Elsevier Editorial System(tm) for Vaccine
Manuscript Draft

Manuscript Number:

Title: Vaccinations in prison settings: a systematic review to assess the situation in EU/EEA countries

Article Type: Review Article

Keywords: Vaccination; Prison; systematic review; EU/EAA countries

Corresponding Author: Professor Giordano Madeddu,

Corresponding Author's Institution: Department of Medical, Surgical and Experimental Sciences, Unit of Infectious Diseases, University of Sassari, Sassari, Italy

First Author: Giordano Madeddu

Order of Authors: Giordano Madeddu; Hilde Vroling; Anouk Oordt-Speets; Sergio Babudieri, Prof; Eamon O'Moore, MD; Marije Vonk Noordegraaf; Roberto Monarca; Pier Luigi Lopalco, Prof; Dagmar Hedrich; Lara Tavoschi, PhD, MPH

Abstract: Introduction: In 2016, more than 600,000 persons were being held in EU/EEA correctional facilities on a given day. People in prison may be at risk of vaccine-preventable diseases. While vaccination is effective also for people in prisone, little is known on coverage and implementation options.
Methods: We performed a systematic review on existing evidence on vaccination in prison settings in the EU/EEA. We searched peer-reviewed and grey literature following international methodology and reporting standards, to gather records published between 1980 and 2016 in all languages. We analysed quantitative (uptake, acceptance, (cost-)effectiveness) and qualitative (barriers) outcomes.
Results: Out of 7,041 identified records, 19 full-text articles were included from peer-reviewed literature and two from grey literature. Of these, 18 reported on hepatitis A and/or B virus (HAV/HBV), two on influenza and one on MMR vaccination. Two studies on HAV vaccine reported varying acceptance (5%-91%) and uptake rates (62.9%-70.5%). Seven studies reported on HBV vaccination. A comparative study showed a significantly higher uptake of the third HBV vaccine dose with the very rapid (63%) compared to the standard schedule (20%). HBV vaccination was generally well accepted (54%-100%), whereas uptake was variable (dose 1:23%-100%, dose 2:48%-92%, dose 3:19%-80%). One study on the combined HAV/HBV vaccine reported an acceptance rate of 34%, and declining uptake following dose 1. One study on influenza vaccine showed an uptake of 42%-46%, while another reported a MMR vaccine acceptance of 80% and an uptake of 74%. Overall, main reasons for non-vaccination included release from/or transfer between prisons, and refusal.
Conclusions: This systematic review highlighted important knowledge gaps and operational challenges for vaccination in prison settings. Vaccination is an effective measure that warrants comprehensive and tailored implementation to reduce the preventable disease burden, avoid risks of large outbreaks of vaccine-preventable diseases, and contribute to health equity for people in prison.

Suggested Reviewers: Irene Veldhuijzen
National Institute for Public Health and the Environment, Utrecht, Netherlands
irene.veldhuijzen@rivm.nl

Esther Aspinall
Health Protection Scotland
Esther.Aspinall@gcu.ac.uk

Jillian Mullen
EASL International Liver Foundation
j.mullen@easl-ilf.org

Andrew Freedman
University of Cardiff
Freedman@cardiff.ac.uk

Opposed Reviewers:

Cover Letter

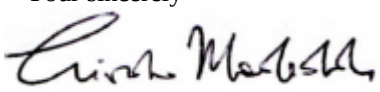
Sassari October 23rd, 2018

Dear Dr. Gregory A. Poland
Editor-in-chief
Vaccine

I submit, on behalf of my co-authors, the article "Vaccinations in prison settings: a systematic review to assess the situation in EU/EEA countries" to be considered for publication in "Vaccine" as a Review article.

As you know, more than 600,000 persons were being held in EU/EEA correctional facilities on a given day in 2016, with considerable variation between countries. In Europe, as globally, most people in prisons belong to socially deprived communities, with an increasing proportion of immigrants and persons with minority ethnic background. This is associated with lower vaccination coverages for various diseases among people entering prison settings. Therefore, this population group may benefit from expanded adult vaccination programmes in consideration of both the higher burden and increased risk of infectious diseases transmission within prison settings.
Furthermore, despite the availability of guidelines and policy documents on health in prison settings, sections on the prevention of communicable diseases with vaccination are generally limited in scope and do not adequately reflect their importance. While valid, most recommendations and approaches for the general population are not easily applicable in prison settings. Still, research into vaccination programs and factors related to vaccination coverage in prison settings is limited. However, prison settings may offer an opportunity for those who are detained to access healthcare services. Effective vaccination interventions in prison settings have proven to result in large health benefits accruing in the general community, a phenomenon referred to as "community dividend".
With this systematic review we aimed at identifying strengths, weaknesses and research gaps of vaccination interventions in European prison settings. Assuming there are no plausible nor biological reasons for differences in the effectiveness of vaccination inside or outside prison settings, the focus of this review was on vaccination strategies and service delivery rather than on vaccine effectiveness, as the latter is already extensively covered in existing and well-established guidance documents. This systematic review is part of a larger joint project by ECDC and the European Monitoring Centre for Drug and Drug Addiction (EMCCDA), which aims to produce a European guidance document on prevention and control of communicable diseases in prison settings in the EU/EEA.
The authors warrant the absence of any conflict of interest and that the article is original and has not been submitted for publication to any other journal or been previously published.

