

Hepatitis B Vaccination Coverage in Germany: Systematic Review

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Abstract

Background: Despite being considered as a low prevalence country for hepatitis B (HBV), some populations in Germany are at higher risk of infection. In the context of the World Health Organization's (WHO) viral hepatitis elimination goals a valid epidemiological data base is needed to plan and monitor the national response. Prevention strategies include general and targeted HBV vaccination programmes.

Objective: The aim of this work was to estimate the HBV vaccination coverage (VC) in the general population (GP) and different population groups in Germany from available evidence and to identify current evidence gaps for future research.

Methods: We conducted a systematic review on HBV VC in the general population and populations at high risk of HBV exposure or severe infection in Germany. We included eligible publications (01/01/2017 to 06/06/2020) from databases Embase, Pubmed and Livivo, from a previous scoping review (including data published 01/01/2005-17/03/2017), from the national surveillance system and screened the reference lists of all publications at full text level. Risk of bias was assessed using the Hoy et al tool.

Results: We included 68 publications of 67 studies and assigned them to the respective population groups. Twenty-one studies contained data among children/adolescents and three among adults from the GP (VC 65.8% - 90.5% and 22.9% - 52.1%, respectively), one among travellers to HBV endemic countries (VC 89%), 13 among immunocompromised populations (VC 11.5% - 89%), 16 among populations with occupational risk and 16 with non-occupational risk of HBV exposure (VC 63.6% - 96.5% and 4.4% - 52%, respectively).

Conclusion: Comprehensive evidence at low risk of bias was identified for children/adolescents. However, 25 years after including HBV in the national immunisation schedule, VC in Germany is still below the 95%-goal defined by WHO. For people at occupational risk of HBV exposure, VC was mostly reported to be over the WHO goal of 80%, but quality of evidence was heterogeneous and should be improved. For people at non-occupational risk of HBV exposure, evidence was sparse and of low quality. The low VC highlights the need for future research to plan vaccination programmes targeting these populations.

Background

Hepatitis B is a potentially life-threatening viral infection causing acute and chronic infection. In the World Health Organization (WHO) European Region, around 15 million people are infected with the hepatitis B virus (HBV). Annually, 56,000 persons die, mostly due to chronic HBV infection-related long-term sequelae like liver cirrhosis and hepatocellular carcinoma (1). There is no specific treatment available for acute HBV infection, and treatment of chronic HBV infection can prevent the development of sequelae but mostly does not eradicate the virus. However, since the 1980s highly effective vaccines against HBV are available.

With a HBV prevalence of 0.3% found in the latest population-based survey *German Health Interview and Examination Survey for Adults* (DEGS1) Germany is considered to be a low prevalence country (2). Still, some populations in Germany may be at higher risk of HBV because of frequent contacts with infected blood or body fluids by occupational or non-occupational exposure or because they migrated from HBV endemic countries (3-6). Higher prevalence among these groups has been reported (7).

Since 1995 the three, respectively four-dose (depending on the vaccine used) HBV vaccination in early infancy (0 to 14 months) and catch-up vaccination in non-vaccinated adolescents up to 18 years are part of the national immunisation schedule by the *German Standing Committee on Vaccination* (STIKO) (8) and are covered by the German health insurance funds. Furthermore, HBV vaccination (including booster doses if applicable) is recommended for travellers to areas with a high HBV seroprevalence in the population, for adults at risk of severe HBV due to immunodeficiency /immunosuppression and increased risk for occupational or non-occupational HBV exposure (e.g. intravenous drug use, changing sexual contacts) (9). For adults in the general population not belonging to one of the above-mentioned indication groups, vaccination is not recommended.

The European Vaccine Action Plan 2015–2020 defined HBV control through immunisation as one of its major strategic goals (10). Furthermore, to reach the goal of eliminating viral hepatitis as a public health threat in Europe by 2030, the action plan for the health sector response to viral hepatitis in the WHO European Region, which was released in 2016, states worldwide vaccination goals to reduce transmission of HBV (11). These include overall HBV childhood vaccination coverage (VC) of 95% with three doses of HBV vaccine, prevention of mother to child transmission and 80% VC in health care workers (HCW). The prevention of HBV transmission associated with intravenous drug use is highlighted as an important element of the action plan, including control through vaccination. Meanwhile, the German government's integrated strategy for human immunodeficiency viruses (HIV), HBV, Hepatitis C (HCV) and other sexually transmitted infections calls for data to improve the national response to the WHO elimination goals (12). This strategy focuses on viral hepatitis control, and prevention strategies among groups at increased risk of acquiring and transmitting the viral hepatitis. In this context, evidence-based knowledge about HBV VC in different population groups in Germany is essential to support targeted vaccination programmes in populations with vaccination gaps, and to monitor their implementation.

The aim of this work is therefore to estimate the VC in different population groups in Germany in light of the available evidence, and to identify evidence gaps as a target for further research.

Methods

Search strategy and review process

The systematic review followed a protocol registered in the Prospective Register for Systematic Reviews (PROSPERO; registration no. CRD42020186280). The search and reporting methods used were consistent

with the guidelines in the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement (13).

The research question was “What is HBV immunisation coverage in Germany?”. According to the eligibility criteria we included publications of studies investigating the HBV VC in Germany with no restrictions regarding region or data collection setting and published in German or English language. We excluded studies with data collection ending before 01/01/2005.

We searched MEDLINE, Embase and Livivo on 19 May 2020 and updated this search on 06 July 2020. For details on the complete search strategy, see additional file 1.

Abstracts and full texts were screened applying predefined eligibility criteria (see additional file 2). When publications were identified that used the same data set, the publication with less information regarding VC was excluded.

We manually screened the reference lists of all publications included in full text-screening and the reports of the national surveillance data published by the Robert Koch Institute at title/abstract- and full text-level. Moreover, we included the identified publications regarding HBV VC in Germany from a scoping review we previously conducted with a search time frame from 01 January 2005 – 09 March 2017 (14) and re-assessed them regarding eligibility.

Standardised forms were used to extract study characteristics and to assess risk of bias. We extracted the following data: study design, study population, region of data collection, number of study participants, setting, sampling frame and sampling of participants, study period, inclusion criteria, study instruments, demographics of the study population (age, sex), number of participants for outcome VC, definition for vaccinated participants and corresponding results for VC.

Screening and data extraction were done by two independent reviewers. Discrepancies were resolved by discussion.

For conference abstracts, we tried to identify the responding publication or contacted the authors for further information on study characteristics. Conference abstracts without any information on VC and study characteristics were excluded.

Data analysis

Data was analysed by population group. We used the definitions of the study population according to respective publication. If possible, data was allocated to pre-defined population groups including

1. a) children/adolescents from the general population (GP);
2. b) adults from the GP;
3. c) travellers to HBV endemic countries;

4. d) people at risk of severe course of HBV infection due to immunosuppression: people living with HIV (PLWH), patients on haemodialysis or with other non-VH related underlying diseases;
5. e) people at increased risk of occupational exposure: health-care workers (HCW), people working in facilities where HBV infected people are likely to be present;
6. f) people at increased risk of non-occupational HBV exposure: household contacts of people living with viral hepatitis (PLWVH), people who are part of a migrant population from HBV endemic countries, people at high risk of acquiring HBV through sexual contacts (e.g. men who have sex with men, MSM), people who inject drugs (PWID) and people in prisons and closed settings.

The study instruments used to estimate the VC were categorised as i) serostatus (isolated positive anti-HBs); ii) vaccination card; iii) medical records and iii) self-reported vaccination status. VC was calculated as the proportion of vaccinated participants among all participants (unless the denominator used in the respective publication was the number susceptible) and reported as percentages including 95% confidence intervals where available.

HBV VC was reported as coverage of complete and incomplete vaccination schedule according to the 2017 STIKO recommendations (8). For children complete HBV vaccination schedule was defined as primary immunisation with at least three doses of monovalent vaccine or four doses of hexavalent vaccine. For adults, a complete HBV vaccination schedule was defined as primary immunisation with at least three doses of monovalent/bivalent vaccine. An incomplete vaccination schedule for children were defined as one to two doses of monovalent vaccine or one to three doses of hexavalent vaccine and for adults as one to two doses of monovalent/bivalent vaccine. A vaccination schedule was defined as “not specified”, when the number of vaccination doses received could not be assessed by the study instrument, when the vaccination doses received could not be assessed for the whole study population or when it was stated as “not specified” in the respective publication.

Current protection was defined based on STIKO recommendations for booster dose for respective indication groups (e.g. HCW) and VC of current protection was reported separately.

When the VC was calculated (only) for the HBV susceptible population, this was indicated.

Risk of bias assessment

For all studies the Hoy et al. risk of bias tool (15) was used to assess internal validity of the studies. Studies with a total score below six points were categorised as being at high risk of bias.

