Vaccine-preventable diseases other than tuberculosis, and homelessness: A scoping review of the published literature, 1980 to 2020

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Main text (3024/5000 words)

1. Introduction.

In addition to mental illness and unintentional injuries, people experiencing homelessness (PEH) are exposed to communicable diseases, which may lead to outbreaks that can become serious public health concerns [1]. High rates of infectious disease have been recorded in the literature among PEH, including respiratory tract infections [2], gastrointestinal infections [3], skin infections, arthropod-borne diseases [4], and blood-borne and sexually transmitted infections [1].

The prevalence of these infectious diseases among the PEH varies greatly, depending on exposure factors. Generally, frequent alcohol and tobacco consumption or illicit drug use significantly impair the health status of PEH [1]. Those sleeping on the street, outdoors in vehicles or in abandoned buildings are at high risk of food-borne disease [3] and human louse-transmitted disease [5] (as the result of exposure to unhygienic environments) . PEH are also at risk of blood-borne and sexually transmitted infections (as the result of injected drug use and unprotected sexual practices) [6, 7]. In addition, living in overcrowded accommodations, poor environmental conditions (poor ventilation, lack of sufficient food) and lack of continuity of care (omission of preventive measures, delayed diagnosis, interrupted or poor quality treatment) may increase vulnerability to infection, including transmissible disease. Consequently, when outbreaks occur in these settings, they spread rapidly, often with a high probability of prolonged transmission [1].

Evidence suggests that vaccination is still the most effective strategy for preventing infectious disease, resulting in significant reductions in illness, disability and death from several VPD [8]. Implementing routine vaccination may not only ensure long-term protection against VPD through the progressive increase of population immunity, limiting the number of preventable deaths among PEH during an outbreak [3], but also protects vulnerable members of the general population who have not received all vaccines [9].

Tuberculosis (TB) in PEH has been extensively described in several recent review papers [10-13]. This scoping review of the published literature aims to describe outbreaks of VPDs or VPD

prevalence (other than TB) in both an infant and adult homeless population during the period 1980-2020.

2. Materials and Methods

The review protocol are available at OSF website (https://osf.io/4a8dx). The scoping review followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [14].

Information source. A literature search was performed to identify relevant articles published from 1980 to December 8th, 2020 in PubMed/Medline (in English), Scopus (in English), Web of Science databases (in English), SciELO (in English, Portuguese and Spanish), and Google Scholar (in French), using Harzing's Publish or Perish software (version 7.0, Harzing.com, UK). Search strings were tailored to each database. The combinations (#3) of homelessness terms (#1) and disease terms (#2) were used as following:

#1: "homeless" OR "homelessness" OR "street people"

#2: "diphtheria" OR "*Corynebacterium diphtheriae*" OR "tetanus" OR "*Condyloma accuminata"* OR "polio" OR "poliovirus" OR "poliomyelitis" OR "pertussis" OR "whooping cough" OR "*Bordetella pertussis*" OR "*Haemophilus influenzae* type b" OR "hepatitis B" OR "pneumococcal" OR "*Streptococcus pneumoniae*" OR "meningococcal" OR "meningococcus" OR "*Neisseria meningitidis*" OR "mumps" OR "measles" OR "rubella" OR "Human papillomavirus" OR "influenza" OR "flu" OR "hepatitis A" OR "shingles" OR "Varicella" OR "chickenpox" OR "typhoid" OR "Salmonella" OR "Rotavirus" OR "cholera" OR "*Vibrio cholerae* " OR "yellow fever" OR "rabies" OR "lyssaviruses" OR "Japanese encephalitis" OR "leptospirosis" OR "Leptospira"

#3: #1 AND #2

Combinations of the search terms in Spanish, Portuguese and French are shown in Supplementary data.

2.2. Inclusion and exclusion criteria. For inclusion, an article had to fulfil the following criteria: articles (1) written in English (focused language), French, Spanish, or Portuguese languages (if any); (2) published in peer-reviewed journals; (3) reporting outbreaks of VPD or VPD prevalence in

an infant or adult PEH. If two or more similar studies were conducted on the same population, the most recent publication was selected for inclusion.

Articles were excluded if the studies were reviews, case reports, editorial, letters, books, comments, or reported only vaccination rates. An additional manual search was conducted by reviewing reference lists of papers retrieved through the electronic search.

***Data analysis*.** Search results were compiled in the Endnote software (version 9.3, Clariate, USA), and duplicates were removed. The screening based on title and abstract were performed independently by two investigators (TD and SC) for inclusion. All disagreements were resolved by discussion and mutual agreement, and full-texts were reviewed if necessary. For eligible articles, full texts were assessed by two investigators (TD and VT).

Relevant information from the studies was charted in Microsoft Excel 2016 (Microsoft, USA). Data table elements were created and were reviewed by all authors to ensure consistency of information extraction. Data extracted included date of study, study design, place of study, setting, population at risk, disease attack rate, age, sex, diagnostic tools, vaccine recommendations from authors, risk factors for diseases, mortality rate, co-infections with other VPD, and previous vaccination rate when available. Extractions were performed independently by two investigators (TD and PG).

3. Results

As presented in Figure 1, the search identified a total of 2917 records after removing duplicates, of which 81 articles/reports fulfilled the eligibility criteria (Figure 1). Additional manual search conducted by reviewing reference lists of selected papers did not result in identifying other relevant articles. Seventy-seven were written in English, two in Spanish, one in French and one in Portuguese. The main findings of these articles are presented in Table 1.

Hepatitis B (Table 1)

Forty-four hepatitis B articles reporting on vulnerable populations including notably PEH, were retrieved [6, 15-57]. Overall, 274,340 individuals were enrolled between 1988 and 2019. Twenty- nine studies were conducted in adults (mean age: 25-49 years, range 16-86 years) [6, 16-23, 25-28, 32-37, 30-44, 48, 49, 53, 56, 57], five studies were conducted in street youth (mean age:10-16 years, range 8-

18 years) [24, 29-31, 55], and ten in both children and adults (mean age: 14-26 years, range 9-65 years) [15, 38, 39, 45-47, 50-52, 54]. Studies were conducted in the USA (n=17) [16, 21, 36-38, 41, 44-51, 53, 56, 57], Iran (n=4) [6, 20, 24, 31], Canada [39, 52, 55], Brazil [22, 40, 54] France [17, 19, 43], the UK [26, 28, 33], (n=3 per country), Australia [34], Costa Rica [27], Czech Republic [35], Germany [25], India [29], Ireland [32], Peru [23], Philippines [30], Colombia [15], Sound Africa [18], and Spain [39] (n=1 per country). Forty-two studies reported seroprevalence surveys [6, 15-22, 24-46, 48-57]. The prevalence of anti-HBc antibodies ranged from 10.4% to 80.3% (past infection) and that of HBsAg ranged from 0.4% to 4.7% (ongoing infection). Two retrospective questionnaire surveys reported rates of 1.6% and 6% of past HBV infection among participants [23, 47]. HBV seroprevalence rates among PEH was significantly higher than in non-PEH included in the studies, or than in the general population studies conducted at the same period (n=15) [18, 19, 21, 22, 25, 34, 35, 39, 43, 46, 51, 42, 54-56].

HBV past infection among PEH was shown to be positively associated with older age [22, 46, 52], with homosexual or bisexual practices, having a sexual partner(s) with a history of unspecified hepatitis or insertive anal penetration [18, 22, 46, 52], having black skin colour [23], reporting injected drug use (IDU) [6, 18, 25-27, 32-35, 38, 39, 42, 44, 48, 52, 53], and alcohol use [36]. One study conducted among 189 PEH in Australia reported that 6.3% of individuals with a past HBV infection also had a past hepatitis A (HAV) infection [34]. No hepatitis B–related deaths were reported.

Nine studies reported vaccination status against HBV infection and were conducted in the USA (n=3), the UK (n=2), Canada, France, Germany, Brazil (n=1 per country).: Six studies were based on questionnaires, with vaccination rates ranging 9%-54% (at least one dose) and 11.8%->66% (3 doses) [25, 33, 47, 48, 50, 52], and three studies showed immunisation rates of 21.8%-38.7% through serological tests [22, 26]. Anti-HBV vaccination was strongly recommended by all authors for high risk groups such as street youth or injected drug users (n=26 studies) [15, 17-19, 22, 25, 26, 34, 35, 38-40, 42-48, 50-52, 54-57].

Hepatitis A (Table 2)

Nineteen articles on HAV conducted among PEH fulfilled the eligibility criteria [34, 38, 39, 58-73]. Overall, 12,336 individuals were enrolled between 1991 and 2019. Eleven studies were conducted

in adults (mean age: 19-45 years, range 16-74 years) [34, 59-62, 64, 66-68, 70, 71], and eight in populations comprising children and adults (mean age: 25-42 years, range 0-90 years) [38, 39, 58, 53, 65, 69, 72, 73]. Studies were conducted in the USA (n=8) [38, 58, 60-63, 66, 70], Canada (n=4) [39, 59, 71, 72], Brazil [73], the UK [69], France [68], Czech Republic [65], The Netherlands [67], Iran [64] and Australia [34] (n=1 per country).

Nine surveys addressed the seroprevalence of total anti-HAV antibodies among 7616 individuals: six revealed a high prevalence of 19.3%-94.8% among PEH in Brazil, Canada, the USA and France [34, 38, 39, 64, 70, 73], while two studies showed lower seroprevalence rates of 4.7%-6.3% among Canadian street youth, but with a high prevalence of risk factors for infection [71, 72]. Four studies reported risk factors for high prevalence of HAV infection (aging >41 years, reporting IDU, having sexual partner(s) with history of unspecified hepatitis, male subjects reporting insertive anal penetration or those originating from a country with a high anti-HAV prevalence or in Africa) [38, 68, 71, 72]. Other studies described ten outbreaks of Hepatitis A in several cities in the UK, The Netherlands, Czech republic and the USA; the numbers of confirmed cases in hospitals ranged from 42 to 1521 per outbreak (resulting in a total of 4720 outbreak-associated cases with a high prevalence of 14.0%-78.0% being PEH) [58-63, 65, 66, 68, 69]. HAV-associated deaths ranged from 0-4.8% during outbreaks. Rates of co-infection with HAV and HBV (or HCV) were 3.0%, 6.3% and 34.0% in three studies [34, 59, 63]. No data about previous vaccination rates were available. Vaccination of homeless populations against HAV was strongly recommended in 17 studies [34, 38, 39, 58-61, 63, 65-73].

Pneumococcal infections (Table 3)

Thirteen studies concerning pneumococcal infections in PEH were retrieved between 1988 and 2018 [2, 74-85]: eleven studies were conducted in adults (mean age: 19-54 years, range 16-78 years) and one in a population comprising children and adults (mean age: 42 years, range 0-90 years). Most studies were conducted in Canada (n=8) [65, 77-83], followed by the USA (n=4) [74, 76, 84, 85], and France (n=1) [2]. One molecular prevalence survey reported rate of 12.4% for pneumococcal nasopharyngeal carriage among a total of 477 sheltered PEH in Marseille, France between 2015-2017 [2], and prevalence was positively associated with respiratory symptoms and signs. One study assessed serotype of 2885 IPD isolates and reported a 7% proportion being from PEH [Metcalf]. Other studies

described eleven outbreaks of invasive pneumococcal disease (IPD) occurring in different cities in Canada, the USA and France; of those, two studies reported 153 PEH hospitalised with IPD, which accounted for 1.4%-8.4% of all PEH present in two cities, Toronto (Canada) and Anchorage (USA) [83, 84]; nine other studies reported a high proportion (4.7%-48.8%) of homelessness among 4742 individuals hospitalised with IPD [75-82, 85]. PEH with IDP were typically younger [80, 84], more likely to be male [80], smokers [80, 82, 83], alcohol abusers [80, 82, 89], illegal drug users [80, 82], and to have a primary diagnosis of pneumonia [83], HIV infection or liver disease [83] when compared with non-PEH. Of nine studies, two characterising the serotype of isolated *Streptococcus pneumoniae* strains showed that serotypes 1, 4, 5, 8 and 12F were positively associated with homelessness in Canada [75, 77, 79]. Serotypes 4, 7F, 12F and 20 were more likely to be reported among PEH in the USA [74]. A serotype 1 IPD outbreak was reported among sheltered PEH in Paris, France between 1988-1989 [85]. The mortality rate was 0%-15.6% among infected PEH during outbreaks. By using a questionnaire, previous vaccination rates among the homeless population were reported to be 9.0%-37.0% in Canada (n=3), and France (n=1) [75, 77, 83, 85]. The pneumococcal vaccine was recommended for homeless populations in all articles.