Thank you for kind attention to our paper.
Your sincerely



Corresponding author:

Prof. Giordano Madeddu (MD)

Unit of Infectious Diseases

Department of Medical, Surgical and Experimental Sciences

University of Sassari,

Viale San Pietro 43, 07100 Sassari, Italy

Tel +39 079 213307

Fax +39 079 228781

e-mail giordano@uniss.it

Suggested reviewers

First Name	Last Name	Institution	E-mail Address
Irene	Veldhuijzen	National Institute for Public Health and the Environment, Utrecht, Netherlands	irene.veldhuijzen@rivm.nl
Esther	Aspinall	Health Protection Scotland	Esther.Aspinall@gcu.ac.uk
Jillian	Mullen	EASL International Liver Foundation	j.mullen@easl-ilf.org
Andrew	Freedman	University of Cardiff	Freedman@cardiff.ac.uk

*Abstract

ABSTRACT

Introduction: In 2016, more than 600,000 persons were being held in EU/EEA correctional facilities on a given day. People in prison may be at risk of vaccine-preventable diseases. While vaccination is effective also for people in prisone, little is known on coverage and implementation options.

Methods: We performed a systematic review on existing evidence on vaccination in prison settings in the EU/EEA. We searched peer-reviewed and grey literature following international methodology and reporting standards, to gather records published between 1980 and 2016 in all languages. We analysed quantitative (uptake, acceptance, (cost-)effectiveness) and qualitative (barriers) outcomes.

Results: Out of 7,041 identified records, 19 full-text articles were included from peer-reviewed literature and two from grey literature. Of these, 18 reported on hepatitis A and/or B virus (HAV/HBV), two on influenza and one on MMR vaccination. Two studies on HAV vaccine reported varying acceptance (5%-91%) and uptake rates (62.9%-70.5%). Seven studies reported on HBV vaccination. A comparative study showed a significantly higher uptake of the third HBV vaccine dose with the very rapid (63%) compared to the standard schedule (20%). HBV vaccination was generally well accepted (54%-100%), whereas uptake was variable (dose 1:23%-100%, dose 2:48%-92%, dose 3:19%-80%). One study on the combined HAV/HBV vaccine reported an acceptance rate of 34%, and declining uptake following dose 1. One study on influenza vaccine showed an uptake of 42%-46%, while another reported a MMR vaccine acceptance of 80% and an uptake of 74%. Overall, main reasons for non-vaccination included release from/or transfer between prisons, and refusal.

Conclusions: This systematic review highlighted important knowledge gaps and operational challenges for vaccination in prison settings. Vaccination is an effective measure that warrants comprehensive and tailored implementation to reduce the preventable disease burden, avoid risks of large outbreaks of vaccine-preventable diseases, and contribute to health equity for people in prison.

*Title Page

Vaccinations in prison settings: a systematic review to assess the situation in EU/EEA countries

[1]Giordano Madeddu; [2]Hilde Vroling; [2]Anouk Oordt-Speets; [1]Sergio Babudieri; [3]Eamon O'Moore; [2]Marije Vonk Noordegraaf; [4]Roberto Monarca; [5]Pier Luigi Lopalco; [6]Dagmanr Hedrich; [7]Lara Tavoschi

[1]Department of Medical, Surgical and Experimental Sciences, Unit of Infectious Diseases, University of Sassari, Sassari, Italy

[2]Pallas Health Research and Consultancy B.V., Rotterdam, the Netherlands

[3]Health and Justice Team, Public Health England and UK Collaborating Centre, WHO Health in Prisons Programme (Europe), Reading, United Kingdom

[4] Health Without Barriers - European Federation for Prison Health, Viterbo, Italy

[5] Department of Translational Research and New Technologies in Medicine and Surgery; University of Pisa, Pisa, Italy

[6] European Monitoring Centre on Drugs and Drug Addiction, Lisbon, Portugal

[7] Department of Translational Research and New Technologies in Medicine and Surgery; University of Pisa, Pisa, Italy and European Centre for Disease Prevention and Control, Stockholm, Sweden

Key words: Vaccination; Prison; systematic review; EU/EAA countries

Corresponding author:

Prof. Giordano Madeddu

Unit of Infectious Diseases, Department of Medical, Surgical and Experimental Sciences

University of Sassari

Viale San Pietro 43 - 07100 Sassari, Italy

Tel +39 079213307 – Fax +39 079229781

e-mail: giordano@uniss.it

NTRODUCTION

Vaccination has proven to be among the most efficient and cost-effective public health interventions to reduce mortality and morbidity from infectious diseases worldwide [1], second only to general hygiene improvements [2]. Although expanded programmes of immunization are well established in the European Union/European Economic Area (EU/EEA), vaccination coverage may be sub-optimal due to various factors including vaccine hesitancy [3], lack of knowledge and health literacy, as well as barriers to access [4], [5]. In particular, lower vaccination coverage is registered among specific population groups, including individuals belonging to socially deprived communities [6], [7].