Results

Selection of studies

We identified 3,215 titles in electronic databases. 165 additional titles were found by manual search. After removal of duplicates, abstract and full-text screening, 41 publications were identified which contained relevant data on HBV VC in Germany. After removal of two non-informative conference abstracts, 39 publications were included in the systematic review (2, 16-52). Additionally, 29 publications matching the inclusion criteria were added from the scoping review (53-81), giving a total of 68 publications in the final review. For details see figure 1.

Figure 1: Study flow

Study characteristics

Sixty-five of the included publications were articles in scientific journals, two were dissertations and one was a conference abstract.

The included publications reported on data from 67 different studies. The nationwide population-based survey DEGS1 assessed VC using different study tools and the results were therefore published in two separate publications (2, 41).

All 67 included studies had a cross-sectional design, while six of them additionally contained a cohort element (28, 35, 47, 70, 75, 82). However, longitudinal data was not considered for this review.

In 27 studies, data was collected up to 2010. In three studies the data collection time frame was not reported, these studies were published in 2012 (57), 2018 (47) and 2019 (29).

Twenty-nine studies contained nationwide data. For three of these studies (reported in four publications), the sample was drawn from the German residential register (2, 39-41), for two from other national registers (38, 48) and for two from the health insurance refund claims of Associations of Statutory Health Insurance Physicians (ASHIP) (16, 44).

In 29 studies, vaccination status was taken from vaccination cards or from medical records, were vaccination was documented. In 13 studies, blood samples were tested for isolated positive anti-HBs as an indicator of vaccination or medical records were screened for serological results. In 20 studies, the vaccination status was self-reported and in two studies medical records were checked without clearly reporting for which parameter (53, 63). In two studies, health insurance data was analysed (16, 44). For DEGS1, participants presented vaccination cards and anti-HBs was investigated in a sub-group.

In 35 studies the coverage of the complete VC schedule (called complete VC hereafter) was reported. In 12 of them, coverage of incomplete vaccination schedule (called incomplete VC hereafter). For the remaining 32 studies the reported VC was assessed as "not specified". For 11 studies VC of current protection was calculated.

In two studies, only VC among the susceptible study population was available (26, 57). In two further studies VC for susceptible part study population was calculated separately (47, 49).

The main study characteristics of the included publications are shown in additional file 3.

Hepatitis B vaccination coverage by population group

In seven studies, HBV VC was investigated in different study populations, either as a single entity or as a sub-population (e.g. HIV-positive MSM) (18, 19, 28, 37, 49, 60, 62). Where applicable, these studies were therefore allocated to more than one population group below (28, 37, 49).

Twenty-four studies reported data on HBV VC among children and adolescents. Among these, thirteen studies contained data from the yearly mandatory national primary school entry medical and developmental check-up, showing a complete HBV VC between 86% and 90.5% (2005 and 2017) (36, 43, 45, 46, 64-69, 71-73). Two studies contained data from the national population-based health survey of children and adolescents (German Health Interview and Examination Survey for Children and Adolescents, KiGGS and KiGGS Wave 2), reporting a complete VC among three to 17 year old children of 65.8% (2003-2006) and 84.4% (2014-2017) (39, 40), respectively.

Three studies estimated HBV VC in the adult general population. Using random samples of individuals aged 18 to 79 years drawn between 2008 and 2011, the nationwide health survey DEGS1 reported an unspecified VC of 32.9% (by check of vaccination cards and self-report) versus 22.9% (by serological marker) (2, 41). A study of patients from an emergency room in Berlin performed in 2010/2011 showed an unspecified VC of 25.2% (self-reported) (56) and in another study complete VC of patients visiting occupational physicians was 52.1%.

Regarding travel-related indication for HBV vaccination, one study was identified reporting an unspecified VC of 89% in a web-based survey (59).

Thirteen studies were related to immunocompromised populations including three in PLWH (two of them only including MSM) (28, 49, 70), seven in patients with autoimmune diseases (21, 30, 33, 34, 50, 52, 58), two in patients with liver cirrhosis resp. after liver transplantation (26, 51) and one in alcohol-dependant people during detoxication therapy (75). The unspecified VC in PLWH was between 47.1% and 47.7% in HIV-positive MSM and 11.5% in HIV-positive patients non-restricted to MSM. In other immunosuppressed populations, the complete/not specified VC was between 11.8% and 89.0% For three of 13 studies relating to immunosuppressed populations, the VC with current protection was reported (33, 34, 51).

Sixteen studies investigated VC among populations at occupational risk of HBV exposure. Six studies looked at students of different health occupations (e.g. medical students, nursing students) and reported a complete/unspecified VC between 63.9% and 93.1% (54, 61, 74, 78-80). In nine studies the HBV VC was measured among hospital personnel including medical doctors, nurses, paramedics and other medical staff resulting in a complete/not specified VC between 63.6% and 96.5% (29, 38, 42, 53, 55, 76, 77, 81,

83). One study estimated the not specified VC among educational personnel in schools for handicapped persons at 80.1% (22). For eight studies, VC with current protection was reported (54, 61, 76-81). In one of them, a study among health care students, current protection was higher than 80% (94%) (61).

Sixteen studies considered people at increased risk of non-occupational HBV exposure. Two studies were conducted among household contacts of PLWVH reporting a not specified VC of 54.0% and 55.2% in family and partners (57, 60) and 61.7% in children and siblings of PLWVH (60). For one study, the VC with current protection was reported (57) (17% of family members with known anti-HBs titre >10 IU/L).

Seven studies reported outcomes among individuals who were part of a migrant population from HBV endemic countries. One of these studies was a sub analysis of data from the school entry examination in Bavaria (37). Two studies measured a not specified VC of 4.4% resp. 14.9% in unaccompanied refugee minors (UAM) (31, 35) and three a not specified VC between 9.1% and 18.6% in adult refugees (23, 27, 32). For patients with a direct or indirect migration background of a general medicine practice the not specified VC was 17.4% (25). The complete VC in pre-school children with direct/indirect migration background was 84.5% (37).

Three studies were related to MSM. One of them reported on an internet-based survey showing complete VC of 52.3% (20). The two other studies were conducted among HIV-positive MSM (see above) with a VC between 47.1% and 47.7% (28, 49).

In four studies data was collected among PWID. The not specified VC was between 10.5% and 52.5% in drug consumption facilities and in consumption places on the street (24, 47, 62), and between 19.0% and 49.0% in opioid substitution treatment centres (62, 63).

For other populations at non-occupational risk for HBV exposure (e.g. prisoners, sex workers), no studies were identified.

The VC by population group including main study characteristics is illustrated in figures 2-4.

Figure 2: vaccination coverage in Germany among the general population and travellers to HBV endemic countries, %, 2005-2019, (*publication allocated to two population groups, \$ HBV VC only in HBV susceptible people, \$\$ HBV VC also in HBV susceptible people available, +current: additional information on % of currently protected available)

Figure 3: vaccination coverage in Germany among populations at risk for severe HBV infection due to immunosuppression, %, 2005-2019, (*publication allocated to two population groups, \$ HBV VC only in HBV susceptible people, \$\$ HBV VC also in HBV susceptible people available, +current: additional information on % of currently protected available)

Figure 4: vaccination coverage in Germany among populations at risk for occupational HBV exposure, %, 2005-2019, (*publication allocated to two population groups, \$ HBV VC only in HBV susceptible people,

\$\$ HBV VC also in HBV susceptible people available, +current: additional information on % of currently protected available)

Figure 5: vaccination coverage in Germany among populations at risk for non-occupational HBV exposure, %, 2005-2019, (*publication allocated to two population groups, \$ HBV VC only in HBV susceptible people, \$\$ HBV VC also in HBV susceptible people available, +current: additional information on % of currently protected available)

Risk of Bias

Risk of bias was low in 51 of 68 publications. In the remaining 17 publications risk of bias was assessed to be high. All publications among children/adolescents and adults in the GP were at low risk of bias. Six of 16 publications on populations at occupational risk for HBV were at high risk of bias, whereas the proportion was 8/16 for publications on populations at non-occupational risk for HBV. Important weaknesses of publications at high risk of bias were the use of self-reporting (n=7), serology (n=8) or medical records with unclear parameters (n=2) as study instruments, and a missing proper case definition for complete/incomplete HBV immunisation (n=12) as well as weak methods used to represent the target population (no national representativeness n=12, inadequate sampling frame n=13, inadequate sampling n=8). For details see additional file 4.

Discussion

This systematic review gives a comprehensive overview of the currently available evidence on HBV VC in different population groups in Germany.

High coverage of universal childhood immunisation is the most important means by which control HBV by eliminating the risk of transmission in a whole generation before risk behaviour even starts. Consequently, a high VC is essential to build this protection in this group, correspondingly the target VC for this group as determined by the WHO is 95%.”