Diphtheria (Table 3)

Six diphtheria outbreak investigations were identified between 1972 and 2019. Overall, 1259 diphtheria cases were confirmed by culture (with a high prevalence of 12.0%-95.0% cases being PEH) [86-91]. Three studies were conducted in adults (mean age: 40-45 years, range 16->71 years) [87-89], and two in both children and adults (mean age: 37-38 years, range 4-87 years) [90, 91]. An early investigation conducted in Seattle, USA between 1972-1982 reported an outbreak of respiratory and cutaneous infections among 1100 patients, including 95% PEH [91]. Molecular studies performed in different types of samples (details not provided) collected in Germany and Poland showed a high 53.9%-100% prevalence of genotype ST8 [87, 88]. Cutaneous infection was reported among PEH in Switzerland, Germany and France between 1996-1997 and in the USA between 2018-2019 [86, 89]. One study conducted in France between 1987-1993 reported 40 patients with systemic infection [90].

Several risk factors for diphtheria infection were identified, including alcohol abuse [87-89, 91], poor hygiene, crowding conditions, contaminated fomites, underlying skin disease, hyperendemic

streptococcal pyoderma, and introduction of new strains from exogenous reservoirs [91]. Death from diphtheria was reported in two studies, with 0.9%-36.0% lethality rates [90, 91]. No data about previous vaccination status was available. One study recommended the need for vaccination boosters in alcoholic PEH [91].

Seasonal influenza (Table 3)

Four PCR-based prevalence surveys conducted among 1103 PEH or persons from marginalised populations between 2005 and 2018 fulfilled the eligibility criteria [2, 17, 92, 93]. Three were conducted among adult sheltered PEH in Marseille, France, and one was conducted among marginalised populations, including PEH, in Tijuana, Mexico. Three studies were conducted in adults (mean age: 35-44 years, range 18-84 years) [2, 17, 92] and one in a population comprising children and adults (mean age: 41 years, range 7-76 years) [93]. These studies reported a 1.0-3.0% rate of influenza nasopharyngeal carriage among sheltered PEH. Using a questionnaire, the previous seasonal influenza vaccination rate among the homeless population was 9.0% in Mexico and 15.0% in France. The rate of co-infection with *S. pneumoniae* and influenza viruses was 0.2% among PEH in Marseille, France [2]. No influenza deaths were reported. All authors recommended vaccination against influenza for PEH.

Human papillomavirus (HPV) infection (Table 3)

Only two American studies concerning HPV infection fulfilled the eligibility criteria. They were conducted in young adults (range 16-29 years) [50, 94]. One molecular prevalence survey was conducted among 130 men having sex with men, of whom 22.6% were homeless and 75% had at least one high-risk HPV type [94]. Another epidemiological study using Pap smear testing in 2960 young female PEH revealed a 2.0% rate of HPV infection [50]. Information about vaccination rates was not recorded. No deaths were reported. The vaccination against HPV-16 was recommended for homeless men who have sex with men [94].

Other VPD

No reports about measles, tetanus, poliomyelitis, pertussis, *H. influenzae* type b infection, meningococcal C infection, mumps, rubella, varicella, chickenpox, typhoid fever, rotavirus infection,

cholera, yellow fever, lyssaviruses, rabies, Japanese encephalitis and leptospirosis among PEH were retrieved.

4. Discussion

This review identified that HBV infection, HAV infection, IPD, and diphtheria were the most commonly reported VPDs among PEH between 1980 and 2020. Few studies were published on influenza in PEH and those published evidenced a low prevalence of influenza in this population. Further investigations are needed to conclude whether vaccination against influenza can be recommended in PEH.

High rates of HBV and HAV infection in PEH were observed through serological surveys in low endemicity countries, including the USA, Canada, France, and in moderate endemicity countries such as Iran and Brazil. Outbreaks of HAV infection were reported in the US. Currently, three modes of HBV transmission have been recognised: perinatal, sexual and parenteral/percutaneous transmission [95], whilst acute HAV is a highly contagious infection resulting from faeco-oral transmission and has been one of the major aetiologies for foodborne disease [96]. PEH, notably those using injected drugs and having at-risk sexual practices, should therefore benefit from vaccination against HBV and HAV infections, together with the provision of injection kits, drug substitutes and condoms.

Outbreaks of IPD were reported in PEH in Canada, and several risk factors were identified, including smoking, alcohol abuse, illegal drug use and having several chronic diseases. Given that the serotypes attributable to these outbreaks (1, 4, 5, 8, 7F, 12F, 20) are among those included in the 23-valent pneumococcal polysaccharide vaccine, vaccination of PEH against IPD should be considered, notably when presenting with risk factors.

Finally, because of several diphtheria outbreaks occurring among PEH, updating vaccination against this disease should be also considered in this population, as in the general population.

To the best of our knowledge, specific vaccination recommendations for PEH in national guidelines have been made in only two countries. The 23-valent pneumococcal polysaccharide vaccine (PPSV23) was recommended early in 2008 by the Canadian National Advisory Committee on Immunization (NACI) for all PEH. In the USA, the adult immunisation schedule [97], updated

annually by the Advisory Committee on Immunization Practices (ACIP), has recommended HAV vaccination for all PEH aged > 1 year since October 2018 [3].

In France, the Ministry of Solidarity and Health (Table 4) recommends HAV vaccination for: children aged > 1 year having at least one family member originating from a country with a high prevalence of anti-HAV antibody, for patients with cystic fibrosis or liver disease (notably viral hepatitis and alcohol abuse), for institutionalised infants or young disabled persons, for men having sex with men, for professionals exposed to HAV or involved in collective food preparation and for travellers to endemic areas. For HBV, IPD, and diphtheria, primary vaccination is recommended for all children. The HBV vaccination is notably recommended for institutionalised infants or young disabled persons, for persons in psychiatric institutions, for those with at-risk sexual practices, those using injected drugs or having chronic liver disease or HIV infection, for those with at least one family member with HBV infection, for detained persons, for professionals exposed to HBV (notably health care professionals) and for travellers to endemic areas [98]. PPSV23 together with PCV13 (13-valent pneumococcal conjugate vaccine) is especially recommended for those with several chronic conditions (HIV infection, chronic respiratory disease, heart failure, etc.). No specific recommendations concerning diphtheria vaccination are given for high risk groups other than professionals.

Delivering vaccines to homeless populations has always been a challenge. Combining easy access and education is probably the best approach to vaccination administration programmes in this population. We suggest making vaccines available at homeless shelters or homeless restaurants through medical or paramedical staff. For homeless IDU, the availability of vaccines at syringe-exchange sites could provide more opportunities for them to access vaccination [48]. Additionally, we also suggest applying a rapid serological testing strategy in areas where PEH tend to aggregate, including HBsAg detection (for HBV) [99] and IgM/IgG anti-HAV, since a substantial proportion of individuals may already have antibodies against these infections due to past exposure to the viruses or previous vaccination.

Because this review was restricted to articles written in general languages such as English, Spanish, Portuguese and French, the data collected are mainly from the North American and European continents. Limitations include the possible lack of articles from Asian and African regions. Despite

these limitations, our review showed that implementation of vaccination coverage against communicable diseases in the homeless population is a major public health priority. We strongly recommend updating vaccination against HAV, HBV, pneumococcal infection and diphtheria in PEH when entering homeless shelters or whenever they are present in a healthcare setting, rather than as a response measure to prevent outbreaks after the first case has occurred.

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References (99/100)

[1]. Badiaga S, Raoult D, Brouqui P. Preventing and controlling emerging and reemerging transmissible diseases in the homeless. Emerg Infect Dis 2008; 14(9):1353-9. http://doi.org/10.3201/eid1409.080204.

[2]. Ly TDA, Edouard S, Badiaga S, Tissot-Dupont H, Hoang VT, Pommier de Santi V, et al. Epidemiology of respiratory pathogen carriage in the homeless population within two shelters in Marseille, France, 2015-2017: cross sectional 1-day surveys. Clin Microbiol Infect 2019; 25(2):249.e1-249.e6. http://doi.org/10.1016/j.cmi.2018.04.032.

[3]. Doshani M, Weng M, Moore KL, Romero JR, Nelson NP. Recommendations of the Advisory Committee on Immunization Practices for Use of Hepatitis A Vaccine for Persons Experiencing Homelessness. MMWR Morb Mortal Wkly Rep 2019; 68(6):153-156. http://doi.org/10.15585/mmwr.mm6806a6.

[4]. Brouqui P, Raoult D. Arthropod-borne diseases in homeless. Ann N Y Acad Sci 2006; 1078:223-235. http://doi.org/10.1196/annals.1374.041.

[5]. World Health Organization. A global brief on vector-borne diseases, https://apps.who.int/iris/handle/10665/111008 ; 2008 [accessed 20 September 2020].

[6]. Vahdani P, Hosseini-Moghaddam SM, Family A, Moheb-Dezfouli R. Prevalence of HBV, HCV, HIV and syphilis among homeless subjects older than fifteen years in Tehran. Arch Iran Med 2009; 12(5):483-487.

[7]. Robertson MJ, Cousineau MR. Health status and access to health services among the urban homeless. Am J Public Health 1986;76:561-563.

[8]. Andre FA, R Booy , HL Bock , J Clemens , SK Datta , TJ John , et al. Vaccination greatly reduces disease, disability, death and inequity worldwide, https://www.who.int/bulletin/volumes/86/2/07-040089/en/ ; 2008 [accessed 20 September 2020].

[9]. Borba RC, Vidal VM, Moreira LO. The re-emergency and persistence of vaccine preventable diseases. An Acad Bras Cienc 2015; 87(2 Suppl):1311-1322. http://doi.org/10.1590/0001-3765201520140663.

288 [10]. Hamilton K, Tolfree R, Mytton J. A systematic review of active case-finding strategies for
289 tuberculosis in homeless populations. Int J Tuberc Lung Dis 2018; 22(10):1135-1144.
290 http://doi.org/10.5588/ijtld.17.0784.
291 [11]. Heuvelings CC, Greve PF, de Vries SG, Visser BJ, Bélard S, Janssen S, et al. Effectiveness of
292 service models and organisational structures supporting tuberculosis identification and
293 management in hard-to-reach populations in countries of low and medium tuberculosis
294 incidence: a systematic review. BMJ Open 2018; 8(9):e019642. http://doi.org/10.1136/bmjopen-
295 2017-019642.
296 [12]. Parriott A, Malekinejad M, Miller AP, Marks SM, Horvath H, Kahn JG. Care Cascade for
297 targeted tuberculosis testing and linkage to Care in Homeless Populations in the United States: a
298 meta-analysis. BMC Public Health 2018;18(1):485. http://doi.org/10.1186/s12889-018-5393-x.
299 [13]. Getahun H, Matteelli A, Abubakar I, Aziz MA, Baddeley A, Barreira D, et al. Management of
300 latent *Mycobacterium tuberculosis* infection: WHO guidelines for low tuberculosis burden
301 countries. Eur Respir J 2015;46(6):1563-1576. http://doi.org/10.1183/13993003.01245-2015.
302 [14]. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for
303 Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med 2018;169(7):467-
304 473. http://doi.org/10.7326/M18-0850.
305 [15]. Cardona-Arias JA, Correa JCC, Higuita-Gutiérrez LF. Prevalence of hepatitis B/C viruses and
306 associated factors in key groups attending a health services institution in Colombia, 2019. PLoS
307 One 2020;15(9):e0238655. http://doi.org/10.1371/journal.pone.0238655.
308 [16]. Fuster D, Gelberg L. Community Screening, Identification, and Referral to Primary Care, for
309 Hepatitis C, B, and HIV Among Homeless Persons in Los Angeles. J Community Health 2019;
310 44(6):1044-1054. http://doi.org/10.1007/s10900-019-00679-w.
311 [17]. Ly TDA, Dao TL, Hoang VT, Braunstein D, Brouqui P, Lagier JC, et al. Pattern of infections in
312 French and migrant homeless hospitalised at Marseille infectious disease units, France: A
313 retrospective study, 2017-2018. Travel Med Infect Dis 2020:101768.
314 http://doi.org/10.1016/j.tmaid.2020.101768.