In 2016, more than 600,000 persons were being held in EU/EEA correctional facilities on a given day, with considerable variation between countries [8]. In Europe, as globally, most people in prisons belong to socially deprived communities, with an increasing proportion of migrants and persons with minority ethnic backgrounds [8] , [9]. This is associated with lower vaccination coverages for various diseases among people entering prison settings and increased vulnerability to vaccine-preventable diseases with outbreak potential in custodial settings e.g. varicella [10]. Yet, this population group may benefit from expanded adult vaccination programmes in consideration of both the higher burden and increased risk of infectious diseases transmission within prison settings [11]. Compared with the general public, people in prison have a higher prevalence of infection for a number of diseases for which data ara available, such as human immunodeficiency virus (HIV), hepatitis B virus (HBV), hepatitis C virus (HCV), syphilis, gonorrhoea, chlamydia and tuberculosis (TB) [12], [13], [14]. In addition, people who inject drugs (PWID) form a large part of the imprisoned population, with studies showing that The prevalence of substance abuse and dependence, although highly variable, is typically many orders of magnitude higher in prisoners than the general population, particularly for women [15]. The increased prevalence of communicable diseases among people in prisons is recognised as a major risk for the health of both people living and working in prisons and also for the general population, as the vast majority of people in prisons return to their communities after short periods of incarceration [8],[9], [16].

In existing guidelines and policy documents on prison health, sections on the prevention of communicable diseases through vaccination are generally limited in scope and do not adequately reflect the importance of this prevention measure. At the same time, vaccination recommendations and approaches for the general population are – while valid- not easily applicable in prison settings. Despite the fact that prison settings may offer an opportunity for those who are detained to access healthcare services, research into vaccination programs and factors related to vaccination coverage in prison settings is limited. However, prison settings may offer an opportunity for those who are detained to access healthcare services. Effective vaccination interventions in prison settings have proven to result in large health benefits accruing in the general community, a phenomenon referred to as "community dividend" [17]. With this systematic review we aim at identifying strengths, weaknesses and research gaps of vaccination interventions in European prison settings. Assuming there are no plausible nor biological reasons for differences in the effectiveness of vaccination inside or outside prison settings, the focus of this review was on vaccination strategies and service delivery rather than on vaccine effectiveness, as the latter is already extensively covered in existing and well-established guidance documents. This systematic review is part of a larger joint project by ECDC and the European Monitoring Centre for Drug and Drug Addiction (EMCCDA), which aims to produce a European guidance document on prevention and control of communicable diseases in prison settings in the EU/EEA.

METHODS

We performed a systematic review of the literature following international methodology and reporting standards, including peer-reviewed and grey literature, to gather existing evidence on vaccine interventions in prison settings in the EU/EEA. Prison settings were defined as prisons, jails and other custodial settings functioning as prison (excluding migrant centres and police detention rooms) and people in prisons were defined as all adult individuals (≥18 years) detained in prison settings.

The peer-reviewed literature search was carried out on February 4th 2016 in PubMed, Embase.com and Cochrane databases covering the project broader research area (see web appendix). In brief for this specific topic, a search string on prison settings was combined with a search string on vaccination (PubMed and Embase.com). In Cochrane Library, a search using only terms for prison settings was conducted, limited to systematic reviews and economic evaluations. Articles in these three databases were searched from 1980 onwards, and no language limit was applied.

A grey literature search focussed on EU/EEA countries was performed to complement the peer-reviewed literature. Unpublished articles, abstracts (from 2010 only), research reports, case studies, and service models from 2005 were searched on pre-defined websites and were obtained through a call for papers (see web appendix). Searches on the websites were conducted until 30 June 2016 using search terms for vaccination in prison settings (i.e. prison, jail, correctional, incarcerated). A call for papers was issued via Health without Barriers, the European Federation for prison health network, between April 2016 and June 2016.

Study selection, quality control and quality assessment

Articles were selected by screening the titles and abstracts, followed by screening of the full-text articles, based on a set of pre-defined inclusion and exclusion criteria (for the complete list of inclusion/exclusion criteria see web appendix). In brief, only literature from EU/EEA/European Fare Trade Association (EFTA) (candidate) countries and other Western countries (i.e. Australia, Canada, New Zealand, Switzerland and USA) were selected. Articles from these non-EU/EEA countries were included to broaden the evidence base. Article types included randomised controlled trials (RCTs), non-randomised, prospective comparative studies, prospective observational studies (e.g. cohort studies), retrospective observational studies (e.g. case-control studies) and cross-sectional studies. Meta-analyses and systematic reviews were checked in full text, but only original articles were included.

Selection based on title and abstract was performed by two independent researchers, who discussed in case of doubts. All selected records (including articles when doubts remained) were checked by a third

researcher with expertise in the field of prison health, who then took the final decision on inclusion or exclusion for full-text selection. Screening and critical appraisal of 50% of the full-text articles was performed in duplicate by two independent reviewers. The results were compared and discussed early in the review process, and any disagreements were adjudicated by a third reviewer. The process of selection and inclusion and exclusion of articles, including the reasons for exclusion of full-text papers, was registered in an Endnote library (version X7).

The quality of the included peer-reviewed articles was assessed using standard Evidence Based Medicine checklists. For this review, we used the National Institute for Health and Clinical Excellence (NICE) checklists, when appropriate. The assessment of surveillance studies or other observational study designs, for which no standard checklists are available, was performed based on relevant aspects of the existing NICE checklists, supplemented with a set of questions for a specific study design. Predefined aspects of a study were qualitatively scored using - - or -, +/-, + or ++. For the studies included in the review, the level of evidence per individual article was determined based on a combination of the study design and risk of bias (using Grading of Recommendations Assessment, Development and Evaluation (GRADE) risk of bias criteria) (see web appendix).