In this review, we identified a comprehensive evidence base for children and adolescents which was overall at low risk of bias. Nevertheless, the results of KiGGS (2003-2006) showed that despite a recommendation being in place since 1995 the coverage of timely protective HBV vaccination in infants up to 14 months was low (5.5%) (40). KiGGS Wave 2 conducted between 2013 and 2018 reported a considerably higher HBV VC in all included age groups (39). Data on timely protective HBV vaccination schedules are currently being analysed. The gap in VC between the two surveys shows the slow increase in VC after the introduction of a vaccination in the national immunisation schedule. Still, the VC in KiGGS Wave 2 remained below the WHO 95%-VC goal in all age groups.

The data from KiGGS Wave 2 correlates with the data based on the yearly nationwide examination of all children entering primary school between 2014-2017, where the mean VC in four to seven-year olds was

within the same range. But also in this yearly survey, the VC never reached the 95%-goal and, more importantly, the VC did not significantly increase over the years (36, 46, 73, 84).

In the school entry examinations, the mean VC for the simultaneously scheduled diphtheria vaccination was higher compared to HBV in all years (95.6% for diphtheria versus 88.0% for HBV) (36, 45, 46, 64-69, 71-73, 84). This illustrates the missed opportunity of timely HBV vaccination and delay of this specific vaccination to older age.

For the adult GP, the evidence was outdated, but at low risk of bias. HBV catch-up vaccination in adults is currently only recommended for selected populations which results in a low VC among the adult population in Germany. Limitations of these findings include that data from the population-based survey DEGS1 was outdated and may not represent the current situation. But the DEGS1 update *germ-study (Gesundheits- und Ernährungsstudie in Deutschland)* is already planned to be conducted in 2022 and will provide new results on HBV VC among the adult GP in Germany.

There was only one publication regarding HBV VC in travellers to Hepatitis A endemic countries. VC was high, but the results might be biased, as the survey was online and the demographics of the study population were not reported.

Evidence for people at risk for severe HBV due to immunosuppression, except PLWH, was extensive and overall at low risk of bias. Nevertheless, most identified literature relates to clinical populations with autoimmune diseases. VC in adults was low to moderate despite already warranted access to health care and vaccination recommendations. Reasons for low coverage in this group (including alarmingly low current protection) of patients remain unclear.

HBV vaccination for populations at increased occupational and non-occupational risk for HBV exposure is the second pillar for prevention of HBV transmission in Germany and, therefore, to decrease the burden of disease (9). In contrast to populations at occupational risk, for other populations indicated for HBV vaccination, no VC goal has been defined by WHO, nevertheless, vaccination is recommended by STIKO. Large VC gaps in these groups may hinder the success of HBV elimination in Germany and should, therefore, be recognized at an early stage and considered in prevention strategies.

Comprehensive evidence of mixed quality was identified for people at occupational risk for HBV exposure. The large number of identified publications regarding HCW in this review reported a wide range of VC, but it must be noted that the study populations were heterogeneous and evidence varied in terms of risk of bias. VC was often self-reported, resulting in a lack of reliability (85, 86) and a potential overestimation of the real VC. Moreover, most studies were conducted at local or regional level, thus reflecting local prevention efforts of single hospitals, and the representativeness of the results for the whole country might be limited. However, since 2016, the RKI has been conducting a yearly and nationwide online-survey on vaccination uptake of HCW in German hospitals (83). This survey and also three quarters of the other studies, reported a VC fulfilling the WHO goal of 80%. Moreover, for the majority of studies with low VC data collection started before 2010, matching the increase of VC over

time for the GP. In half of the conducted studies, in addition to the not specified/complete VC, the VC of current protection was also surveyed, which was below 80% for seven of eight studies. Furthermore, no pattern in VC among different occupational groups could be identified. Overall, primary immunisation seems to be adequate in HCW but current protection is insufficient.

Large evidence and VC gaps were identified among populations at non-occupational risk for HBV exposure. Especially for household contacts of PLWVH, people who migrated from HBV endemic countries, MSM and PWID, the number of conducted studies was low. No studies were available on prisoners or sex workers.

The available evidence and the VC of household members of PLWVH was low (not specified VC 54%-61%), but VC increased when measured in susceptible household members only (73%-84%). However, current protection was reported to be below 60%. However, VC was self-reported and only 17% of persons currently protected knew their antibody titre.

Regarding migrant populations from HBV endemic countries, evidence was divided by data for newly arrived refugees and for persons already living in Germany, but with a migrational background. The available evidence for refugees was at high to intermediate risk of bias and included local/regional studies conducted in reception centres. Overall HBV VC among adolescents (UAM) was below 20% with a minimum of 4.4%. HBV VC was measured in study populations with different compositions in terms of country of origin, mostly from Sub-Saharan Africa, Syria and Afghanistan, which may explain the variation in VC (87). Among children with a migrational background entering school in Bavaria, a subgroup analysis of children born in Germany but with either one or both parents from a migrational background did not differ from the VC among children with parents born in Germany [27]. Insufficient language mediation was a limitation of this study, so children of migrants with poor German language skills may have been underrepresented. A survey conducted in people with migration background seeking care in a general practice reported a VC of only 57.1% in under 20-year olds decreasing with age, demonstrating a vaccination gap especially in the age group who should have been covered by the universal childhood immunisation program. Limiting the validity of the data, this study was at high risk of bias and the study population was a convenience sample of individuals with any migrational background, country of birth and/or length of stay in Germany. Therefore, conclusions regarding the overall population of persons with a migrational background from HBV endemic countries in Germany, as well as persons with a specific migrational background, cannot be drawn based on the evidence included in this review.

For MSM the evidence was limited and of mixed quality, and the reported VC was low (between 47% and 52%). This did not increase over time and, surprisingly, did not differ between HIV-positive and HIV-negative study populations. A limitation was the use of self-reported vaccination status in two of the three studies. In the Europe-wide EMIS-2010 survey among MSM, the complete VC was higher in Germany (52%) as compared to the European average (44.7%). In this study, vaccination uptake was higher in MSM who were affected by universal vaccination recommendations, as well as in MSM who

were affected by specific vaccination recommendations. This matched the result that being “out” was correlated with being vaccinated in older MSM, but not in younger MSM, who were covered by the universal childhood immunisation (20).

For PWID, the limited evidence on HBV VC was at high risk of bias and the VC varied substantially between studies. In two smaller local studies, the not specified VC was noticeably lower (10.5% and 19%, respectively) than in the two larger, nationwide studies (32%-52%). The wide range of VC among PWID might be due to the specific characteristics of the study populations, including age, with younger people having been covered by infant vaccination which has been in place since 1995, whereas older PWID could only benefit from risk group vaccination. Furthermore, differences at local level such as specific campaigns may explain the variation, which has also been described by Haussig et al (24). Moreover, in this study self-reported vaccination status among PWID was only reported to be correct in 45% of participants, so VC might be overestimated in the study of Mone et al included in this review (62). In contrast to the data from Germany, the UK reported a VC of 77% from a voluntary unlinked-anonymous monitoring (UAM) among PWID in 2015-2016 (88). However, this VC was self-reported and high numbers may be explained by data collection in sentinel locations, which might be settings with comprehensive vaccination programs. In Germany, low HBV VC among PWID was observed not only in street-based or in low-threshold drug services, but also in opioid substitution therapy clinics (OST) (24, 63).

However, as in all populations with an increased risk for HBV exposure, a considerable proportion of the study population may have already been infected with HBV (i.e. no longer susceptible) and, therefore, have no indication for HBV immunisation. Unfortunately, this was only addressed by four studies in different populations, so that a systematic comparison was not possible.

In this review, data on populations for whom vaccination is recommended often came from smaller, local studies with convenience samples. This may have biased the results and also limited the representativeness. Moreover, statistically reliable evidence on HBV VC among subgroups (e.g. groups of people with a certain migrational background) cannot be derived from these samples. Many of the studies obtained data on vaccination status from self-reports, which have low validity and lead to an overestimation of VC (86, 89-91). Also, results obtained from serology without further information on past immunisation only provide information on a current titre. They do not provide any information about long-term protection received by complete primary immunisation and booster doses. Thus, even fully vaccinated people may not have any detectable titre at the moment of investigation (92, 93). Moreover, in some publications the definition of complete or incomplete vaccination status was not reported (and not all differentiated between incomplete and complete vaccination), which may have resulted in an overestimation of VC and must be considered when interpreting the results. The assumption that the exclusion of children without vaccination cards from the VC analysis derived from school entry examinations might result in an overestimate of VC was refuted by Rieck et al, who validated the results by comparison with health insurance billing data (84). In terms of comparability of studies, the study populations and settings varied within the defined population groups and, as described above, data collection tools and definition of complete vaccination differed between the studies.