315 [18]. Scheibe A, Young K, Versfeld A, Spearman CW, Sonderup MW, Prabdial-Sing N, et al.
316 Hepatitis B, hepatitis C and HIV prevalence and related sexual and substance use risk practices
317 among key populations who access HIV prevention, treatment and related services in South
318 Africa: findings from a seven-city cross-sectional survey (2017). BMC Infect Dis
319 2020;20(1):655. http://doi.org/10.1186/s12879-020-05359-y.
320 [19]. Legoupil C, Peltier A, Henry Kagan V, Segouin C, Alberti C, de Massé L, et al. Out-of-Hospital
321 screening for HIV, HBV, HCV and Syphilis in a vulnerable population, a public health
322 challenge. AIDS Care 2017; 29(6):686-688. http://doi.org/10.1080/09540121.2016.1231886.
323 [20]. Doosti-Irani A, Mokhaeri H, Chegini Sharafi A, Aghasadeghi MR, Hajimiragha M, Saki M, et al.
324 Prevalence of HIV, HBV, and HCV and Related Risk Factors amongst Male Homeless People in
325 Lorestan Province, the West of Iran. J Res Health Sci 2017; 17(1):e00373.
326 [21]. Noska AJ, Belperio PS, Loomis TP, O'Toole TP, Backus LI. Prevalence of Human
327 Immunodeficiency Virus, Hepatitis C Virus, and Hepatitis B Virus Among Homeless and
328 Nonhomeless United States Veterans. Clin Infect Dis 2017; 65(2):252-258.
329 http://doi.org/10.1093/cid/cix295.
330 [22]. Carvalho PMRDS, Matos MA, Martins RMB, Pinheiro RS, Caetano KAA, Souza MM, et al.
331 Prevalence, risk factors and hepatitis B immunization: helping fill the gap on hepatitis B
332 epidemiology among homeless people, Goiânia, Central Brazil. Cad Saude Publica
333 2017;33(7):e00109216. http://doi.org/10.1590/0102-311X00109216.
334 [23]. Moquillaza-Risco M, León E, Dongo M, Munayco CV. Características sociodemográficas y de
335 salud de los adultos mayores en situación de calle en Lima, Perú. Rev Peru Med Exp Salud
336 Pública 2015; 32:693–700.
337 [24]. Foroughi M, Moayedi-Nia S, Shoghli A, Bayanolhagh S, Sedaghat A, Mohajeri M, et al.
338 Prevalence of HIV, HBV and HCV among street and labour children in Tehran, Iran. Sex
339 Transm Infect. 2017;93(6):421-423. http://doi.org/10.1136/sextrans-2016-052557.
340 [25]. Haussig JM, Nielsen S, Gassowski M, Bremer V, Marcus U, Wenz B, et al. A large proportion of
341 people who inject drugs are susceptible to hepatitis B: Results from a bio-behavioural study in
342 eight German cities. Int J Infect Dis 2018; 66:5-13. http://doi.org/10.1016/j.ijid.2017.10.008.

343 [26]. Aldridge RW, Story A, Hwang SW, Nordentoft M, Luchenski SA, Hartwell G, et al. Morbidity
344 and mortality in homeless individuals, prisoners, sex workers, and individuals with substance use
345 disorders in high-income countries: a systematic review and meta-analysis. Lancet 2018;
346 391(10117):241-250. http://doi.org/10.1016/S0140-6736(17)31869-X.
347 [27]. Leiva-Hidalgo J, Madrigal-Méndez A, Salas-Segura D. Seroprevalence of Heptatis B, C and VIH
348 en Homeless People in Costa Rica. Rev Costarric Salud Pública 2013; 22:113–118.
349 [28]. Craine N, Hickman M, Parry JV, Smith J, McDonald T, Lyons M. Characteristics of injecting
350 drug users accessing different types of needle and syringe programme or using secondary
351 distribution. J Public Health (Oxf); 32(3):328-235. http://doi.org/10.1093/pubmed/fdp131.
352 [29]. Bal B, Mitra R, Mallick AH, Chakraborti S, Sarkar K. Nontobacco substance use, sexual abuse,
353 HIV, and sexually transmitted infection among street children in Kolkata, India. Subst Use
354 Misuse 2010; 45(10):1668-1682. http://doi.org/10.3109/10826081003674856.
355 [30]. Njord L, Merrill RM, Njord R, Pachano JD, Hackett A. Characterizing health behaviors and
356 infectious disease prevalence among Filipino street children. Int J Adolesc Med Health 2008
357 ;20(3):367-374. http://doi.org/10.1515/ijamh.2008.20.3.367.
358 [31]. Vahdani P, Hosseini-Moghaddam SM, Gachkar L, Sharafi K. Prevalence of hepatitis B, hepatitis
359 C, human immunodeficiency virus, and syphilis among street children residing in southern
360 Tehran, Iran. Arch Iran Med 2006; 9(2):153-155.
361 [32]. O'Carroll A, O'Reilly F. Health of the homeless in Dublin: has anything changed in the context of
362 Ireland's economic boom? Eur J Public Health. 2008; 18(5):448-453.
363 http://doi.org/10.1093/eurpub/ckn038.
364 [33]. Lyons M, Walker M, Craine N, Smith J. Incidence of blood borne viral hepatitis in injecting drug
365 users in South Wales: a de-linked prospective cohort study. National Public Health Service for
366 Wales 2006; 16 –19.
367 [34]. Poulos R, Ferson M, Orr K, Lucy A, Botham S, McCarthy M, Stern J, Dixon J, Murray C, Polis
368 S. Risk factors and seroprevalence of markers for hepatitis A, B and C in persons subject to
369 homelessness in inner Sydney. Aust N Z J Public Health 2007;31(3):247-51.
370 http://doi.org/10.1111/j.1467-842x.2007.00056.x.

371 [35]. Volf V, Marx D, Pliskova L, Sümegh L, Celko A. A survey of hepatitis B and C prevalence
372 amongst the homeless community of Prague. Eur J Public Health. 2008;18(1):44-47.
373 http://doi.org/10.1093/eurpub/ckm072.
374 [36]. Stein JA, Andersen RM, Robertson M, Gelberg L. Impact of hepatitis B and C infection on health
375 services utilization in homeless adults: a test of the Gelberg-Andersen Behavioral Model for
376 Vulnerable Populations. Health Psychol 2012; 31(1):20-30. http://doi.org/10.1037/a0023643.
377 [37]. Boyce DE, Tice AD, Ona FV, Akinaka KT, Lusk H. Viral hepatitis in a homeless shelter in
378 Hawai'i. Hawaii Med J 2009;68(5):113-115.
379 [38]. Garfein RS, Swartzendruber A, Ouellet LJ, Kapadia F, Hudson SM, Thiede H, et al. Methods to
380 recruit and retain a cohort of young-adult injection drug users for the Third Collaborative
381 Injection Drug Users Study/Drug Users Intervention Trial (CIDUS III/DUIT). Drug Alcohol
382 Depend 2007;91 Suppl 1:S4-17. http://doi.org/10.1016/j.drugalcdep.2007.05.007.
383 [39]. Moses S, Mestery K, Kaita KD, Minuk GY. Viral hepatitis in a Canadian street-involved
384 population. Can J Public Health. 2002;93(2):123-128.
385 [40]. Brito VO, Parra D, Facchini R, Buchalla CM. [HIV infection, hepatitis B and C and syphilis in
386 homeless people, in the city of São Paulo, Brazil]. Rev Saude Publica 2007; 41 Suppl 2:47-56.
387 Portuguese.
388 [41]. Harris HW, Young DM. Care of injection drug users with soft tissue infections in San Francisco,
389 California. Arch Surg 2002; 137(11):1217-1222.
390 http://doi.org/doi:10.1001/archsurg.137.11.1217.
391 [42]. Vallejo F, Toro C, de la Fuente L, Brugal MT, Soriano V, Silva TC, et al. Prevalence of and risk
392 factors for hepatitis B virus infection among street-recruited young injection and non-injection
393 heroin users in Barcelona, Madrid and Seville. Eur Addict Res 2008;14(3):116-24.
394 http://doi.org/10.1159/000130415.
395 [43]. Ly TDA, Hoang VT, Louni M, Dao TL, Badiaga S, Tissot-Dupont H, et al. Epidemiological
396 serosurvey and molecular characterisation of sexually transmitted infections among 1,890
397 sheltered PEH in Marseille: cross-sectional one day-surveys (2000-2015). J Infect 2020:S0163-
398 4453(20)30723-4. http://doi.org/10.1016/j.jinf.2020.11.026.

399 [44]. Klinkenberg WD, Caslyn RJ, Morse GA, Yonker RD, McCudden S, Ketema F, et al. Prevalence
400 of human immunodefi ciency virus, hepatitis B, and hepatitis C among homeless persons with
401 co-occurring severe mental illness and substance use disorders. Compr Psychiatry 2003; 44:293–
402 302. http://doi.org/10.1016/S0010-440X(03)00094-4.
403 [45]. Noell J, Rohde P, Ochs L, Yovanoff P, Alter MJ, Schmid S, Bullard J, Black C. Incidence and
404 prevalence of chlamydia, herpes, and viral hepatitis in a homeless adolescent population. Sex
405 Transm Dis 2001; 28(1):4-10. http://doi.org/doi:10.1097/00007435-200101000-00003.
406 [46]. Beech BM, Myers L, Beech DJ, Kernick NS. Human immunodeficiency syndrome and hepatitis
407 B and C infections among homeless adolescents. Semin Pediatr Infect Dis 2003;14(1):12-9.
408 [47]. Lifson AR, Halcón LL. Substance abuse and high-risk needle-related behaviors among homeless
409 youth in Minneapolis: implications for prevention. J Urban Health 2001; 78(4):690-698.
410 http://doi.org/10.1093/jurban/78.4.690.
411 [48]. Altice FL, Bruce RD, Walton MR, Buitrago MI. Adherence to hepatitis B virus vaccination at
412 syringe exchange sites. J Urban Health 2005; 82(1):151-161.
413 http://doi.org/10.1093/jurban/jti016.
414 [49]. Cheung RC, Hanson AK, Maganti K, Keeffe EB, Matsui SM. Viral hepatitis and other infectious
415 diseases in a homeless population. J Clin Gastroenterol 2002; 34(4):476-80.
416 http://doi.org/10.1097/00004836-200204000-00021.
417 [50]. Steele RW, Ramgoolam A, Evans J Jr. Health services for homeless adolescents. Semin Pediatr
418 Infect Dis 2003; 14(1):38-42. http://doi.org/10.1053/spid.2003.127216.
419 [51]. Alderman EM, Shapiro A, Spigland I, Coupey SM, Bashir M, Fox AS. Are there risk factors for
420 hepatitis B infection in inner-city adolescents that justify prevaccination screening? J Adolesc
421 Health 1998; 22(5):389-393.
422 [52]. Roy E, Haley N, Lemire N, Boivin JF, Leclerc P, Vincelette J. Hepatitis B virus infection among
423 street youths in Montreal. CMAJ 1999; 161(6):689-693.
424 [53]. López-Zetina J, Kerndt P, Ford W, Woerhle T, Weber M. Prevalence of HIV and hepatitis B and
425 self-reported injection risk behavior during detention among street-recruited injection drug users