Data extraction

Data from included studies were extracted into pre-defined evidence tables by one researcher, and reviewed by a second researcher. Evidence tables contained information on study characteristics (i.e. country, design, study period, follow-up, prison setting, study objective, data sources and definitions); study population (i.e. source population, inclusion and exclusion criteria, sample description: sample size, age, gender, risk groups); models of care; and relevant outcomes. The evidence tables also included a column with comments on quality aspects of the study and the final level of evidence.

Summary and synthesis of results

The findings were analysed by disease and vaccination strategy. Outcomes of interest included accessibility, feasibility and acceptability of vaccination at entrance and during prison stay, and qualitative description of

interventions/modes of service delivery. The following quantitative outcomes were of interest: acceptance (number of subjects accepting the first dose of vaccination divided by the number of subjects eligible for vaccination), uptake (number of subjects vaccinated divided by the total study sample (dose 1); the number of subjects vaccinated with subsequent doses divided by the number of subjects that received the first dose), measures of effectiveness (e.g. change in communicable disease incidence or prevalence) and cost-effectiveness of vaccination in prison settings.

Pooling of data was planned if more than one study on a given outcome was available and data from these studies were sufficiently homogeneous in terms of clinical, methodological and statistical characteristics. Otherwise, narrative syntheses were conducted.

RESULTS

A total of 7,041 articles were identified from the three electronic databases covering the project broader research area. Of these, 19 full-text articles on vaccine interventions in prison settings in the EU/EEA were finally included after applying the inclusion and exclusion criteria. Of the 19 articles, 16 reported on vaccination against HAV and/or HBV, two articles on vaccination against influenza and one on the MMR vaccine (Table 1). From the grey literature, focused solely on EU/EAA, two unpublished research reports were included after applying the inclusion and exclusion criteria and check for duplicity with the peer-reviewed literature. Both unpublished research reports were on hepatitis vaccination (one on HAV and one on HBV). See Figures 1 and 2 for an overview of the selection procedure in the peer-reviewed and grey literature.

Hepatitis A

Two studies from EU/EAA countries were found on HAV vaccination in a correctional facility [18],[19], as shown in Table 2. In a UK study all inmates were offered one dose of HAV vaccine during a one-day mass vaccination and thereafter all individuals admitted to prison were offered the vaccine. Vaccination was

actively promoted by nurses, and information letters and leaflets were distributed. The acceptance rate was 91% whereas uptake was not reported. In one unpublished research report from Italy, a single dose HAV was offered at entrance to a regional prison in Florence [19]. The acceptance rate increased from 5% in 2010 to 40.8% in 2013. Of those who accepted, 62.9% were vaccinated in 2012 and 70.5% in 2013 (others were released before receiving vaccine).

Hepatitis B

Four studies from the EU/EEA region and three studies outside this region reported on acceptance and uptake of HBV vaccination (Table 2). In the only comparative study (Denmark), a higher uptake was found with the very rapid schedule (1, 7, 21 days) compared to the standard schedule (1, 30, 180 days). Acceptance was the same in using both schedules (100%), but the uptake of the third dose was significantly higher when using the very rapid schedule (63%) compared to the standard schedule (20%) [20].
Despite differences in vaccine types, schedules, timing and promotion measures between the other non-comparative studies, HBV vaccination was generally well accepted (54%-100%), with more variability in vaccine uptake (dose 1: 23%-100%, dose 2: 48%-92%, dose 3: 19%-80%) [21], [22]. In a longitudinal Italian study the acceptance rate increased from 12.9% in 2009 to 24.3% in 2014 following the availability of dedicated staff, however this was associated with a decreasing rate of completing the vaccination schedule (from 76.1% in 2009 to 51.7% in 2014) [23). In two studies from non-EU/EEA countries the acceptance was 83%-93% and uptake decreased progressively from dose 1 (43% and 67%, respectively) to dose 3 (19% and 40%, respectively) [24], [25]).
The effectiveness of HBV vaccination interventions among inmates was investigated in four studies (two EU/EEA; two non-EU/EEA). Despite different vaccine types, schedules, timing and promotion measures used in these studies, seroconversion (68%-91%) and seroprotection (67%-83%) were generally high [26], [27],[28],[29]).

Three studies and one unpublished report from EU/EEA countries reported the reasons why inmates were not vaccinated with HBV vaccine, which included early release (30%- 74%), transfer (10%-14%), house

arrest (12%), prior HBV infection (53%), refusal of vaccination (12.1%), and withdrawal from study (14%) [20], [21],[22],[23]).

Among non-EU/EEA studies, a pilot HBV immunisation project among female Australian inmates reported that the appropriate time to initiate HBV vaccination was within the first week when inmates were in the reception units [24]. Two studies reported the reasons why inmates were not vaccinated with HBV vaccine, which included early release (12%-34.5%), prior HBV infection (11%-19.4%), refusal of vaccination (5%-7.6%), prior vaccination (5% and 25%), and newly found chronic carriers (0.8%) [24], [25]. A USA survey study among 153 inmates reported that 93% would be willing to accept a HBV vaccine if offered to them [30]. Reasons for refusal of HBV vaccination among 11 inmates were: undecided (n=3), mistrust of government/prison (n=4), already vaccinated (n=2), needle dislike (n=1), and the perception not to be at risk (n=1).