In conclusion, the population-based surveys in the GP as well as the pre-school examinations provide continuous, extensive data and can serve as a monitoring tool for the national vaccination programme. However, populations at high non-occupational risk for HBV exposure (e.g. PWID) are underrepresented in these surveys and targeted studies among these groups are still lacking. Of note, no studies were identified on VC in people in prisons, sex workers or homeless populations. The surveillance of VC in German HCW provides a large data pool but could possibly be supplemented by a more robust data collection tool.

Given the identified VC in the included studies, more work is needed to improve the overall HBV VC in Germany, in order to reduce transmission and halt the HBV epidemic. One reason for missed or delayed HBV vaccination among children is mistrust among parents in the hexavalent vaccine (94). This vaccine is recommended in early infancy in Germany, for protection against diphtheria, tetanus, pertussis, hepatitis B, polio, and Haemophilus influenzae type b. Paediatricians should advocate against postponing HBV vaccination and actively use catch-up vaccination opportunities for children that were not vaccinated in the first 14 months of age. As most of the GP in Germany are seek health care at general practitioners, and are also usually vaccinated there, promotion of HBV vaccination, including an assessment of personal risk, should be implemented here. This might also increase general awareness regarding HBV transmission risks, and sensitize persons at high risk for either HBV exposure or a severe course of infection. In Germany, equal access to health care facilities (with full coverage of costs even for persons without health insurance) and non-stigmatizing counselling are the basis for reaching the whole population. Educational material in different languages is essential in order to ensure accessibility for persons without sufficient German language skills. For PWID, on-site options for vaccination in low-threshold settings and/or as part of harm reduction services, including the “don’t ask, vaccinate”-strategy ,and accelerated immunisation schedules, should be offered (95). Incentives could help to encourage PWID to get vaccinated (96).

As vaccination is the most successful prevention measure implemented in the response to HBV, the gaps in evidence on HBV VC in Germany should be filled, and HBV vaccination progress should be continuously evaluated. The reasons for low VC among different population groups should be fully understood in order to manage targeted vaccination campaigns, tackle vaccination gaps and drive HBV elimination in Germany.

Abbreviations

DEGS1 German Health Interview and Examination Survey for Adults

GP general population

HAV hepatitis A virus

HBV hepatitis B virus

HIV human immunodeficiency virus

KiGGS study on the health of children, adolescents and young adults in Germany

MSM men who have sex with men

PLWH people living with HIV

PLWVH people living with viral hepatitis

PWID people who inject drugs

STIKO German Standing Committee on Vaccination

VC vaccination coverage

VH viral hepatitis

WHO World Health Organization

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The datasets supporting the conclusions of this article are included within the article and its additional files.

Competing interests

The authors declare that they have no competing interests.

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Author Contributions

RZ and VB conceptualized the scoping review. SD supervised the scoping review. GS, IS, NS, SAL, SB, SD, RT and RZ carried out the scoping review.

SD supervised the systematic review. GS carried out the study. GS, IS, SD, RZ were part of the review team. GS and SD performed the analyses. GS and SD drafted the manuscript. TH provided technical advice. All authors critically revised the manuscript and approved the final version.

GS is corresponding author.

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Not applicable

References

1. World Health Organization (WHO), Regional Office for Europe. Hepatitis B in the WHO European Region. Fact sheet – July 2018. 2018 [Available from: http://www.euro.who.int/__data/assets/pdf_file/0007/377251/fact-sheet-hepatitis-b-eng.pdf?ua=1].
2. Poethko-Müller C, Zimmermann R, Hamouda O, Faber M, Stark K, Ross RS, et al. Epidemiology of hepatitis A, B, and C among adults in Germany: Results of the German health interview and examination survey for Adults (DEGS1). *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz*. 2013;56(5–6):707–15.
3. Falla AM, Hofstraat SHI, Duffell E, Hahné SJM, Tavoschi L, Veldhuijzen IK. Hepatitis B/C in the countries of the EU/EEA: a systematic review of the prevalence among at-risk groups. *BMC Infect Dis*. 2018;18(1):79.
4. Tavoschi L, Mason L, Petriti U, Bunge E, Veldhuijzen I, Duffell E. Hepatitis B and C among healthcare workers and patient groups at increased risk of iatrogenic transmission in the European Union/European Economic Area. *The Journal of hospital infection*. 2019;102(4):359–68.
5. Ahmad AA, Falla AM, Duffell E, Noori T, Bechini A, Reintjes R, et al. Estimating the scale of chronic hepatitis B virus infection among migrants in EU/EEA countries. *BMC Infect Dis*. 2018;18(1):34.
6. World Health Organization. Global and Country Estimates of immunization coverage and chronic HBV infection: World Health Organization; 2020 [Available from: <http://whohbsagdashboard.com/#global-strategies>].

7. Sperle I, Steffen G, Leendertz SA, Sarma N, Beermann S, Thamm R, et al. Prevalence of Hepatitis B, C, and D in Germany: Results From a Scoping Review. *Frontiers in public health*. 2020;8:424.
8. Ständige Impfkommision (STIKO). Empfehlungen der Ständigen Impfkommision (STIKO) am Robert Koch-Institut *Epid Bull*. 2017:333–76.
9. Harder T, Remschmidt C, Falkenhorst G, Zimmermann R. Background paper to the revised recommendation for hepatitis B vaccination of persons at particular risk and for hepatitis B postexposure prophylaxis in Germany. *Bundesgesundheitsbl*. 2013;56:1565–76.
10. (WHO) WHO. European Vaccine Action Plan 2015–2020. Copenhagen; 2014.
11. World Health Organization Regional Office for Europe. Action plan for the health sector response to viral hepatitis in the WHO European Region. Denmark: WHO Regional Office for Europe; 2017.
12. Bundesministerium für Gesundheit, Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung. Strategie zur Eindämmung von HIV, Hepatitis B und C und anderen sexuell übertragbaren Infektionen. Bis 2030 - Bedarfsorientiert · Integriert · Sektorübergreifend. Berlin; 2016.
13. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. *Open medicine: a peer-reviewed, independent, open-access journal*. 2009;3(3):e123-30.
14. Steffen G, Sperle I, Leendertz SA, Sarma N, Beermann S, Thamm R, et al. The epidemiology of Hepatitis B, C and D in Germany: A scoping review. *PLoS One*. 2020;15(3):e0229166.
15. Hoy D, Brooks P, Woolf A, Blyth F, March L, Bain C, et al. Assessing risk of bias in prevalence studies: modification of an existing tool and evidence of interrater agreement. *Journal of clinical epidemiology*. 2012;65(9):934–9.
16. Bader H-M. Zu Impfungen bei Kindern im Alter bis zu 24 Monaten. *Epidemiologisches Bulletin*. 2007(34).
17. Bader H-M, Egler P. Impfschutz bei Erwachsenen in Schleswig-Holstein 2011 – ein Update nach acht Jahren. *Epidemiologisches Bulletin*. 2013;13(22).
18. Bader H-M, Heiser A. Zum Impfschutz bei Aufnahme in den Kindergarten in Schleswig-Holstein im Jahr 2009 *Epidemiologisches Bulletin*. 2011(7).
19. Bader H-M, Rasche S. Impfschutz bei Aufnahme in den Kindergarten Schleswig-Holstein 2006. *Schleswig-Holsteinisches Ärzteblatt*. 2007:5.
20. Brandl M, Schmidt AJ, Marcus U, An Der Heiden M, Dudareva S. Are men who have sex with men in Europe protected from hepatitis B? *Epidemiology and infection*. 2020.
21. Cagol L, Seitel T, Ehrenberg S, Frivolt K, Krahl A, Lainka E, et al. Vaccination rate and immunity of children and adolescents with inflammatory bowel disease or autoimmune hepatitis in Germany. *Vaccine*. 2020;38(7):1810–7.
22. Claus M, Kimbel R, Schöne K, Letzel S, Rose DM. Seroepidemiology of hepatitis A and B and vaccination status in staff at German schools for the handicapped. *Journal of Medical Virology*. 2016.