426 in Los Angeles County, 1994-1996. Addiction 2001 ;96(4):589-95.
427 http://doi.org/10.1080/09652140020031638.
428 [54]. Porto SO, Cardoso DD, Queiróz DA, Rosa H, Andrade AL, Zicker F, Martelli CM. Prevalence
429 and risk factors for HBV infection among street youth in central Brazil. J Adolesc Health. 1994
430 Nov;15(7):577-81.
431 [55]. Wang EE, King S, Goldberg E, Bock B, Milner R, Read S. Hepatitis B and human
432 immunodeficiency virus infection in street youths in Toronto, Canada. Pediatr Infect Dis J
433 1991;10(2):130-133.
434 [56]. McMahon BJ, Wainwright K, Bulkow L, Parkinson AJ, Lindenbaum M, Wainwright R,
435 Helminiak C. Response to hepatitis B vaccine in Alaska natives with chronic alcoholism
436 compared with non-alcoholic control subjects. Am J Med 1990; 88(5):460-464.
437 http://doi.org/10.1016/0002-9343(90)90423-b.
438 [57]. Gelberg L, Robertson MJ, Leake B, Wenzel SL, Bakhtiar L, Hardie EA, et al. Hepatitis B among
439 homeless and other impoverished US military veterans in residential care in Los Angeles. Public
440 Health 2001; 115(4):286-291. http://doi.org/10.1038/sj/ph/1900783. PMID: 11464302.
441 [58]. Wilson E, Hofmeister MG, McBee S, Briscoe J, Thomasson E, Olaisen RH, et al. Hepatitis A
442 Outbreak Associated with Drug Use and Homelessness — West Virginia, 2018. MMWR Morb
443 Mortal Wkly Rep 2019; 68(14);330–331.
444 [59]. Sachdeva H, Benusic M, Ota S, Stuart R, Maclachlan J, Dubey V, Andonov A. Community
445 outbreak of hepatitis A disproportionately affecting men who have sex with men in Toronto,
446 Canada, January 2017-November 2018. Can Commun Dis Rep 2019; 45(10):262-268.
447 http://doi.org/10.14745/ccdr.v45i10a03.
448 [60]. Hofmeister MG, Xing J, Foster MA, Augustine RJ, Burkholder C, Collins J, et al. Hepatitis A
449 person-to-person outbreaks: Epidemiology, morbidity burden, and factors associated with
450 hospitalization - Multiple States, 2016-2019. J Infect Dis 2020:jiaa636.
451 http://doi.org/10.1093/infdis/jiaa636.

452 [61]. Peak CM, Stous SS, Healy JM, Hofmeister MG, Lin Y, Ramachandran S, Foster M, Kao A,
453 McDonald EC. Homelessness and Hepatitis A - San Diego County, 2016-2018. Clin Infect Dis
454 2019 ; pii:ciz788. http://doi.org/10.1093/cid/ciz788.
455 [62]. Kreshak AA, Brennan JJ, Vilke GM, Tolia VM, Caccese M, Castillo EM, et al. A Description of
456 a Health System's Emergency Department Patients Who Were Part of a Large Hepatitis A
457 Outbreak. J Emerg Med. 2018; 55(5):620-626. http://doi.org/10.1016/j.jemermed.2018.07.031.
458 [63]. Foster M, Ramachandran S, Myatt K, Donovan D, Bohm S, Fiedler J, et al. Hepatitis A Virus
459 Outbreaks Associated with Drug Use and Homelessness - California, Kentucky, Michigan, and
460 Utah, 2017. MMWR Morb Mortal Wkly Rep 2018; 67(43):1208-1210.
461 http://doi.org/10.15585/mmwr.mm6743a3.
462 [64]. Jahanbakhsh F, Bagheri Amiri F, Sedaghat A, Fahimfar N, Mostafavi E. Prevalence of HAV Ab,
463 HEV (IgG), HSV2 IgG, and Syphilis Among Sheltered Homeless Adults in Tehran, 2012. Int J
464 Health Policy Manag 2018;7(3):225-230. http://doi.org/10.15171/ijhpm.2017.74.
465 [65]. Fabianova K, Cástková J, Beneš C, Kyncl J, Kriz B. Increase in hepatitis A cases in the Czech
466 Republic in 2008 - preliminary report. Eurosurveillance 2008:13(40).
467 [66]. James TL, Aschkenasy M, Eliseo LJ, Olshaker J, Mehta SD. Response to hepatitis A epidemic:
468 emergency department collaboration with public health commission. J Emerg Med 2009;
469 36(4):412-6. http://doi.org/10.1016/j.jemermed.2007.10.001.
470 [67]. Tjon GM, Götz H, Koek AG, de Zwart O, Mertens PL, Coutinho RA. An outbreak of hepatitis A
471 among homeless drug users in Rotterdam, The Netherlands. J Med Virol 2005; 77(3):360-366.
472 [68]. Ly TDA, Hoang VT, Dao TL, Badiaga S, Tissot-Dupont H, Brouqui P, et al. Hepatitis A
473 seroprevalence in PEH, in Marseille, France. Clin Res Hepatol Gastroenterol 2020:101571.
474 http://doi.org/10.1016/j.clinre.2020.11.003.
475 [69]. Syed NA, Hearing SD, Shaw IS, Probert CS, Brooklyn TN, Caul EO, et al. Outbreak of hepatitis
476 A in the injecting drug user and homeless populations in Bristol: control by a targeted
477 vaccination programme and possible parenteral transmission. Eur J Gastroenterol Hepatol 2003;
478 15(8):901-906.

[70]. Hennessey KA, Bangsberg DR, Weinbaum C, Hahn JA. Hepatitis A seroprevalence and risk factors among homeless adults in San Francisco: should homelessness be included in the risk-based strategy for vaccination? Public Health Rep 2009; 124(6):813-817.

[71]. Ochnio JJ, Patrick D, Ho M, Talling DN, Dobson SR. Past infection with hepatitis A virus among Vancouver street youth, injection drug users and men who have sex with men: implications for vaccination programs. CMAJ 2001; 165(3):293-297.

[72]. Roy E, Haley N, Leclerc P, Cédras L, Bédard L, Allard R. Seroprevalence and risk factors for hepatitis A among Montreal street youth. Can J Public Health 2002; 93(1):52-53. Erratum in: Can J Public Health 2002; 93(3):232.

[73]. Queiróz DA, Cardoso DD, Martelli CM, Martins RM, Porto SO, Azevedo MS, et al. [Seroepidemiology of hepatitis A virus infection in street children of Goiânia-Goiás]. Rev Soc Bras Med Trop 1995; 28(3):199-203. Portuguese.

[74]. Metcalf BJ, Chochua S, Walker H, Tran T, Li Z, Varghese J, et al. Invasive pneumococcal strain distributions and isolate clusters associated with persons experiencing homelessness during 2018. Clin Infect Dis 2020:ciaa1680. http://doi.org/10.1093/cid/ciaa1680.

[75]. McKee G, Choi A, Madill C, Marriott J, Kibsey P, Hoyano D. Outbreak of invasive Streptococcus pneumoniae among an inner-city population in Victoria, British Columbia, 2016-2017. Can Commun Dis Rep 2018; 44(12):317-322. http://doi.org/10.14745/ccdr.v44i12a02.

[76]. Beall B, Walker H, Tran T, Li Z, Varghese J, McGee L, et al. Upsurge of conjugate vaccine serotype 4 invasive pneumococcal disease clusters among adults experiencing homelessness in California, Colorado, and New Mexico. J Infect Dis 2020 http://doi.org/10.1093/infdis/jiaa501.

[77]. Schillberg E, Isaac M, Deng X, Peirano G, Wylie JL, Van Caeseele P, et al. Outbreak of invasive Streptococcus pneumoniae serotype 12F among a marginalized inner-city population in Winnipeg, Canada, 2009-2011. Clin Infect Dis; 59(5):651-657. http://doi.org/10.1093/cid/ciu366.

[78]. Tyrrell GJ, Lovgren M, Ibrahim Q, Garg S, Chui L, Boone TJ, Mangan C, PatrickDM, Hoang L, Horsman GB, Van Caeseele P, Marrie TJ. Epidemic of invasive pneumococcal disease, western

Canada, 2005-2009. Emerg Infect Dis 2012; 18(5):733-740. http://doi.org/10.3201/eid1805.110235.

[79]. Vanderkooi OG, Church DL, MacDonald J, Zucol F, Kellner JD. Community-based outbreaks in vulnerable populations of invasive infections caused by Streptococcus pneumoniae serotypes 5 and 8 in Calgary, Canada. PLoS One 2011; 6(12):e28547. http://doi.org/10.1371/journal.pone.0028547.

[80]. Lemay JA, Ricketson LJ, Zwicker L, Kellner JD. Homelessness in Adults with Invasive Pneumococcal Disease (IPD) in Calgary, Canada. Open Forum Infect Dis2019; 6(10). pii: ofz362. http://doi.org/10.1093/ofid/ofz362.

[81]. Marrie TJ, Tyrrell GJ, Majumdar SR, Eurich DT. Invasive Pneumococcal Disease: Still Lots to Learn and a Need for Standardized Data Collection Instruments. Can Respir J 2017; 2017:2397429. http://doi.org/10.1155/2017/2397429.

[82]. Shariatzadeh MR, Huang JQ, Tyrrell GJ, Johnson MM, Marrie TJ. Bacteremic pneumococcal pneumonia: a prospective study in Edmonton and neighboring municipalities. Medicine (Baltimore). 2005; 84(3):147-161.

[83]. Plevneshi A, Svoboda T, Armstrong I, Tyrrell GJ, Miranda A, Green K, Low D, McGeer A; Toronto Invasive Bacterial Diseases Network. Population-based surveillance for invasive pneumococcal disease in homeless adults in Toronto. PLoS One 2009; 4(9):e7255.

[84]. Mosites E, Zulz T, Bruden D, Nolen L, Frick A, Castrodale L, McLaughlin J, Van Beneden C, Hennessy TW, Bruce MG. Risk for Invasive Streptococcal Infections among Adults Experiencing Homelessness, Anchorage, Alaska, USA, 2002-2015. Emerg Infect Dis 2019; 25(10). http://doi.org/10.3201/eid2510.181408.

[85]. Mercat A, Nguyen J, Dautzenberg B. An outbreak of pneumococcal pneumonia in two men's shelters. Chest 1991; 99(1):147-151.

[86]. Xiaoli L, Benoliel E, Peng Y, Aneke J, Cassiday PK, Kay M, et al. Genomic epidemiology of nontoxigenic *Corynebacterium diphtheriae* from King County, Washington State, USA between July 2018 and May 2019. Microb Genom 2020. http://doi.org/10.1099/mgen.0.000467.