Hepatitis A and B combined

Five studies were found on hepatitis A and B combined vaccine, all from outside the EU/EEA. Of these, one study reported data on acceptance, uptake and acceptability [31], one on acceptance and uptake [32]) two on cost-effectiveness [33], [34]), one on accepatbility/barriers [35].

In a USA study, all men who have sex with men (MSM) jail dorm inmates were offered combined HAV and HBV vaccine using the rapid schedule by nurses who visited the dorm once a week during the study period [31]. The acceptance rate was 34%, and the uptake for dose 2, 3 and the booster was 77%, 57%, and 11%, respectively (Table 2).

Another USA study evaluated a pilot program in which state-funded hepatitis vaccines were provided to local health departments to vaccinate jail inmates [32]. In two years, the number of county jails offering vaccination tripled, from 10 in 2003 to 30 by the end of 2005. The total number of hepatitis A/B vaccine doses administered in county jails rose from 2,807 in 2003 to 5,526 in 2005 (no p-values given).

Two studies reporting on the cost-effectiveness of the combined hepatitis A/B vaccine interventions have been identified. Where HAV rates were >200%, 100-200% and <100% relative to the national average, cost-

effectiveness of substituting hepatitis A/B vaccine (addition of one HAV dose) for HBV vaccine (3 doses) would be US$ <0, 2, 131, and 22,819 per life-year saved, respectively [34]. In inmates aged 25 years, vaccination with bivalent hepatitis A/B vaccine without prior screening has the most favourable cost-effectiveness ratio, while in inmates aged 35 years, screening before choosing between HAV, HBV, or the bivalent hepatitis A/B vaccine was the most cost-effective scenario [33].

Reasons for not being vaccinated were refusal of vaccination, ineligibility or absence during vaccination sessions [31]. Another USA survey study reported that among 52 female inmates who had not completed a hepatitis A/B vaccine schedule, 67% were interested in receiving the vaccines [35].

Influenza

Two studies from the USA reported data on influenza vaccination in prison, one included data on uptake and acceptability [36]) and the other on acceptability only [37].

In one study all inmates and staff were offered influenza vaccine shortly after the identification of an influenza outbreak [37]. For this purpose, temporary clinics were set up in prison. The vaccine uptake was 42-46% among inmates and 25-37% among staff, as shown in table 3.
In a survey study, mean coverage of H1N1 influenza vaccine among prison staff during the 2009 H1N1 influenza pandemic was 62%, while that of both seasonal and H1N1 influenza vaccine combined was 69% [36]). These coverage rates were lower compared to other healthcare staff (not in correctional facilities).

The first study reported the following challenges of influenza vaccination during outbreaks: insufficient staff, no easily accessible medical records to establish vaccination status or underlying conditions, lack of access to sufficient quantities of vaccine and antiviral drugs, and lack of skilled personnel to administer large volume of vaccine and antiviral drugs in timely manner [37]. In the second study among 25 correctional facilities, 79% of respondents reported no barriers to storing and administering H1N1 vaccine, while 21% reported storage space for vaccine and 8% reported storage space for supplies as a barrier (Seib 2013).

Measles, mumps and rubella

One study from Canada reported on the acceptance and uptake of MMR vaccination (schedule not reported) during a mumps outbreak [38]. Among inmates, acceptance was 80% and uptake was 74%. Among staff, acceptance was not reported and uptake was 36% (Table 3). This study also reported that 26% of inmates were not vaccinated due to previous mumps infection (4%), previous vaccination (3%), and refusal of vaccination (17%) [38].

DISCUSSION

To our knowledge, this is the first comprehensive systematic review on vaccination in prison settings. Even though vaccination is a prevention mainstay for a number of communicable diseases, it is a rarely researched topic in prison settings and our review identified a limited number of studies covering vaccination for HAV, HBV, influenza, measles, mumps and rubella.

The larger share of evidence was concentrated on HBV vaccine, which has a recognized efficacy and an overall good safety profile also in the prison setting [28]. Our findings indicate an acceptance rate above 80% in most studies, despite a much lower uptake of the last schedule dose. Using the very rapid HBV vaccination schedule offers a clear advantage in terms of both uptake and completion rates, according to one comparative study. The very rapid schedule for HBV is recommended by the World Health Organization (WHO) when more rapid induction of protection is required [39]. Based on this rationale and the contingent challenges due to rapid turnover of people in prison, the very rapid schedule is considered a suitable approach in prison settings [9]). According to our findings in fact, the major identified barriers to the completion of vaccination schedule were release from prison, house arrest and transfer to other prisons [20], [21], [22], [23]. Yet, while completion of the three-dose course may increase using the very rapid vaccination schedule, data on the uptake of the booster dose at 12 months was poorly available from the included studies. Evidence on HBV vaccine effectiveness and duration of protection in the absence of the fourth dose is limited [39].