23. Hampel A, Solbach P, Cornberg M, Schmidt RE, Behrens GM, Jablonka A. [Current seroprevalence, vaccination and predictive value of liver enzymes for hepatitis B among refugees in Germany]. *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz*. 2016;59(5):578–83.
24. Haussig JM, Nielsen S, Gassowski M, Bremer V, Marcus U, Wenz B, et al. A large proportion of people who inject drugs are susceptible to hepatitis B: Results from a bio-behavioural study in eight German cities. *International journal of infectious diseases: IJID : official publication of the International Society for Infectious Diseases*. 2018;66:5–13.
25. Heidrich B, Cetindere A, Beyaz M, Stahmeyer JT, Basaran MM, Braynis B, et al. High prevalence of hepatitis markers in immigrant populations: a prospective screening approach in a real-world setting. *Eur J Gastroenterol Hepatol*. 2014;26(10):1090–7.
26. Herta T, Petroff D, Engelmann C, Herber A, Aehling N, Scheuermann U, et al. Hepatitis b vaccination in patients with liver cirrhosis evaluated for liver transplantation - A simple intervention ensures high adherence. *Annals of Transplantation*. 2019;24:527–31.
27. Jablonka A, Solbach P, Wöbse M, Manns MP, Schmidt RE, Wedemeyer H, et al. Seroprevalence of antibodies and antigens against hepatitis A-E viruses in refugees and asylum seekers in Germany in 2015. *Eur J Gastroenterol Hepatol*. 2017;29(8):939–45.
28. Jansen K, Thamm M, Bock C-T, Scheufele R, Kücherer C, Muenstermann D, et al. High Prevalence and High Incidence of Coinfection with Hepatitis B, Hepatitis C, and Syphilis and Low Rate of Effective Vaccination against Hepatitis B in HIV-Positive Men Who Have Sex with Men with Known Date of HIV Seroconversion in Germany. *PLoS ONE*. 2015;10(11):e0142515.
29. Karnaki P, Baka A, Petralias A, Veloudaki A, Zota D, Linos A. Immunization related behaviour among healthcare workers in Europe: Results of the HProImmune survey. *Central European journal of public health*. 2019;27(3):204–11.
30. Kiltz U, Celik A, Tsiami S, Bühring B, Baraliakos X, Braun J. Gaps in patient safety performance in patients with immunosuppressive therapy: Results of screening for infections and vaccination status in a large real-life cohort. *Annals of the Rheumatic Diseases*. 2019;78:1377–8.
31. Kloning T, Nowotny T, Alberer M, Hoelscher M, Hoffmann A, Froeschl G. Morbidity profile and sociodemographic characteristics of unaccompanied refugee minors seen by paediatric practices between October 2014 and February 2016 in Bavaria, Germany. *BMC public health*. 2018;18(1):983.
32. Kortas AZ, Polenz J, von Hayek J, Rüdiger S, Rottbauer W, Storr U, et al. Screening for infectious diseases among asylum seekers newly arrived in Germany in 2015: a systematic single-centre analysis. *Public Health*. 2017;153:1–8.
33. Krasselt M, Baerwald C, Seifert O. Insufficient vaccination rates in patients with systemic lupus erythematosus in a German outpatient clinic. *Zeitschrift für Rheumatologie*. 2018;77(8):727–34.
34. Krasselt M, Ivanov JP, Baerwald C, Seifert O. Low vaccination rates among patients with rheumatoid arthritis in a German outpatient clinic. *Rheumatology International*. 2017;37(2):229–37.
35. Marquardt L, Krämer A, Fischer F, Prüfer-Krämer L. Health status and disease burden of unaccompanied asylum-seeking adolescents in Bielefeld, Germany: cross-sectional pilot study.

- Tropical medicine & international health: TM & IH. 2016;21(2):210-8.
36. Matysiak-Klose D, Robert Koch-Institut (RKI). Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2015. *Epid Bull.* 2017;2017(16):137–42.
 37. Mikolajczyk RT, Akmatov MK, Stich H, Krämer A, Kretzschmar M. Association between acculturation and childhood vaccination coverage in migrant populations: A population based study from a rural region in Bavaria, Germany. *International Journal of Public Health.* 2008;53(4):180–7.
 38. Neufeind J, Betsch C, Habersaat KB, Eckardt M, Schmid P, Wichmann O. Barriers and drivers to adult vaccination among family physicians - Insights for tailoring the immunization program in Germany. *Vaccine.* 2020;38(27):4252–62.
 39. Poethko-Müller C, Kuhnert R, Gillesberg Lassen S, Siedler A. [Vaccination coverage of children and adolescents in Germany: New data from KiGGS Wave 2 and trends from the KiGGS study]. *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz.* 2019;62(4):410–21.
 40. Poethko-Müller C, Kuhnert R, Schlaud M. Vaccination coverage and predictors for vaccination level: Results of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS). *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz.* 2007;50(5–6):851–62.
 41. Poethko-Müller C, Schmitz R. Vaccination coverage in German adults: results of the German Health Interview and Examination Survey for Adults (DEGS1). *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz.* 2013;56(5–6):845–57.
 42. Ramich T, Eickholz P, Wicker S. Work-related infections in dentistry: risk perception and preventive measures. *Clinical oral investigations.* 2017.
 43. Rieck T. Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2017. *Epidemiologisches Bulletin.* 2019(18):147–53.
 44. Rieck T, Feig M, Eckmanns T, Benzler J, Siedler A, Wichmann O. Vaccination coverage among children in Germany estimated by analysis of health insurance claims data. *Human vaccines & immunotherapeutics.* 2014;10(2):476–84.
 45. Rieck T, Robert Koch-Institut (RKI). Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2011. *Epid Bull.* 2013;2013(16):129–33.
 46. Robert Koch-Institut. Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2016. *Epid Bull.* 2018;16.
 47. Scherbaum N, Timm J, Richter F, Bonnet U, Bombeck J, Lajos S, et al. Outcome of a hepatitis B vaccination program for clients of a drug consumption facility. *Journal of clinical virology: the official publication of the Pan American Society for Clinical Virology.* 2018;106:28–32.
 48. Schuster T, Borgmann-Staudt A, König CJ, Sommerhauser G, Korte E, Holling H, et al. Vaccinations and Screening Examinations – Prevention Awareness Among Children of Childhood Cancer Survivors in Germany
 49. Impfungen und Vorsorgeuntersuchungen – Präventionsverhalten bei Nachkommen ehemaliger kideronkologischer Patienten in Deutschland. *Klin Padiatr.* 2020;232(3):143–50.

50. Spinner CD, Boesecke C, Jordan C, Wyen C, Kümmerle T, Knecht G, et al. Prevalence of asymptomatic sexually transmitted infections in HIV-positive men who have sex with men in Germany: results of a multicentre cross-sectional study. *Infection*. 2018;46(3):341–7.
51. Teich N, Klugmann T, Tiedemann A, Holler B, Mössner J, Liebetrau A, et al. Vaccination coverage in immunosuppressed patients: results of a regional health services research study. *Deutsches Arzteblatt international*. 2011;108(7):105–11.
52. Weltermann B, Herwig A, Dehnen D, Herzer K. Vaccination Status of Pneumococcal and Other Vaccines in 444 Liver Transplant Patients Compared to a Representative Population Sample. *Ann Transplant*. 2016;21:200–7.
53. Wilckens V, Kannengiesser K, Hoxhold K, Frenkel C, Kucharzik T, Maaser C. The immunization status of patients with IBD is alarmingly poor before the introduction of specific guidelines. *Scandinavian journal of gastroenterology*. 2011;46(7–8):855–61.
54. Baars S. V89 Prävalenz von Hepatitis B und C bei medizinischen Fachangestellten. *Arbeitsmedizin, Sozialmedizin, Umweltmedizin*. 2011;46(3).
55. Bigl S, Schreiber M, Kötz I. Impfraten von Auszubildenden der Kranken- und Altenpflege. *Ärzteblatt Sachsen*. 2011;10(2011):527–31.
56. Burckhardt F, Deleré Y, Wiese-Posselt M. Impfstatus sowie Einstellung und Verhalten von Hebammen zu Impfungen – Ergebnisse einer Querschnittsstudie. *Epid Bull*. 2008;2008(21):163–9.
57. Darstein F. Prävalenz und Risikofaktoren von Hepatitis B und C bei Patienten einer Berliner Rettungsstelle; eine analytische Querschnittstudie ; Prevalence and risk factors for Hepatitis B and C among patients attending a German Emergency Department ; an analytical cross-sectional study: Freie Universität Berlin Universitätsbibliothek, Garystr. 39, 14195 Berlin; 2015.
58. Deterding K, Heidelberger S, Wiebner B, Meining K, Cornberg M, P. Manns M, et al. Knowledge and management of hepatitis B virus infected patients in Germany. *Deutsche Medizinische Wochenschrift*. 2012;137(15):774–9.
59. Feuchtenberger M, Schäfer A, Philipp Nigg A, Rupert Kraus M. Hepatitis B Serology in Patients with Rheumatic Diseases. *Open Rheumatol J [Internet]*. 2016 2016; 10:[39–48 pp.].
60. Heywood AE, Nothdurft H, Tessier D, Moodley M, Rombo L, Marano C, et al. Pre-travel advice, attitudes and hepatitis A and B vaccination rates among travellers from seven countries. *Journal of travel medicine*. 2016;24(1).
61. Lutgehetmann M, Meyer F, Volz T, Lohse AW, Fischer C, Dandri M, et al. Knowledge about HBV, prevention behaviour and treatment adherence of patients with chronic hepatitis B in a large referral centre in Germany. *Zeitschrift für Gastroenterologie*. 2010;48(9):1126–32.
62. Mäding C, Jacob C, Münch C, Von Lindeman K, Klewer J, Kugler J. Vaccination coverage among students from a German health care college. *American Journal of Infection Control*. 2015;43(2):191–4.
63. Mone JS. Untersuchungen zur nicht bestimmungsgemäßen Verwendung von Substitutionsmitteln und zum Gesundheitszustand von substituierten und nicht substituierten Opiatabhängigen in