533 [87]. Dangel A, Berger A, Konrad R, Bischoff H, Sing A. Geographically Diverse Clusters of
534 Nontoxigenic *Corynebacterium diphtheriae* Infection, Germany, 2016-2017. Emerg Infect Dis
535 2018; 24(7):1239-1245. http://doi.org/10.3201/eid2407.172026.
536 [88]. Zasada AA. Nontoxigenic highly pathogenic clone of *Corynebacterium diphtheriae*, Poland,
537 2004-2012. Emerg Infect Dis. 2013; 19(11):1870-1972. http://doi.org/10.3201/eid1911.130297.
538 [89]. Funke G, Altwegg M, Frommelt L, von Graevenitz A. Emergence of related nontoxigenic
539 *Corynebacterium diphtheriae* biotype mitis strains in Western Europe. Emerg Infect Dis 1999;
540 5(3):477-780. http://doi.org/10.3201/eid0503.990326.
541 [90]. Patey O, Bimet F, Riegel P, Halioua B, Emond JP, Estrangin E, et al. Clinical and molecular
542 study of *Corynebacterium diphtheriae* systemic infections in France. Coryne Study Group. J
543 Clin Microbiol 1997; 35(2):441-445
544 [91]. Harnisch JP, Tronca E, Nolan CM, Turck M, Holmes KK. Diphtheria among alcoholic urban
545 adults. A decade of experience in Seattle. Ann Intern Med 1989; 111(1):71-82.
546 http://doi.org/10.7326/0003-4819-111-1-71.
547 [92]. Rodwell TC, Robertson AM, Aguirre N, Vera A, Anderson CM, Lozada R, et al. Pandemic
548 (H1N1) 2009 Surveillance in Marginalized Populations, Tijuana, Mexico. Emerg Infect Dis
549 2010;16(8):1292-5. http://doi.org/10.3201/eid1608.100196.
550 [93]. Badiaga S, Richet H, Azas P, Zandotti C, Rey F, Charrel R, et al. Contribution of a shelter-based
551 survey for screening respiratory diseases in the homeless. Eur J Public Health 2009;19(2):157-
552 60. http://doi.org/10.1093/eurpub/ckn142.
553 [94]. Nyitray AG, Fujimoto K, Zhao J, Giuliano AR, Schneider JA, Hwang LY. Prevalence of and
554 Risk Factors for Anal Human Papillomavirus Infection in a Sample of Young, Predominantly
555 Black Men Who Have Sex With Men, Houston, Texas. J Infect Dis 2018;217(5):777-784.
556 [95]. Hou J, Liu Z, Gu F. Epidemiology and Prevention of Hepatitis B Virus Infection. Int J Med Sci.
557 2005;2(1):50-57. http://doi.org/10.7150/ijms.2.50.
558 [96]. Havelaar AH, Kirk MD, Torgerson PR, Gibb HJ, Hald T, Lake RJ, et al. World Health
559 Organization global estimates and regional comparisons of the burden of foodborne disease in
560 2010. PLoS Med 2015; 12:e1001923.

561 [97]. Centers for Disease control and Prevention. Adult immunization Schedule,
562 https://www.cdc.gov/vaccines/schedules/downloads/adult/adult-combined-schedule.pdf ; 2020
563 [accessed 20 September 2020].
564 [98]. Ministère des solidarité et de la santé. Calendrier des vaccinations et recommandations vaccinales
565 2020, https://vaccination-info-
566 service.fr/var/vis/storage/original/application/download/calendrier_vaccinations_2020-2.pdf;
567 2020 [accessed 20 September 2020].
568 [99]. European Centre for Disease Prevention and Control. Public health guidance on HIV, hepatitis B
569 and C testing in the EU/EEA, https://www.ecdc.europa.eu/sites/portal/files/documents/HIV-
570 hepatitis-B-and-C-testing-public-health-guidance.pdf; 2018[accessed 20 September 2020].

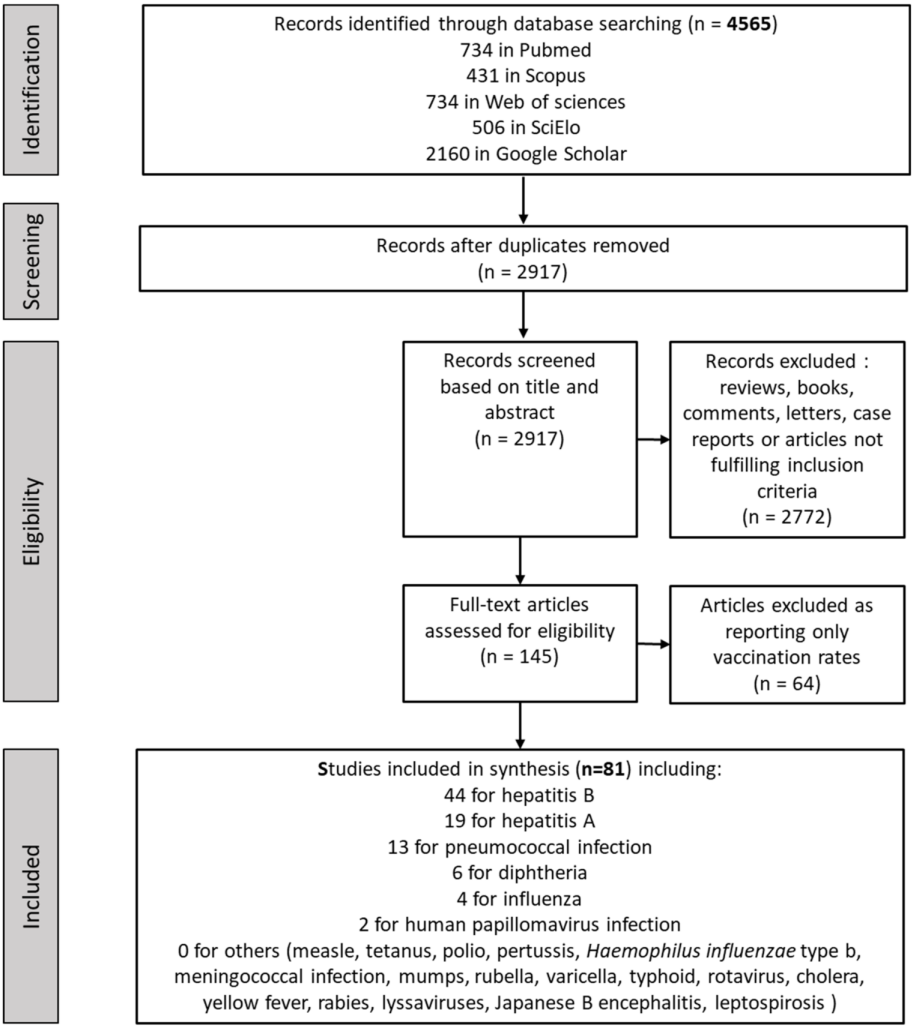
Identification
Records identified through database searching (n = 4565)
734 in Pubmed
431 in Scopus
734 in Web of sciences
506 in SciElo
2160 in Google Scholar
Screening
Records after duplicates removed
(n = 2917)
Eligibility
Records screened based on title and abstract
(n = 2917)
Records excluded : reviews, books, comments, letters, case reports or articles not fulfilling inclusion criteria
(n = 2772)
Full-text articles assessed for eligibility
(n = 145)
Articles excluded as reporting only vaccination rates
(n = 64)
Included
Studies included in synthesis (n=81) including:
44 for hepatitis B
19 for hepatitis A
13 for pneumococcal infection
6 for diphtheria
4 for influenza
2 for human papillomavirus infection
0 for others (measle, tetanus, polio, pertussis, Haemophilus influenzae type b, meningococcal infection, mumps, rubella, varicella, typhoid, rotavirus, cholera, yellow fever, rabies, lyssaviruses, Japanese B encephalitis, leptospirosis)

Table 1. Descriptive analysis of outbreak and prevalence of hepatitis B infection among people experiencing homelessness

Date of study	Study design	Place of study	Setting	Population at risk/Attack rate (of susceptible)	Age (years) (Mean ± SD; range)	Male (%)	Diagnostic tools	Vaccine recommendations from authors	Risk factors identified/ Comments	Mortality rate (%)	Co-infections with other VPD	Previous vaccination rate	References
Year 2019	Seroprevalence survey	Colombia	Care centers	1,061 PEH: ongoing HBV infection (0.4%)	Range: adolescents <21.0 to >60	85.9%	Serology (HBsAg)	Need for vaccination		0%			[15]
Before year 2019	Seroprevalence survey	Los Angeles, USA	Homeless shelters and streets	137 PEH: HBV infections (57.7%)	Mean ± SD: 48.6 ± 8.2	87.5%	Serology			0%			[16]
Between 2017-2018	Seroprevalence survey	Marseille, France	Hospital (infectious disease units)	98 PEH hospitalised with different infections: ongoing HBV infection (2%)	Mean ± SD: 43.3 ± 16.8	87.6%	Serology (HBsAg, anti-HBs, and anti-HBc)	Need for vaccination		0%			[17]
Year 2017	Seroprevalence survey	Sound Africa	Community centre	3,439 persons (sex workers, MSM, IDUr), including PEH (24%): ongoing HBV infection (4%)	Mean: 29.0	52%	Serology (HBsAg)	Need for vaccination		0%			[18]
Year 2016	Seroprevalence survey	France	Streets	341 vulnerable population-patients including PEH: HBV infection (6.5%)	Range: 40.0 – 49.0	About 50.0%	Serology (ELISA test for HBsAg, anti-HBs, and anti-HBc)	Specific anti-HBV vaccination campaigns targeting these specific populations.	Higher rate among PEH than general population	0%			[19]
Year 2015	Seroprevalence survey	Khorramabad, Iran	Community centre	307 PEH: ongoing HBV infection (1.0%)	Mean ± SD: 35.9 ± 9.6	100%	Serology (HBsAg, anti-HBs, and anti-HBc)			0%			[20]
Year 2015	Seroprevalence survey	USA	Hospitals	242,740 PEH: ongoing HBV infection (1.0%)	Mean ± SD: 50.0 ± 16.0	88.9%	Serology (HBsAg)		Higher rate among PEH than general population	0%			[21]
Between August 2014 and June 2015	Seroprevalence survey	Goiânia, Brazil	Homeless shelter	359 PEH: HBV infection (21.8%) including past (21.2%) and ongoing (0.6%) infection	Mean: 36.0; range 18.0–86.0	81.3%	Serology	Need for health services administrators to provide more opportunities for HBV vaccination	Higher rate among PEH than adult population of capitals in the same region of the country. HBV infection was associated with age > 50 (aPR=3.1), black skin colour (1.8), homosexuality (2.6) or bisexuality (1.8).	0%		Estimated through serological test :21.8%	[22]
Between 2012-2014	Retrospective questionnaire survey	Lima, Perú	Homeless shelter	302 PEH: HBV infection (approximately 1.6%)	Range: >60.0	82.0%	Questionnaire			0%			[23]
Between 2012-2013	Seroprevalence survey	Tehran, Iran	Street and related organisations (municipality, welfare organisation, police, non-governmental	1,000 street and working children: ongoing HBV (1.7%)	Mean ± SD: 15.6 ± 2.5; range: 10.0 – 18.0	95.0%	Rapid serological testing			0%			[24]