Besides universal childhood vaccination, the WHO recommends HBV vaccination for a number of groups at increased risk, including people in prison, PWID and people with HIV and/or HCV infection[39]. While almost all EU/EEA countries have already adopted childhood immunization programmes, targeted vaccination initiatives are heterogeneous with most countries offering HBV vaccination to PWID, HIV- and HCV-infected individuals. However, only a limited number of countries include people in prison among the target groups, despite the overrepresentation in prison of people with HIV and HCV infections [14] and of people with substance use disorders, including PWID [15].

Co-administration of HAV and HBV vaccine to people in prison was explored in a few studies, either targeting the whole prison population [32] or a selected group, such as MSM (Costumbrado 2012 31). In consideration of the burden of chronic liver diseases and HIV in the prison population, addition of HAV vaccination to the HBV vaccine offered to all people in prison may be considered, based on the WHO recommendation for targeted HAV vaccination [40]. However, underlying seroprevalence and susceptibility to the disease would need to be taken into consideration to assess the most affordable vaccination strategy and its optimal implementation in a given country or region, as indicated by the two cost-effectiveness studies included in the analysis [33], [34]. In particular, the offer of vaccination for HBV or a combination of HAB and HBV may be influenced by a preliminary serology assessment to investigate pre-existing immunity to either of the two viruses [33]. This approach may be of relevance in most of the EU/EEA countries, as according to a recently published analysis, the region is characterized by low or very low endemicity for HAV and by an increasing proportion of susceptible persons, in particular among the younger age groups [41]. HAV circulation in a context of high susceptibility to infection may result in large outbreaks, as recently occurred among MSM in the EU/EEA [42]. Although no cases have been reported from prison settings to date, there is potential for such events to occur among the prison population. Currently HAV vaccination is considered a core measure for outbreak control activities [40]; yet, its use to prevent and control outbreak-prone diseases in prison is a less researched topic in the literature.

Evidence on vaccination in outbreak situations was limited to two studies, one reporting on seasonal flu outbreaks occurring in two prisons [37], and one on MMR vaccine administration in the context of a mumps

outbreak control effort [38]. Despite the scarcity of scientific evidence, outbreaks of vaccine-preventable diseases in prison settings are not that rare [43]. While single individuals in prison may be at lower risk of exposure to diseases such as flu or measles, these settings house large populations with high turnover, are often overcrowded, vaccine coverage may be suboptimal and susceptibility to disease variable [8], [9]. Organisational issues related to outbreak management, such as limited personnel to handle the medical surge, timely access to sufficient quantities of vaccine and lack of skilled personnel to administer a large volume of vaccine may be quite challenging in this setting (Robinson 2012, Walkty 2011).

Preventive vaccination against seasonal and pandemic flu in prison settings is also of relevance in consideration of the changing demographic and aging of the prison population [8], the accompanying burden of chronic diseases in this population [44], coupled with the higher prevalence of smokers in this setting [44] . Current guidelines recommend offering seasonal flu vaccination to high risk groups only in the general population, including the elderly and the chronically ill [45], [46], [47], which should be extended to people in prison across the EU/EEA. However, seasonal flu vaccination coverage is suboptimal in the region [48] and complying with these guidelines in prison settings may result in operational challenges, e.g. identification and offer of vaccination only to individuals belonging to the groups at risk. In consideration of the potential for outbreak events to occur in closed settings, universal seasonal flu vaccination campaigns may constitute a more effective measure, given the caveat of affordability. While prison staff are not often identified as a target group for seasonal flu vaccination, they were targeted in two articles retrieved through this review [36], [37]. Providing adequate seasonal flu vaccination coverage among staff may not only benefit the single individual, but also protect the prison population from disease introduction from the broader community [49]. Of note, in a pandemic flu situation, vaccination of staff may preserve functionality of services. Based on a similar rationale, flu vaccination is recommended for healthcare workers [9]. Given these observations, prison settings may warrant inclusion in a national flu pandemic plan [36], as already done in some European countries such as the UK [50].

The findings from our review are limited to certain vaccine-preventable diseases, although adult vaccination programmes include a number of other vaccines, such as pneumococcal and meningococcal

vaccination and tetanus booster [51]. Implementation of these vaccination programmes in prison settings might also be relevant. Taken into consideration the life-course approach promoted by the WHO in the Global Vaccine Action Plan, vaccination in adulthood is an essential component of a comprehensive communicable diseases prevention strategy [52]. Adult vaccination in prison settings may have an even stronger rationale based on the overall higher burden of disease in this population [9], [12]. Vaccination in prison may also offer the opportunity for prison health services to reach people belonging to deprived and underserved communities who may suffer from suboptimal access to services while in the community. In this scenario, women in prison may warrant some special considerations, not only for their specific needs (e.g. HPV vaccination), but also for their children's. Importantly, provision of adequate vaccination services to children and infants born to women in detention, including birth-dose HBV vaccination when appropriate, is to be considered and planned for.

Scaling-up vaccination in prison settings may not only result in single individual's protection against disease, but may also produce a "community dividend" effect by contributing to achieving herd immunity in the broader population or at least among specific groups at higher risk. This phenomenon has been well described in Scotland, where the benefits of targeted HBV vaccination scale-up in prison have largely accrued among PWID in the community [17].