- Deutschland: Universität Hamburg; Medizin. Medizin; 2015.
64. Müller MC, Pichler M, Martin G, Plörer D, Winter C, Pogarell O, et al. Burden of disease and level of patient's medical care in substitution treatment for opiates. *Medizinische Klinik*. 2009;104(12):913–7.
 65. Reiter S, Robert Koch-Institut (RKI). Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2005. *Epid Bull*. 2006;2006(48):430–1.
 66. Reiter S, Robert Koch-Institut (RKI). Zu den Impfquoten bei den Schuleingangsuntersuchungen in Deutschland 2006. *Epid Bull*. 2008;2008(7):55–7.
 67. Reiter S, Robert Koch-Institut (RKI). Impfquoten bei den Schuleingangsuntersuchungen in Deutschland 2007. *Epid Bull*. 2009;2009(16):143–5.
 68. Reiter S, Robert Koch-Institut (RKI). Impfquoten bei den Schuleingangsuntersuchungen in Deutschland 2008. *Epid Bull*. 2010;2010(16):137–40.
 69. Reiter S, Robert Koch-Institut (RKI). Impfquoten bei den Schuleingangsuntersuchungen in Deutschland 2009. *Epid Bull*. 2011;2011(16):125–9.
 70. Reiter S, Robert Koch-Institut (RKI). Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2010. *Epid Bull*. 2012;2012(16):135–9.
 71. Reuter S, Oette M, Wilhelm FC, Beggel B, Kaiser R, Balduin M, et al. Prevalence and characteristics of hepatitis B and C virus infections in treatment-naïve HIV-infected patients. *Medical Microbiology and Immunology*. 2011;200(1):39–49.
 72. Rieck T, Robert Koch-Institut (RKI). Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2012. *Epid Bull*. 2014;2014(16):137–41.
 73. Rieck T, Robert Koch-Institut (RKI). Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2013. *Epid Bull*. 2015;2015(16):131–5.
 74. Rieck T, Robert Koch-Institut (RKI). Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2014. *Epid Bull*. 2016;2016(16):129–33.
 75. Schmid K, Merkl K, Hiddemann-Koca K, Drexler H. Obligatory occupational health check increases vaccination rates among medical students. *Journal of Hospital Infection*. 2008;70(1):71–5.
 76. Schmidt CS, Schön D, Schulte B, Lüth S, Polywka S, Reimer J. Viral hepatitis in alcohol-Dependent inpatients prevalence, risk factors, and treatment uptake. *Journal of Addiction Medicine*. 2013;7(6):417–21.
 77. Voigt K, Kuhne F, Twork S, Gobel A, Kugler J, Bergmann A. Current vaccination status of health-care personnel in Brandenburg, Saxony And Saxony-Anhalt. *Gesundheitswesen (Bundesverband der Ärzte des Öffentlichen Gesundheitsdienstes (Germany))*. 2008;70(7):408–14.
 78. Voigt K, Rühle F, Bergmann A, Schübel J, Hirsch K, Riemenschneider H. Vaccination status among nurses in hospitals. Results of a cross sectional study at Harzkrlinikum Dorothea Christiane Erxleben Quedlinburg. *Pflege*. 2016;29(4):205–12.

79. von Lindeman K, Kugler J, Klewer J. Vaccinations among students in health care professions. *Pflege Zeitschrift*. 2011;64(12):740–3.
80. Wicker S, Rabenau HF, Doerr HW, Allwinn R. Are medical students sufficiently vaccinated? *LaboratoriumsMedizin*. 2009;33(4):223–7.
81. Wicker S, Rabenau HF, Gottschalk R, Doerr HW, Allwinn R. Seroprevalence of vaccine preventable and blood transmissible viral infections (measles, mumps, rubella, polio, HBV, HCV and HIV) in medical students. *Medical microbiology and immunology*. 2007;196(3):145–50.
82. Wicker S, Rabenau HF, Klemstein S, Gottschalk R. Needlestick injuries in emergency medical services. *Anesthesiologie und Intensivmedizin*. 2010;51(8):456–65.
83. Schmidt AJ, Marcus U. Self-reported history of sexually transmissible infections (STIs) and STI-related utilization of the German health care system by men who have sex with men: Data from a large convenience sample. *BMC Infectious Diseases*. 2011;11.
84. Bödecker B, Neufeind J, O W. OKAPII: Influenza-Impfquoten-Monitoring im Krankenhaus. *Epid Bull*. 2019(44):467–9.
85. Rieck T; Steffen A; Schmid-Küpke N; Feig M; Wichmann O; Siedler A. KV-Impfsurveillance: Ergänzungen zu den Impfdaten aus den Schuleingangsuntersuchungen. *Epid Bull*. 2016;16:134.
86. Denniston MM, Byrd KK, Kleven RM, Drobeniuc J, Kamili S, Jiles RB. An assessment of the performance of self-reported vaccination status for hepatitis B, National Health and Nutrition Examination Survey 1999–2008. *American journal of public health*. 2013;103(10):1865–73.
87. Loulergue P, Pulcini C, Massin S, Bernhard M, Fonteneau L, Levy-Bruhl D, et al. Validity of self-reported vaccination status among French healthcare students. *Clinical microbiology and infection: the official publication of the European Society of Clinical Microbiology and Infectious Diseases*. 2014;20(12):O1152-4.
88. World Health Organization. Hepatitis B (HepB3) immunization coverage among 1-year-olds (%) World Health Organization; 2020 [Available from: [https://www.who.int/data/gho/data/indicators/indicator-details/GHO/hepatitis-b-\(hepb3\)-immunization-coverage-among-1-year-olds](https://www.who.int/data/gho/data/indicators/indicator-details/GHO/hepatitis-b-(hepb3)-immunization-coverage-among-1-year-olds).]
89. Njoroge J, Hope VD, O'Halloran C, Edmundson C, Glass R, Parry JV, et al. Are there missed opportunities for vaccinating against hepatitis B among people who inject drugs in the UK? *Epidemiology and infection*. 2019;147:e244.
90. Boyd A, Gozlan J, Carrat F, Rougier H, Girard PM, Lacombe K, et al. Self-reported patient history to assess hepatitis B virus serological status during a large screening campaign. *Epidemiology and infection*. 2018:1–8.
91. Kuo I, Mudrick DW, Strathdee SA, Thomas DL, Sherman SG. Poor validity of self-reported hepatitis B virus infection and vaccination status among young drug users. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*. 2004;38(4):587–90.
92. Topp L, Day C, Dore GJ, Maher L. Poor criterion validity of self-reported hepatitis B infection and vaccination status among injecting drug users: a review. *Drug and alcohol review*. 2009;28(6):669–75.

93. Lao TT. Long-term persistence of immunity after hepatitis B vaccination: Is this substantiated by the literature? *Human vaccines & immunotherapeutics*. 2017;13(4):918–20.
94. Romanò L, Galli C, Tagliacarne C, Tosti ME, Velati C, Fomiatti L, et al. Persistence of immunity 18–19 years after vaccination against hepatitis B in 2 cohorts of vaccinees primed as infants or as adolescents in Italy. *Human vaccines & immunotherapeutics*. 2017;13(5):981–5.
95. Bundeszentrale für gesundheitliche Aufklärung (BZgA). Einstellungen, Wissen und Verhalten von Erwachsenen und Eltern gegenüber Impfungen – Ergebnisse der Repräsentativbefragung 2018 zum Infektionsschutz. Köln; 2019.
96. Walsh N, Verster A, Rodolph M, Akl EA. WHO guidance on the prevention of viral hepatitis B and C among people who inject drugs. *The International journal on drug policy*. 2014;25(3):363–71.
97. Weaver T, Metrebian N, Hellier J, Pilling S, Charles V, Little N, et al. Use of contingency management incentives to improve completion of hepatitis B vaccination in people undergoing treatment for heroin dependence: a cluster randomised trial. *The Lancet*. 2014;384(9938):153–63.