			organisations)										
Between 2011 and 2014	Seroprevalence survey	Berlin, Essen, Leipzig, Frankfurt, Cologne, Hanover, Munich, Hamburg, Germany	Four local low-threshold drug services	2,077 IDUr including PEH (66.0%): ongoing or past HBV infection (38.0%)	Range: 29.0 – 41.0	76.7%	Serology (HBsAg, anti-HBs, and anti-HBc)	Need for vaccination, IDUr should be tested and counselled regularly for HBV	Higher rate among PEH than general population. HBV infection status was significantly associated with homelessness (OR=1.4, p<0.05)	0%		Questionnaire 32.0%	[25]
Between May 2011 and June 2013	Seroprevalence survey	London, UK	Homeless hostels	489 PEH: HBV infection (11.8%) including past (10.4%) and ongoing (1.4%) HBV infection	Range: 30.0 – 49.0	89.0%	Serology (Architect immunoassay for HBsAg, anti-HBs, and anti-HBc)	HBV vaccination recommended	HBV infection was associated with IDU (aOR=23.7)	0%		Estimated through serological test: 28.7%	[26]
Year 2011	Seroprevalence survey	San Jose, Costa Rica	Homeless shelter	100 PEH: HBV infection (32.0%)	Mean: 35.0	82.0%	Serology			0%			[27]
Before 2010	Seroprevalence survey	South Wales, UK	Treatment services, needle and syringe programmes, hostels and the street	651 PEH: HBV infection (9.4%)	Mean: 29.6, adults	74.0%	Serology			0%			[28]
Year 2008	Seroprevalence survey	Kolkata, India	Community centre	554 street children: HBV infection (around 3%)	Mean: 13.0; range: 11.0 – 15.0	65.0%	Serology			0%			[29]
Year 2007	Seroprevalence survey	Paco, Philippines	Community centre	179 street children: HBV infection (7.9%)	Range: 8.0–17.0		Serology			0%			[30]
Before 2006	Seroprevalence survey	Tehran, Iran	Community centre	102 street children: ongoing HBV infection (3.0%)	Mean ± SD: 10.1 ± 3.0	38.0%	Serology (HBsAg, anti-HBs, and anti-HBc)			0%			[31]
Between April-July 2007	Seroprevalence survey	Tehran, Iran	Community centre	202 PEH: HBV infection (34.7%)	Mean ± SD: 45.0 ± 17.7; range: >15.0	100%	Serology (HBsAg, anti-HBs, and anti-HBc)		HBV infection was positively associated intravenous drug abuse and imprisonment	0%			[6]
Year 2005	Seroprevalence survey	Dublin, Ireland	Temporary accommodation	363 PEH: HBV infection (5.0%)	Adults >18.0	61.0%	Serology		HBV infection was positively associated with IDU	0%			[32]
Between 2004-2006	Seroprevalence survey	South Wales, UK		421 IDUr including 39% PEH: HBV infection (13%)	Mean: 30.0		Serology			0%		54%	[33]
Between 2003-2005	Seroprevalence survey	Sydney, Australia	Medical clinic for homeless	189 PEH: HBV infection (33.6%) including past (32.0%) and ongoing (1.6%) infection	Mean: 42; range: 18.0 – 74.0	86.0%	Serology (HBsAg, anti-HBs, and anti-HBc)	Need for HBV vaccination	Higher rate among PEH than general population. Past HBV infection was positively associated with IDU.	0%	About 6.3% (12/189) were HAV-past HBV co-infection		[34]

Year 2005	Seroprevalence survey	Prague, Czech Republic	Community centre for youth and adults	98 PEH: HBV infection (7.2%)	Range: 16.0 – >50.0	89.7%	Serology (HBsAg, HBeAg, anti-HBs, and anti-HBc) and qPCR	Negative subjects will be offered vaccination	Higher rate among PEH than general population. HBV infection was positively associated with IDU.	0%			[35]
Year 2003-2004	Seroprevalence survey	Skid Row, Los Angeles, USA	19 shelter programmes at 10 locations and 22 meal programmes at 9 locations	534 PEH: HBV infection (31.0%)	Mean: 46.0	80.0%	Serology		HBV infection was positively associated with IDU, alcohol use, older age, and risky sexual behaviour	0%			[36]
Year 2003	Seroprevalence survey	Hawaii, USA	Homeless shelters	40 PEH: ongoing HBV (2.5%)	Adults		Serology (HBsAg, anti-HBs, and anti-HBc)			0%			[37]
Years 2002-2004	Seroprevalence survey	Baltimore, Chicago, Los Angeles, New York, and Seattle, USA	Community centres for IDU administration	3,285 IDUr including 47.6% PEH: HBV infection (22.4%)	Mean: 23.8 15.0 – 30.0		Serology (HBsAg, anti-HBs, and anti-HBc)	Need for HBV vaccination		0%			[38]
Years 2002-2003	Seroprevalence survey	Canada	Streets	533 street-involved persons: HBV infection (12.0%) including past (9.0%) and ongoing (3.0%) infection	Mean: 25.7; range: 11.0 – 65.0	47.0%	Serology (HBsAg, anti-HBs, and anti-HBc)	Successful HBV vaccination can be achieved in the majority of this population,	Higher rate among PEH than general population.	0%			[39]
Years 2002-2003	Seroprevalence survey	São Paulo, SP, Brazil	Five homeless shelters	330 sheltered PEH: HBV infection (33.9%) including previous (30.6%) and ongoing (3.3%) infection	Mean: 40.2; range: 18.0 – 72.0	80.9%	Serology (ELISA test for HBsAg, anti-HBs, and anti-HBc)	Vaccination against hepatitis B must be implemented to reduce infection in this vulnerable group.		0%			[40]
Between 2001-2002	Seroprevalence survey	San Francisco, California, USA	Surgical service for soft tissue infection	3,365 IDUr including 30.0% PEH: HBV infection (12.0%)	Mean ± SD: 40.0 ± 5.0	70.0%	Serology			0%			[41]
Years 2001-2003	Seroprevalence survey	Barcelona, Madrid and Seville, Spain	Health and social centres	949 heroin users including 14.0% PEH: HBV infection (17.2%)	Mean: 25.7; range: 18–30	72.7%	Serology (HBsAg, anti-HBs, and anti-HBc)	The vaccination strategy urgently needs to be reinforced and redesigned.	HBV infection was positively associated with IDU.	0%			[42]
Between 2000-2015	Seroprevalence survey	Marseille, France	Two homeless shelters	1,890 PEH: previous (35.7%) and ongoing (4.1%) HBV infection	Mean ± SD: 43.1 ± 16.4; range: 18 – 86	95.2%	Serology (HBsAg, anti-HBs, and anti-HBc) and sequencing	Need for HBV vaccination	Higher rate among PEH than general population. HBV infection was positively associated with individuals born in sub-Saharan African or Asian countries as compared to Europe	0%		Estimated through serological test :6.5%	[43]
Between June-October 2000.	Seroprevalence survey	Baltimore, Marilance, USA	Hospitals, social service agencies, emergency shelters, soup kitchens,	172 PEH with concomitant severe mental Illness and substance use disorders: HBV infection (33%)	Mean: 39.8	77.9%	Serology (HBsAg, anti-HBs, and anti-HBc)	Vaccination should be offered to PEH with severe mental illness and substance use disorders		0%			[44]

			and street locations										
Years 2000s	Seroprevalence survey	A large northwestern US city, USA	Streets	536 adolescent PEH: HBV infection (3.4%)	Mean: 18.8 ±1.6; range: 14.0 – 20.0	59.5%	Serology (HBsAg, anti-HBs, and anti-HBc)	Need for HBV vaccination	HBV infection was positively associated with self-reported IDU	0%			[45]
Years 2000s	Seroprevalence survey	USA	Temporary shelters	150 PEH adolescents: HBV infection (17.0%)	Range: 14.0 – 23.0	70.0%	Serology (ELISA test for HBsAg, anti-HBs, and anti-HBc)	HBV vaccination programmes targeting homeless youth	Higher rate among PEH than most previous reports such as Porto et al., 1994 about street youth. HBV infection was positively associated with sexual preference (homosexual/bisexual vs heterosexual) and ages	0%			[46]
Between 1998-1999	Retrospective questionnaire survey	Minneapolis, Minnesota, New York, USA	Coffee houses and drop-in centres	105 street youths: HBV infection (6.0%)	Range: 15.0 – 22.0	60.0%	Questionnaire	Recommendation for HBV vaccination		0%		43% reporting receiving vaccine	[47]
Between 1998-2001	Seroprevalence survey	New Haven, USA	Community Health Service	212 IDUr, including 76 PEH (36.0%): HBV infection (37%) including past (33.3%) and ongoing (4.7%) infection	Mean: 38.2	69.0%	Serology (ELISA test for HBsAg, anti-HBs, and anti-HBc)	Syringe exchange sites were more highly motivated to complete vaccination.	Completing three vaccinations was positively associated with homeless IDUr	0%		>66% for 3 doses	[48]
Between 1995-2000	Seroprevalence survey	Stanford, California, USA	Domiciliary care for homeless veterans	829 PEH: ongoing HBV infection (1.2%)	Mean: 43.5 ± 7.0 range: 18.0 – 64.0	96.0%	Serology (HBsAg, anti-HBs, and anti-HBc)			0%			[49]
Between 1995-2002	Seroprevalence survey	New Orleans, Louisiana, USA	Emergency shelters	4,005 PEH adolescents: ongoing HBV infection (0.6%)	Range: 16.0 – 21.0	32.0%	Serology	Application of vaccination		0%		Questionnaire 9%	[50]
Year 1996	Seroprevalence survey	New York, USA	Inner-city hospital-based adolescent clinic or a health facility	53 PEH: HBV infection (44.4%)	Mean: 18.0; range: 13.0 – 21.0	26.0%	Serology (HBsAg, anti-HBs, and anti-HBc)	Homelessness may be indications for pre-vaccination screening for HBV infection in adolescents	Higher rate among PEH than non- PEH	0%			[51]
Between December 1995 and September 1996	Seroprevalence survey	Montreal, Canada	Services of street youth agencies	437 street youths: HBV infection (9.2%)	Range: 14.0 – 25.0	69.3%	Serology (HBsAg, anti-HBs, and anti-HBc)	Early and complete HBV vaccination among this vulnerable population is urgently needed.	Higher rate among PEH than general population, aged 14 to 30 years. HBV infection was positively associated with age (>18.0 years), with IDU, those having a sexual partner who had unspecified hepatitis.	0%		38.5% (at least one dose) and 11.8% (3 doses)	[52]
Between 1994-1996	Seroprevalence survey	Los Angeles County, California, USA	Streets	642 participants including 36.0% PEH: HBV infection (83.3%) including past (80.3%) and ongoing (3.1%) infection	Mean: 43.0; range 18.0 – 70.0	71.0%	Serology (HBsAg, anti-HBs, and anti-HBc)		Past infection was positively associated while in detention and having been ever arrested for possession of IDU paraphernalia	0%			[53]

Between September 1990 and July 1991	Seroprevalence survey	Brazil	Market places, streets and state institutions	496 street adolescents: HBV infection (15.5%) including past (13.5%) and ongoing (2.0%) infection	Mean: 13.6; range 9.0 – 20.0	97.7%	Serology (EIA)	Baseline information for policy changes in hepatitis B prevention	Street-based youth had a higher HBV marker-positive rate when compared to home-based teens (OR = 4.1, p<0.05)	0%			[54]
Years 1990s	Seroprevalence survey	Toronto, Canada	Hospital	44 street youths: Ongoing infection (2.0%)	Mean: 15.7 ± 1.8	18.2%	Serology (HBsAg, anti-HBs, and anti-HBc)	The difficulty in ensuring vaccine coverage in this population would support calls for including hepatitis B vaccination as part of childhood immunisation.	HBV infection was likely to be higher among PEH compared to controls (0%)	0%			[55]
Before 1990	Seroprevalence survey	Alaska, USA	Hospital	64 alcoholics, including PEH: HBV infection (33.4%)	Mean: 35.0	55.0%	Serology (HBsAg, anti-HBs, and anti-HBc)	Need for vaccination	HBV infection was likely to be higher among PEH compared to controls (34.4% versus 11.7%)	0%			[56]
Between Feb 1988 and July 1993	Seroprevalence survey	West Los Angeles, USA	Residential setting	370 male PEH: HBV infection (30.8%) including ongoing (3.0%) and past (30.8%) infection	Mean: 44.1	100%	Serology (ELISA test for HBsAg, anti-HBs, and anti-HBc)	Offer vaccination to PEH adults	HBV infection was positively associated with non-white ethnicity, age (>45.0 years), history of regular heroin use, history of drug detoxification	0%			[57]