Finally, to ensure achievement of the prevention potential of a comprehensive vaccination schedule in prison settings, appropriate monitoring should be in place. Despite the very limited implementation in EU/EEA prison settings, electronic immunisation information systems (IISs) for vaccination may help recording the number of doses received while in prison and thereby help achieving a higher coverage and completion of vaccination post-release. Similarily, the use of IISs can provide a reliable tool to assess individual's vaccination history at entrance into prison and thereby avoid unnecessary and repeated vaccination. IISs may also facilitate coordination between prison health and community immunisation services, which is paramount for schedule completion. Furthermore, vaccination requirements of specific prison populations should be part of health needs assessment to ensure that current and emerging vaccination needs of any prison population is known and planned for [53].

Strengths and limitations

The strengths of this systematic review include a broad search over a long period of time in three peer-reviewed literature databases, supplemented with searches for grey literature on websites and via a call to experts, and using a rigorous methodology to identify, critically appraise, analyse and summarise the relevant evidence [54], [55]. Yet, we could only retrieve a limited number of articles covering few vaccine-preventable diseases. Most studies had a descriptive and observational design without control groups, were conducted in single institutions and had limited generalisability. Outcome definitions varied between studies, and some studies did not clearly define the relevant outcomes used. This mostly concerned the denominators used for various rates, such as the vaccine acceptance and uptake rate. Although we have recalculated several outcome values to prevent incorrect comparisons, this was not always possible due to lacking outcome definitions. Finally, it was often difficult to determine the vaccination factors responsible for the observed effects due to the fact that interventions were often part of a bundle of measures and could therefore not be examined in isolation (i.e. different vaccine brands, schedules, timings and promotion measures).

While the focus of this review was the EU/EEA region, a number of the retrieved studies were conducted in other high-income countries, particularly in the USA. As a result, their findings may not be simply extrapolated to the EU/EEA context due to diversity in the demographic, infrastructural and structural characteristics of the USA prison system. Even within one region, study settings varied widely between included studies (e.g. jails, were persons are generally incarcerated for shorter periods, versus prisons for sentenced individuals).

Conclusions

In this systematic review we have retrieved evidence on vaccination interventions for HAV, HBV, influenza, measles, mumps and rubella. With the exception of HBV, the resulting evidence base is very weak, with very few studies reporting on most vaccine-preventable diseases. This systematic review highlighted important knowledge gaps and operational challenges for vaccination programmes in prison settings. Yet,

this review highlights that vaccination is an effective measure that warrants comprehensive and tailored implementation in prison settings in order to reduce the preventable disease burden, avoid risks of large outbreaks of vaccine-preventable diseases, and contribute to health equity for people in prison.

Declaration of interest/Funding

Financial support

This work was supported by the European Centre for Disease Prevention and Control (framework contract number ECDC/2015/028, specific contract number ECD.5855) and is part of a wider joint undertaking with the European Monitoring Centre on Drugs and Drug Addiction (EMCDDA) to develop European guidance on the prevention of communicable diseases in the prison setting.

Authors' contributions

GM, HV, AOS,EOM, LT have contributed to the conception and design of the study, acquisition of data, analysis and interpretation of data, drafting the manuscript, final approval of the submitted version; SB, PLL, DH have contributed to acquisition and analysis of data, critical revision of important intellectual content and final approval of the submitted version; MVN, RB have contributed to conception of the study and analysis of the data, revision of important intellectual content and final approval of the submitted version.

Potential conflicts of interest

The authors have no conflict of interests to declare.

Acknowledgement

Invaluable inputs were received from the guidance *ad-hoc* scientific panel members: Dr Viktor Mravcik (Czech Republic), Dr Fadi Meroueh (France), Laurent Michel (France), Prof Heino Stöver (Germany), Dr Ruth Zimmermann (Germany), Dr Roberto Ranieri (Italy), Erica Cardoso (Portugal), Teresa Galhardo (Portugal), Dr Rui Morgado (Portugal), Dr Lucia Mihailescu (Romania), Dr Jose-Manuel Royo (Spain), Stefan Enggist (Switzerland), Prof Sharon Hutchinson (UK), Alison Hannah (Penal Reform International), Jan Malinowski (Council of Europe), Lars Møller (WHO), and Dr Ehab Salah (United Nations on Drugs and Crime).

The authors would like to acknowledge the field researchers who contributed to the project: Ruth Gray, Sofia Victoria Casado Hoces, Leon Weichert and Deborah Iwanikow.

The authors would like to acknowledge the ECDC library and ECDC and EMCDDA staff who contributed to the project: Andrew J Amato Gauci, Netta Beer, Helena de Carvalho Gomes, Erika Duffell and Marica Ferri.