Figures

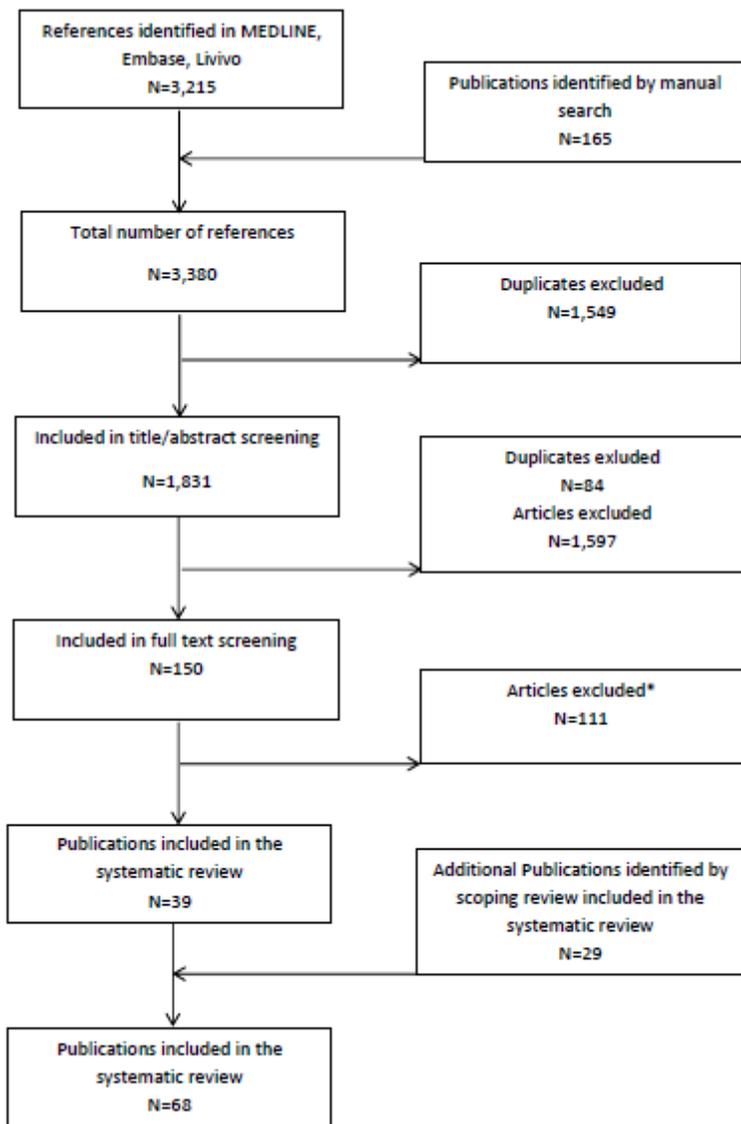


Figure 1

Study flow *reason for exclusion: other content 48, foreign country 34, recommendation 1, outside data collection period 8, newer/other publication with same content 5, no (original) data 11, no fulltext/complete data available 3, quality of reporting 1

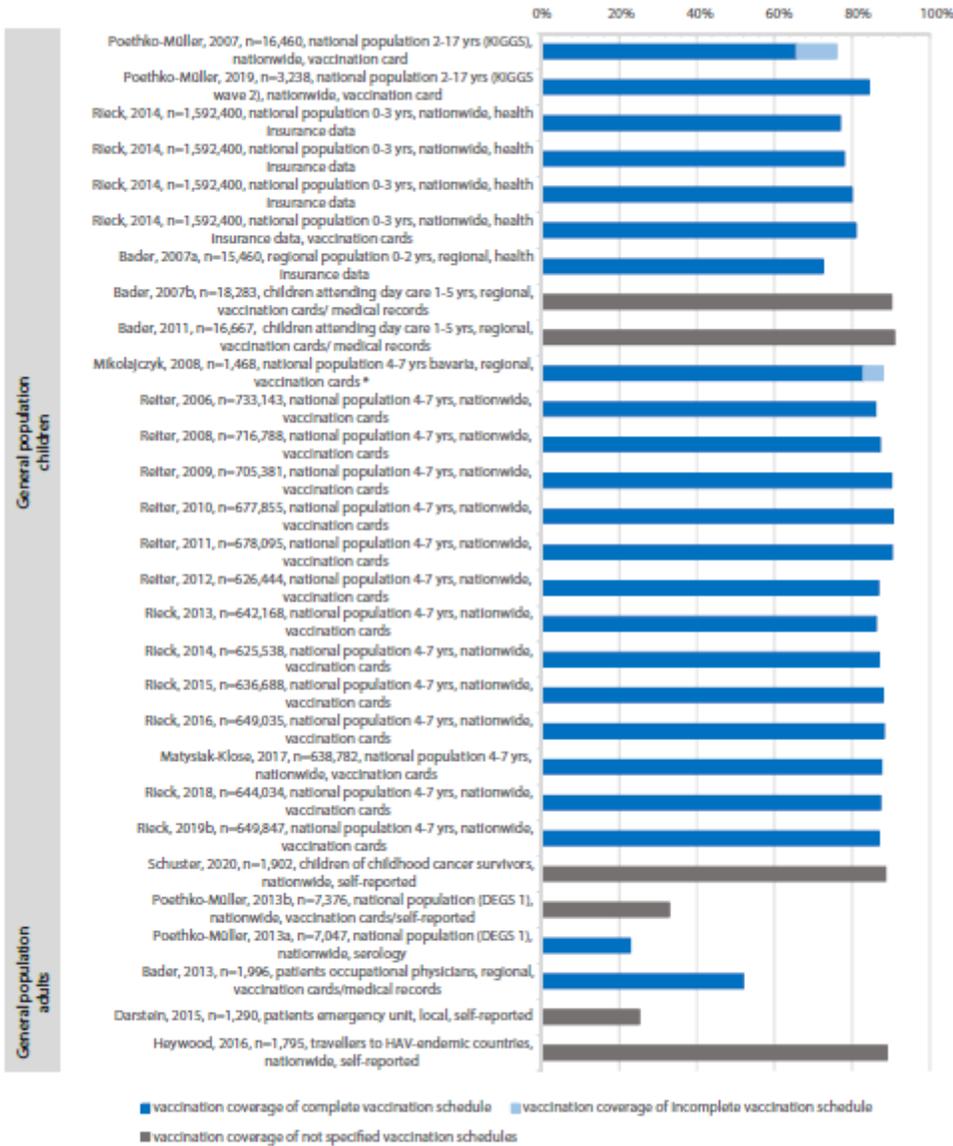


Figure 2

vaccination coverage in Germany among the general population and travellers to HBV endemic countries, %, 2005-2019, (*publication allocated to two population groups, \$ HBV VC only in HBV susceptible people, \$\$ HBV VC also in HBV susceptible people available, +current: additional information on % of currently protected available)

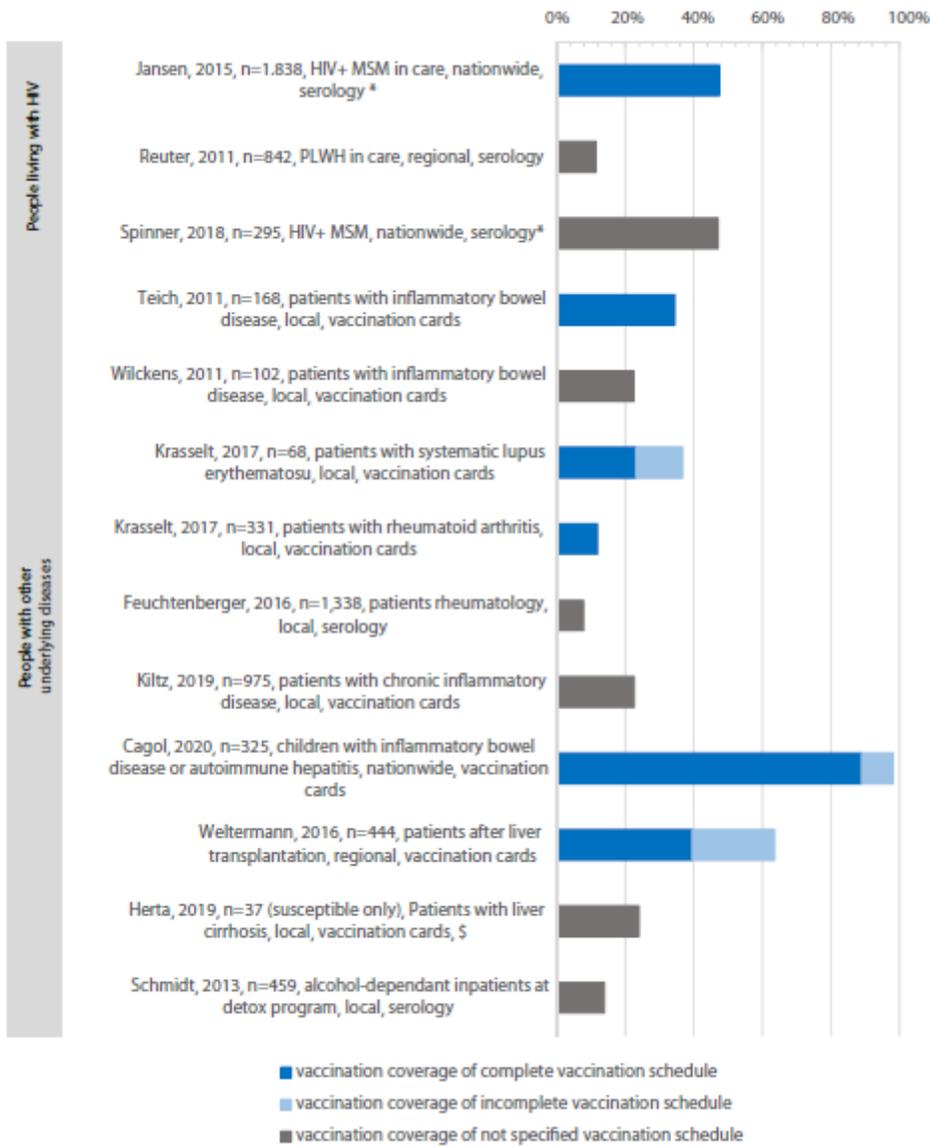


Figure 3

vaccination coverage in Germany among populations at risk for severe HBV infection due to immunosuppression, %, 2005-2019, (*publication allocated to two population groups, \$ HBV VC only in HBV susceptible people, \$\$ HBV VC also in HBV susceptible people available, +current: additional information on % of currently protected available)