Abbreviations. SD, standard deviation; VPD: vaccine-preventable diseases; PEH, people experiencing homelessness; HBV, hepatitis B virus; HBsAg, hepatitis B surface antigen; anti-HBs, antibody to hepatitis B surface antigen; anti-HBc, antibody to hepatitis B core antigen; ELISA, Enzyme-linked immunosorbent assay; aPR: adjusted prevalence ratio; IDU, Injected drug use; IDUr, Injected drug users; OR, Odds-ratio; aOR, adjusted Odds-ratio; HAV, hepatitis A virus; EIA, enzyme immunoassay

Table 2. Descriptive analysis of outbreak and prevalence of hepatitis A infection among people experiencing homelessness

Date of study	Study design	Place of study	Setting	Population at risk/Attack rate (of susceptible)	Age (Mean ± SD; range)	Male (%)	Diagnostic tools	Vaccine recommendations from authors	Risk factors identified/ Comments	Mortality rate (%)	Co-infections with other VPD	Previous vaccination rate	References
Between January-August 2018	Outbreak investigation	West Virginia, USA	Hospitals	664 confirmed HAV cases, including 100 PEH (15.1%)	Mean: 37.0; range: 14.0 – 77.0	60.0%	Serology (IgM anti-HAV) and then genotyping	Support the recent national ACIP recommendation[1]		About 0.1%			[58]
Between 2017-2018	Outbreak investigation	Toronto, Canada	Hospitals	42 confirmed HAV cases (MSM), including 4 PEH (10.0%)	Mean: 38.0	79.0%	Serology (IgM anti-HAV) and then genotyping	Support the recent national ACIP recommendation		0%			[59]
Between 2016-2019	Outbreak investigation	Kentucky, Michigan, West Virginia, USA	Hospitals	817 confirmed HAV cases, including PEH (14%)	Mean: 39.0	62.5%	Serology (IgM anti-HAV) and then genotyping	Support the recent national ACIP recommendation	Prevalence of HAV was significantly higher in MSM, non-injection user	0%			[60]
Between 2016-2018	Outbreak investigation	San Diego County, USA	Hospitals	589 confirmed HAV cases, including 291 PEH (49.0%)	Mean: 43.0		Serology (IgM anti-HAV) and then confirmation by RT-PCR	Support the recent national ACIP recommendation		4.8%	34.0% were HAV-HBV (or HCV) co-infection		[61]
Between 2016-2018	Outbreak investigation	San Diego County, USA	Emergency department	133 confirmed cases, including PEH (64.7%)	Mean: 45.1	68.4%	Serology			6.0%			[62]
Year 2017	Outbreak investigation	California, Kentucky, Michigan, and Utah, USA	Hospitals	1521 confirmed HAV cases, including 524 PEH (34.5%)	Mean: 36.0 – 42.0; range: <1.0 – 90.0	About 66.0%	Serology (IgM anti-HAV) and then genotyping	Support the recent national ACIP recommendation		3.0%	3.0% were HAV-HBV co-infection		[63]
Between June-August 2012	Seroprevalence survey	Tehran, Iran	Homeless shelter, streets, in parks, or in public places	569 PEH anti-HAV positivity (94.3%)	Mean: 42.0	82.4%	Serology (anti-HAV)		Prevalence of HAV significantly was higher in men	0%			[64]
Between May-September 2008	Outbreak investigation	Prague, Czech Republic	Hospitals	602 confirmed HAV cases, including 474 persons (78.7%) in risk groups (e.g. PEH, alcoholics)	Range: 0 – 14.0 (7.6%); 15.0 – 64.0 (78.5%); >65.0 (13.9%)	About 60.0%	laboratory-confirmed in accordance with the European Union case definition [2]	Post-exposure prophylaxis by vaccine was provided to HAV contacts in foci and preventive vaccination was offered to PEH		0%			[65]
Year 2004	Outbreak investigation	Boston, USA	Medical centre	136 confirmed HAV cases, including PEH (61.0%)	Adults >16.0	64.0%		Need for vaccination		0%			[66]
Between January-June 2004	Outbreak investigation	Rotterdam, The Netherlands	Municipal Health Service	93 confirmed HAV cases, including 15 PEH (16.2%) accounting for 0.8% (of 1800 PEH)	Mean: 32.0; range: 21.0 – 44.0		Serology (IgG and IgM anti-HAV)	Large-scale vaccination strategy prevented its further spread.	HAV subtype 3a in 12 PEH in a family	0%			[67]
Between 2003-2005	Seroprevalence survey	Sydney, Australia	Medical clinic for homeless	189 PEH: anti-HAV positivity (40.0%)	Mean: 42.0; range: 18.0 – 74.0	86.0%	Serology (total anti-HAV)	Need for HAV vaccination		0%	About 6.3% (12/189) were HAV-past HBV co-infection		[34]

Between 2002-2015	Seroprevalence survey	Marseille, France	Shelters	967 PEH: anti-HAV IgG positivity (94.8%)	Mean: 42.0 ± 14.6	100%	Serology (IgG anti-HAV)	Need for HAV vaccination	Anti-HAV seroprevalence was associated with being born in Africa and aging >41 years.	0%			[68]
Between 2002-2004	Seroprevalence survey	Baltimore, Chicago, Los Angeles, New York, and Seattle, USA	Centres for IDU administration	3,285 IDUr including 47.6% PEH: anti-HAV positivity (19.3%)	Mean: 23.8; range: 15.0 – 30.0		Serology (total anti-HAV)	Need for HAV vaccination		0%			[38]
Between 2002-2003	Seroprevalence survey	Canada	Streets	533 street-involved persons: IgG anti-HAV positivity (53%)	Mean: 25.7; range: 11.0 – 65.0	47.0%	Serology (IgG anti-HAV)	Successful HAV vaccination can be achieved in the majority of this population.		0%			[39]
Year 2000	Outbreak investigation	Bristol, UK	Hospital	123 confirmed HAV cases, including 28 PEH (23.0%)	Mean: 25.0; range: 2.0 – 74.0	About 70.0%	Serology (IgM anti-HAV)	Administration of a targeted vaccination, education and liaison programme applied; vaccination of these groups is feasible and acceptable in an outbreak situation		0%			[69]
Between 1999-2000	Seroprevalence survey	San Francisco, USA	Shelter and meal programmes	1,138 PEH: anti-HAV positivity (52.0%)	Range: 26.0 – 68.0	75.0%	Serology (IgG and IgM anti-HAV) and questionnaire data	Need for vaccination		0%			[70]
Between March-August 1998	Seroprevalence survey	Vancouver, Canada	Street outreach clinics	111 street youths: anti-HAV positivity (6.3%)	Mean ± SD: 19.6 ± 2.7		Ultrasensitive capture enzyme immunoassay–based method (Salivary sample)	Need to develop routine vaccination programmes	Anti-HAV was positively associated with those reporting IDU	0%			[71]
Between 1995-1996	Seroprevalence survey	Montreal, Canada	Services of Montreal street youth agencies	427 street youths: anti-HAV positivity (4.7%)	Range: 14.0 – 25.0	69.3%	Serology (total anti-HAV)	Vaccination against HAV is actively promoted among Montreal street youth.	Anti-HAV positivity was associated with those having had sexual partner(s) with history of unspecified hepatitis or insertive anal penetration	0%			[72]
Between 1991-1992	Seroprevalence survey	Goiânia-Goiás, Brazil	Day-care centres	397 street youths: anti-HAV positivity (69.7%)	Range: 7.0 – 21.0	91.2%	Serology (IgG and IgM anti-HAV)	Vaccine strategy in developing countries		0%			[73]

Abbreviations. SD, standard deviation; VPD: vaccine-preventable diseases; PEH, people experiencing homelessness; HAV, hepatitis A virus; anti-HAV, antibody to hepatitis A virus; ACIP, Advisory Committee on Immunization Practices; MSM, men who have sex with men; RT-PCR, real time-polymerase chain reaction; HBV, hepatitis B virus; HCV, hepatitis C virus; IDU, Injected drug use; IDUr, Injected drug users;

[1] ACIP recommendation: All persons aged 1 year and older experiencing homelessness should be routinely immunised against hepatitis A. Routine vaccination consists of a 2-dose schedule or a 3-dose schedule when administered with combined hepatitis A and B vaccine.

[2] European Union case definition for HAV (source): https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018D0945&from=EN#page=22.

Table 3. Descriptive analysis of outbreak and prevalence of other vaccine-preventable diseases among people experiencing homelessness

Date of study	Study design	Place of study	Setting	Population at risk/Attack rate (of susceptible)	Age (Mean ± SD; range)	Male (%)	Diagnostic tools	Vaccine recommendations from authors	Risk factors identified/ Comments	Mortality rate (%)	Co–infections with other VPD	Previous vaccination rate	References
A. Pneumococcal infection													
Year 2018	Serotyping surveys	USA	Hospitals	2,885 IPD isolates, including 7% isolates from PEH			Culture isolation and serotyping	Need for vaccination programme for PEH	Serotypes 4, 12F, 20, and 7F represented the highest proportions of isolates that formed related clusters together with highest proportions of isolates from PEH				[74]
Autumn and winter of 2016–2017	Outbreak investigation	Victoria, British Columbia, Canada	Hospitals	84 PEH with confirmed IPD	Mean: 56.3	61.0%	Culture isolation and serotyping (Gram stain, colony morphology on blood agar, bile solubility, susceptibility to optochin)	Pneumococcal vaccination coverage is needed among this marginalised population.	Positive association between serotype 4 IPD and homelessness (OR=4.9; p<0,01)	11.9%		Questionnaire: 13.0%	[75]
Between 2015–2017	Molecular prevalence survey	Marseille, France	Two homeless shelters	477 PEH: Pneumococcal nasopharyngeal carriage (12.4%)	Mean ± SD: 43.6 ± 16.0; range: 18.0 – 84.0	100%	qPCR	Need to increase vaccination rate	Pneumococcal carriage was positively associated with respiratory symptom presentation.	0%	0.2% were *S. pneumococcus*–influenza virus co–carriage		[2]
Between 2010–2018	Outbreak investigation	California, Colorado, and New Mexico, USA	Hospitals	325 serotype 4 cases among adults, including PEH (36.0%)	Adults ≥ 17.0		Culture isolation and whole–genome sequencing	Future vaccine policy discussions should include homelessness as an indication for pneumococcal vaccines.					[76]
Between September 2009 and January 2011	Outbreak investigation	Winnipeg, Canada	Hospitals	169 patients with confirmed IPD, including 20 PEH (11.8%)	Mean: 42.0; range: 0 – 94.0	About 58.0%	Culture isolation, PFGE, MLST, MLVA	Need to vaccinate unvaccinated individuals who are homeless or use illicit drugs	Serotype 12F patients were more likely to report homelessness (OR=12.7; p<0.05).	0%		Questionnaire :37.0%	[77]
Between 2005–2009	Outbreak investigation	Alberta, Canada	Hospitals	1,112 patients with confirmed IPD, including 85 PEH (7.6%)	Mean ± SD: 45.4 ± 22.5	About 59.3%	Culture isolation from site such as blood, CSF, pleural fluid, biopsy tissue, joint aspiration, pericardial fluid, or peritoneal fluid	Need for vaccination programme for PEH		About 11.3%			[78]
Between 2005–2007	Outbreak investigation	Calgary, Canada.	Hospitals	207 patients with confirmed IPD (strain ST5 or ST8), including PEH (48.8%)	Adults ≥16.0		Gram stain, colony morphology on blood agar, bile solubility, susceptibility to optochin and pneumococcal	Vaccination for homeless	Individuals with ST5 or ST8 IPD were more likely to be homeless (% [OR] 53.0% [4.4] or 43.0% [2.6], respectively).	0%			[79]

