology (GN Okoli, CJ Neilson, & DM Harper); Data acquisition (GN Okoli, A Grossman Moon, AE Soos, CJ Neilson & DM Harper); Formal analysis (GN Okoli); Draft manuscript (GN Okoli); Manuscript revisions (GN Okoli, A Grossman Moon, AE Soos, CJ Neilson & DM Harper); Final manuscript draft (GN Okoli, A

Grossman Moon, AE Soos, CJ Neilson & DM Harper); Manuscript guarantor (GN Okoli). The corresponding author (the manuscript's guarantor) attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Data sharing

All data for this study are presented in the manuscript and as supplementary information.

CRediT authorship contribution statement

George N. Okoli: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Alexandra Grossman Moon:** Writing – review & editing, Visualization, Investigation, Data curation. **Alexandra E. Soos:** Writing – review & editing, Visualization, Investigation, Data curation. **Christine J. Neilson:** Writing – review & editing, Visualization, Resources, Methodology, Investigation, Data curation. **Diane M. Harper:** Writing – review & editing, Visualization, Validation, Resources, Methodology, Investigation, Data curation.

Statements and Declarations

All authors declare that they have no perceived conflicts of interest. The corresponding author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2025.127051.

Data availability

No data was used for the research described in the article.

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