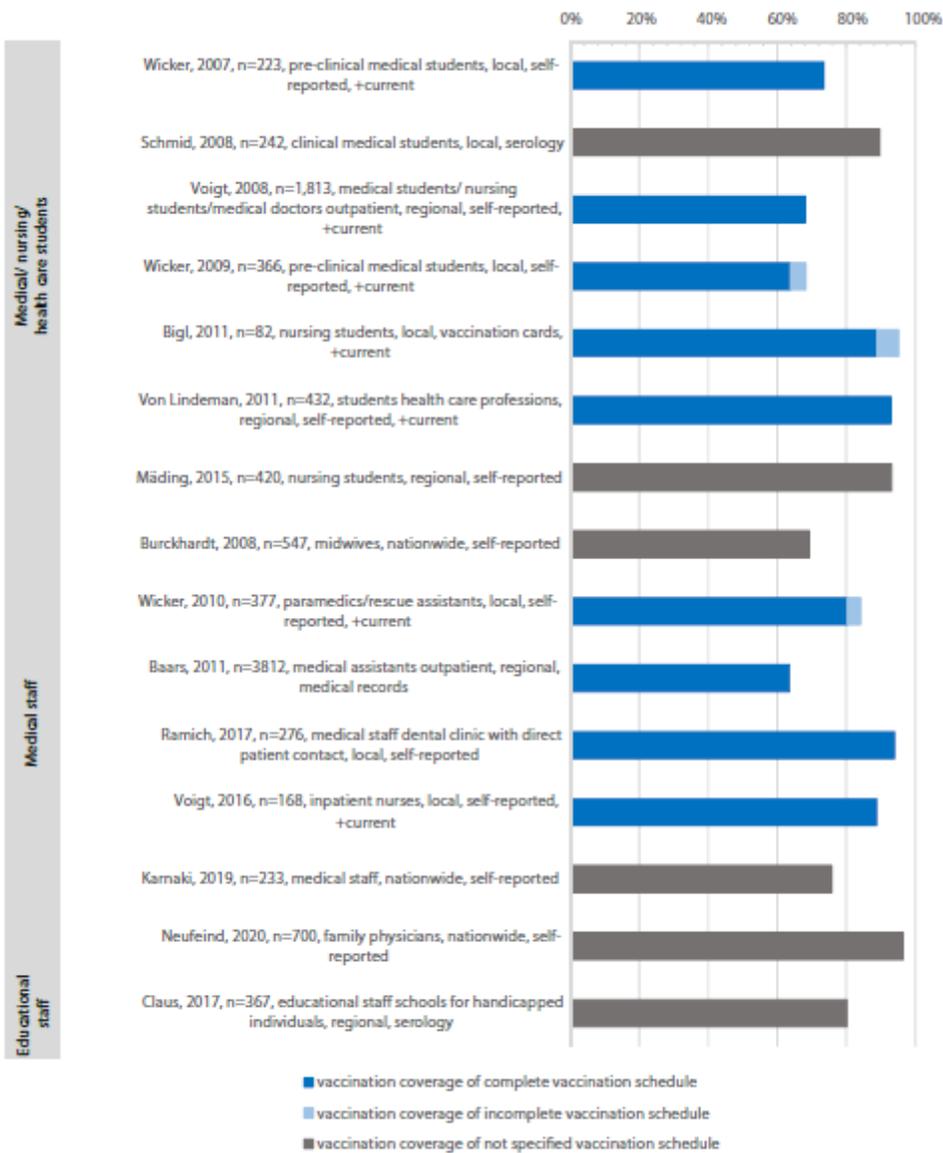


Figure 4

vaccination coverage in Germany among populations at risk for occupational HBV exposure, %, 2005-2019, (*publication allocated to two population groups, \$ HBV VC only in HBV susceptible people, \$\$ HBV VC also in HBV susceptible people available, +current: additional information on % of currently protected available)

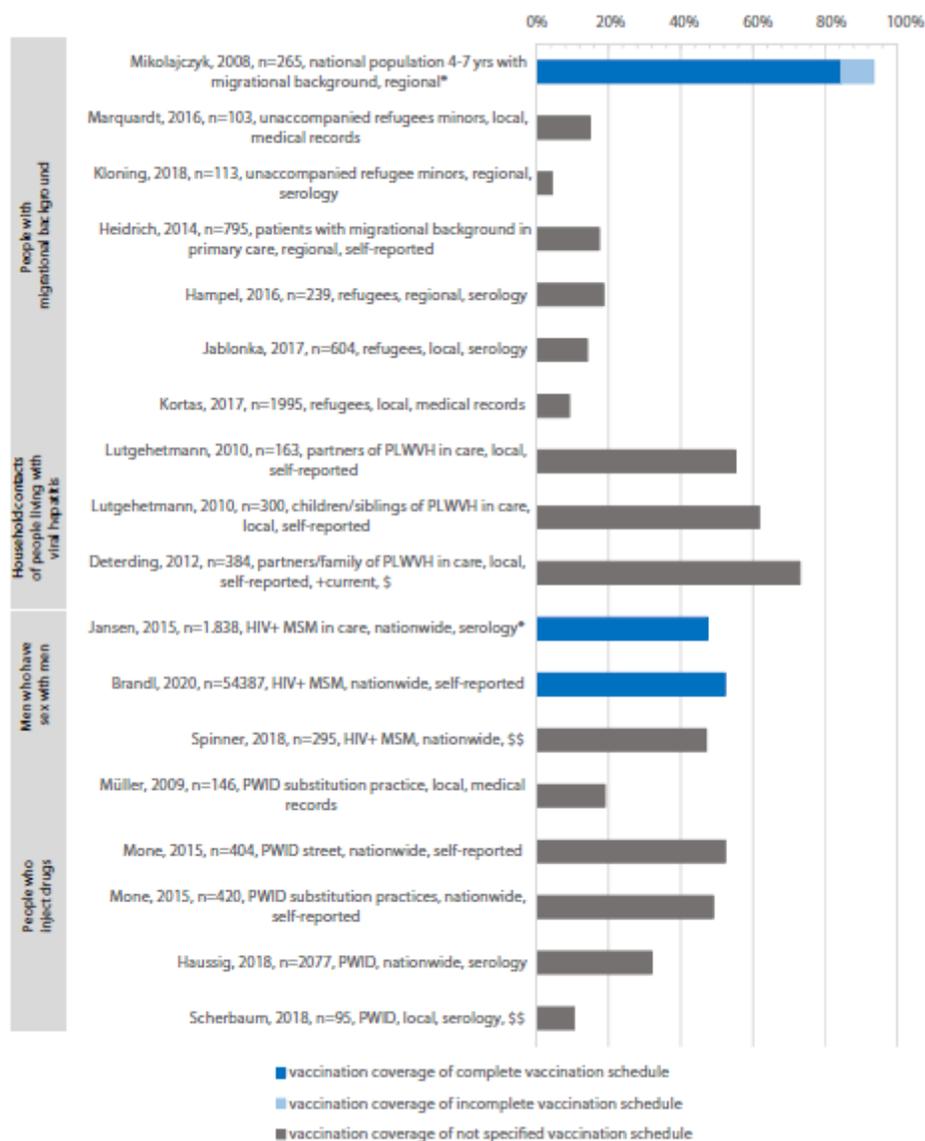


Figure 5

vaccination coverage in Germany among populations at risk for non-occupational HBV exposure, %, 2005-2019, (*publication allocated to two population groups, \$ HBV VC only in HBV susceptible people, \$\$ HBV VC also in HBV susceptible people available, +current: additional information on % of currently protected available)

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