							antibody agglutination and susceptibility testing (broth microdilution).						
Between 2000–2016	Outbreak investigation	Calgary, Canada	Hospitals	1,729 patients with confirmed IPD, including 321 PEH (18.8%)	Mean ± SD: 45.0 ± 27.0	78.8%	Culture isolation and serotyping (Gram stain, colony morphology on blood agar, bile solubility, susceptibility to optochin)	The most effective public health intervention for PEH to specifically prevent IPD is vaccination (both PPV23 and PCV13 vaccinations)	PEH were younger, more often male, smokers, alcohol abusers, illegal drug users, and had a primary diagnosis of pneumonia when compared with non–homeless.	6.9%			[80]
Between 2000–2014	Outbreak investigation	Alberta, Canada	Hospitals	2,435 IPD patients, including 184 PEH (7.4%)	Mean ± SD: 54.2 ± 17.8	56.7%	Culture isolation from site such as blood, CSF, pleural fluid, biopsy tissue, joint aspiration, pericardial fluid, or peritoneal fluid	Vaccination and other intervention programmes should have a high benefit in this population.		About 15.6%			[81]
Between November 2000 to November 2002	Outbreak investigation	Alberta, Canada	Hospitals	129 confirmed BPP patients, including 6 PEH (4.7%)	Adults ≥17.0	About 70%	Culture isolation and serotyping (Gram stain, colony morphology on blood agar, bile solubility, susceptibility to optochin)	PEH should be targeted for vaccination.	The attack rate of BPP among PEH was 266 per 100,000 person-years, 27 times that of the general population. Current smoking, substance abuse, alcohol abuse was predictive of BPP				[82]
Between January 2002 and December 2006	Outbreak investigation	Toronto, Canada	Hospitals	Estimation of 5,050 PEH in Toronto: 69 (1.4%) cases with confirmed IPD including 27 (0.5%) PP	Mean: 45.0; range: 27.0 – 74.0	89.0%	Culture isolation and serotyping (Gram stain, colony morphology on blood agar, bile solubility, susceptibility to optochin)	Vaccination may be effective in reducing the risk.	PEH with IDP were more often smokers, those with HIV infection and liver disease when compared to non– PEH	15.0%		Questionnaire: 9.0%	[83]
Between 2002–2015	Outbreak investigation	Anchorage, Alaska, USA	Hospitals	Estimation of 970 PEH in Anchorage: 84 cases (8.7%) with confirmed IPD	Mean ± SD: 48.0 ± 9.0	65.0%	Culture isolation and serotyping	Increasing the availability of pneumococcal vaccine in PEH could improve the health of this vulnerable group.	Compared to general population (0.16%). PEH were younger, more often alcohol abusers when compared to non–PEH.	0%			[84]
Between April 1988 and March 1989	Outbreak investigation	Paris, France	Hospitals	39 PEH for acute pneumonia: *Streptococcus pneumoniae* serotype 1, resistant to cotrimoxazole,	Mean ± SD: 46.0 ± 11.0; range 27.0–74.0	100%	Culture isolation and serotyping (Gram stain, colony morphology on blood agar, bile solubility, susceptibility to	Sheltered residents would benefit from pneumococcal vaccination.		2.6%		Questionnaire: 10.0%	[85]

				was isolated in 29 patients (74.0%). Blood cultures were positive in 24 (61.0%).			optochin)						
B. Diphtheria													
Between 2018–2019	Outbreak investigation	USA	Hospitals	8 patients with non–respiratory infections, including 7 PEH (87.5%)			Culture isolation and genotyping			0%			[86]
Between 2016–2017	Molecular investigation of outbreak	Germany	Hospitals	76 infected persons, including 25 (32.9%) PEH or those reporting drug abuse; strain ST8 (53.9%)	Mean: 45 .0	83.0%	Culture isolation and genotyping			0%			[87]
Between 2004–2012	Molecular investigation of outbreak	Poland	Hospitals	18 confirmed diphtheria cases, including 31.0% PEH: genotype ST8 (100%)	Range: 16.0 – >71.0		Culture, MLST and PFGE		Homelessness and alcohol were identified as risk factors.	0%			[88]
Between 1996–1997	Outbreak investigation	Switzerland, Germany, France.	Hospitals	17 patients, including 2 PEH (11.8%)	Mean: 40.0; range: 30.0 – 58.0	100%	Culture: Isolation from skin or subcutaneous infections			0%			[89]
Between 1987–1993	Outbreak investigation	France	Hospitals	40 patients with systemic infections, including 13 PEH (31.7%)	Mean: 38.0; range: 4.0 – 87.0	75.0%	culture isolation (blood, osteoarticular, perineal, nasopharyngeal, respiratory tract, skin samples)		Homelessness and alcohol were identified as risk factors.	36%			[90]
Between 1972–1982	Outbreak investigation	Seattle, Washington, USA	Hospitals	1100 infected persons, including 95.0% PEH	Mean: 37.3 (19 PEH children + 1081 adults)	About 91.0%	Culture (nasopharyngeal, respiratory tract, skin samples and environmental samples)	Need for vaccination within 10 years	Alcoholic urban PEH associated with poor hygiene, crowding, season, contaminated fomites, underlying skin disease, hyperendemic streptococcal pyoderma, and introduction of new strains from exogenous reservoirs.	0.9%			[91]
C. Seasonal influenza													

Between 2017–2018	Molecular prevalence survey	Marseille, France	Hospital (infectious disease units)	98 PEH hospitalised for different reasons: influenza virus infection (3.0%)	Mean ± SD: 43.3 ± 16.8	87.6%	qPCR	Need for seasonal flu vaccination		0%			[17]
Between 2015–2017	Molecular prevalence survey	Marseille, France	Two homeless shelters	477 PEH: Nasopharyngeal influenza carriage (1.7%)	Mean ± SD: 43.6 ± 16.0; range: 18.0 – 84.0	100%	qPCR	Need for seasonal flu vaccination	Respiratory viral carriage including influenza viruses was positively associated with respiratory symptoms and signs.	0%	0.2% were *S. pneumococcus*–influenza virus co–carriage	15.1%	[2]
Between May–November 2009	Molecular prevalence survey	Tijuana, Mexico	Outreach units and community clinics	303 persons from marginalised Populations, including PEH: H1N1 infection (2.0%)	Mean: 35.0; range: 29.0 – 43.0	62.0%	qPCR	Need for seasonal flu vaccination		0%		8.9%	[92]
Year 2005	Molecular prevalence survey	Marseille, France	Two homeless shelters	225 PEH: Influenza carriage (1.0%)	Mean: 41.0; range: 7.0 – 76.0	94.0%	qPCR	Need for seasonal flu vaccination		0%			[93]
D. Human papillomavirus													
Between 2014–2016	Molecular prevalence survey	Houston, Illinois, USA	Community centres	130 MSM, including 22.6% PEH; 75.0% had at least 1 high–risk HPV type	Range: 18.0 – 29.0	100%	Consensus PCR for HPV genotyping	Black MSM would benefit from increased HPV vaccination efforts		0%			[94]
Between 1995–2002	Epidemiological survey	New Orleans, Louisiana, USA	Emergency shelter	4,005 PEH: HPV infection (2.0%) among 2723 females	Range: 16.0 – 21.0	32.0%	Pap smear testing						[50]

Abbreviations. SD, standard deviation; VPD: vaccine–preventable diseases; PEH, people experiencing homelessness; IPD, Invasive pneumococcal disease; PFGE, Pulsed–field gel electrophoresis; MLST, Multi–locus sequencing typing; MLVA, multiple–locus variable number tandem repeat analysis; CFS, cerebrospinal fluid; OR, Odds–ratio; BPP, Bacteraemic pneumococcal pneumonia; PP, pneumococcal pneumonia; qPCR: real time polymerase chain reaction; HPV, Human papillomavirus; MSM, men who have sex with men.

Table 4. Summary of vaccination against HAV, HBV, pneumococcus and diphtheria for French children and adults[1]

Vaccines	General recommendations	Specific recommendations
Hepatitis B virus	Primary vaccination is mandatory for all children born after 01 January 2018. Application of 2– or 3–doses depending on type of vaccine – Dose 1: from 2 months – Dose 2: 1 month after dose 1 – Dose 3: 6 months after dose 2	**For high risk groups** – Preschool children in community settings – Newborns whose mothers are carriers of the HBs antigen as well as those born in Guyana or Mayotte – Children and adults in psychiatric institutions – Children and adolescents in institutions for infants or young disabled persons – Persons having sex with multiple partners, having a current or past STI or exposed to STIs – Parenteral or intranasal drug users – Travelers in countries of medium or high endemic disease – Persons residing in areas of moderate or high endemic disease – Persons who are candidates for organ, tissue or cell transplants – Persons in close proximity to someone with acute or chronic hepatitis B – Sexual partners of a person infected with hepatitis B virus or carrier of the HBs antigen – Persons who accumulate exposure factors to the hepatitis B virus – Persons with chronic liver disease – Persons infected with HIV or hepatitis C virus **For professionals** – Medical and pharmaceutical professions: doctor, dental surgeon, pharmacist, midwife – Other health professions: nurse, specialist nurse, masseur–physiotherapist, pedicure–podiatrist, medical electroradiology manipulator, nurse's aide, ambulance driver, childcare assistant, biomedical analysis technician, dental assistant – The abolition of age requirements for the control of immunisation – Establishing proof of immunisation by systematic serological testing – Persons entering training courses for the professions listed in the order of March 6, 2007
Hepatitis A virus	– 1 dose now and 1 dose injected 6–36 months after dose 1	**For high risk groups** – Children aged >1 year whose at least one of member in family originating from a country with a high anti–HAV antibody prevalence – Patients with cystic fibrosis or liver disease – New young received into institutions for infants or handicapped persons – Men having sex with men. – Travelers in countries of medium or high endemic disease **For professionals** – Persons taking care of children (for example nursery staff, childminders) – Persons working in collective reception structures for disabled people – Persons responsible for the treatment of wastewater and sewers
Invasive pneumococcal diseases	Primary vaccination is mandatory for all children born after 01 January 2018. – < 2 years: 3 doses of PCV13 at 2, 4 and 11 months; 1 dose of PPSV23 at 24 months	**For high risk groups** a) Immunocompromised patients (patients concerned by the vaccination recommendations for the immunocompromised)

	– 2–5 years: 2 doses of PCV13 now and after 2 months; 1 dose of PPSV23 2 months after dose 2 – >5 years: 1 dose of PCV13 now and 1 dose of PPSV23 after 2 months	– Asplenic or hyposplenic (including major sickle cell syndromes). – With hereditary immune deficiencies. – With HIV infection. – With a solid tumour or malignant haemopathy. – With transplantation or awaiting solid organ transplantation. – Transplanted haematopoietic stem cells. – Treated with immunosuppressant, biotherapy and/or corticosteroid therapy for a chronic autoimmune or inflammatory disease. – Nephrotic syndrome. b) Non–immunocompromised patients (with an underlying disease predisposing to the occurrence of invasive pneumococcal diseases) – With cyanogenic congenital heart disease, heart failure. – With chronic respiratory failure, obstructive pulmonary disease, emphysema. – With severe asthma under continuous treatment. – With renal failure. – With chronic liver disease of alcoholic or non–alcoholic origin. – With diabetes uncontrolled by simple diet. – With an osteo–meningeal breach, a cochlear implant or candidate for a cochlear implantation.
Diphtheria	Primary vaccination is mandatory for all children born after 01 January 2018. – Dose 1: at 2 months old – Dose 2: at 4 months old – Dose 3: at 11 months old	**For professionals** –Revaccination at age 25, 45 and 65 years, depending on professional activities, with a vaccine containing a reduced dose of diphtheria toxoid.

Abbreviations: STI, sexually transmitted infections; HIV, human immunodeficiency virus; PCV13, 13–valent pneumococcal conjugate vaccine; PPSV23, 23–valent pneumococcal polysaccharide vaccine.
1. According to French vaccination guidelines : Ministère des solidarités et de la santé. Calendrier des vaccinations et recommandations vaccinales 2020 Mars. Available at https://solidarites–sante.gouv.fr/IMG/pdf/calendrier_vaccinal_29juin20.pdf.