REFERENCES

1. Remy V, Largeron N, Quilici S, Carroll S. The economic value of vaccination**:** why prevention is wealth. J Mark Acces Health Policy. 2015;3.
2. ECDC. Immunisation 2016 [Available from: http://ecdc.europa.eu/en/healthtopics/immunisation/pages/index.aspx]
3. MacDonald NE; SAGE Working Group on Vaccine Hesitancy. Vaccine hesitancy: Definition, scope and determinants. Vaccine. 2015 Aug 14;33(34):4161-4. doi: 10.1016/j.vaccine.2015.04.036. Epub 2015 Apr 17.
4. Biasio LR, Carducci A, Fara GM, Giammanco G, Lopalco PL. Health literacy, emotionality, scientific evidence: Elements of an effective communication in public health. Hum Vaccin Immunother. 2018 Jun 3;14(6):1515-1516. doi: 10.1080/21645515.2018.1434382. Epub 2018 Feb 23
5. Lorini C, Santomauro F, Donzellini M, Capecchi L, Bechini A, Boccalini S, Bonanni P, Bonaccorsi G. Health literacy and vaccination: A systematic review. Hum Vaccin Immunother. 2018 Feb 1;14(2):478-488. doi: 10.1080/21645515.2017.1392423. Epub 2017 Dec 6.
6. Mipatrini D, Stefanelli P, Severoni S, Rezza G. Vaccinations in migrants and refugees: a challenge for European health systems. A systematic review of current scientific evidence. Pathog Glob Health. 2017 Mar;111(2):59-68. doi: 10.1080/20477724.2017.1281374. Epub 2017 Feb 6. Review.

7. Fournet N, Mollema L, Ruijs WL, Harmsen IA, Keck F, Durand JY, Cunha MP, Wamsiedel M, Reis R, French J, Smit EG, Kitching A, van Steenbergen JE. Under-vaccinated groups in Europe and their beliefs, attitudes and reasons for non-vaccination; two systematic reviews. BMC Public Health. 2018 Jan 30;18(1):196. doi: 10.1186/s12889-018-5103-8. Review.

8. Aebi M, Chopin J, Tiago MM, Burkardt C. SPACE I – c. Strasbourg: Council of Europe; 2018 http://wp.unil.ch/space/space-i/prison-stock-on-1st-january/2018-2/

9. World Health Organization. Prisons and Health. 2014. Available from: http://www.euro.who.int/__data/assets/pdf_file/0005/249188/Prisons-and-Health.pdf.

10. Perrodeau F, Pillot-Debelleix M, Vergniol J, Lemonnier F, Receveur MC, Trimoulet P, Raymond I, Le Port G, Gromb-Monnoyeur S. Optimizing hepatitis B vaccination in prison. Med Mal Infect. 2016 Mar;46(2):96-9.

11. Hammett TM, Harmon MP, Rhodes W. The burden of infectious disease among inmates of and releases from US correctional facilities, 1997. Am J Public Health 2002; 92:1789–94.

12. Dolan K, Wirtz AL, Moazen B, Ndeffo-Mbah M, Galvani A, Kinner SA, et al. Global burden of HIV, viral hepatitis, and tuberculosis in prisoners and detainees. Lancet. 2016;388(10049):1089-102

13. Tavoschi L, Vroling H, Madeddu G, Babudieri S, Monarca R, Vonk Noordegraaf-Schouten M, Beer N, Gomes Dias J, O'Moore É, Hedrich D, Oordt-Speets A. Active Case Finding for Communicable Diseases in Prison Settings: Increasing Testing Coverage and Uptake Among the Prison Population in the European Union/European Economic Area. Epidemiol Rev. 2018 Jun 1;40(1):105-120. doi:10.1093/epirev/mxy001.

14. 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 Feb 12;18(1):79.

15. Fazel S, Yoon IA, Hayes AJ. Substance use disorders in prisoners: an updated systematic review and meta-regression analysis in recently incarcerated men and women. Addiction. 2017 Oct;112(10):1725-1739.

16. Kamarulzaman A, Reid SE, Schwitters A, Wiessing L, El-Bassel N, Dolan K, et al. Prevention of transmission of HIV, hepatitis B virus, hepatitis C virus, and tuberculosis in prisoners. Lancet. 2016;388(10049):1115-26.

17. Palmateer NE, Goldberg DJ, Munro A, Taylor A, Yeung A, Wallace LA, Mitchell A, Shepherd SJ, Gunson RN, Aitken C, Hutchinson SJ. Association between universal hepatitis B prison vaccination, vaccine uptake and hepatitis B infection among people who inject drugs. Addiction. 2018 Jan;113(1):80-90.

18. Gilbert RL, O'Connor T, Mathew S, Allen K, Piper M, Gill ON. Hepatitis A vaccination--a prison-based solution for a community-based outbreak? Communicable disease and public health / PHLS. 2004;7(4):289-93.

19. Gabbuti A. Richiesta di predisposizione di routine per l'estrazione di dati. 2014 (unpublished).

20. Christensen PB, Fisker N, Krarup HB, Liebert E, Jaroslavtsev N, Christensen K, et al. Hepatitis B vaccination in prison with a 3-week schedule is more efficient than the standard 6-month schedule. Vaccine. 2004;22(29-30):3897-901.

21. Bayas JM, Bruguera M, Martin V, Vidal J, Rodes J, Salleras LY. Hepatitis B vaccination in prisons: the Catalonian experience. Vaccine. 1993;11(14):1441-4.

22. Jacomet C, Guyot-Lenat A, Bonny C, Henquell C, Rude M, Dydymski S, et al. Addressing the challenges of chronic viral infections and addiction in prisons: the PRODEPIST study. Eur J Public Health. 2016;26(1):122-8.

23. Gabbuti A. Valutazione del percorso di screening HBV per l'aggiornamento ed integrazione del protocollo interno all' Istituto. 2014 (unpublished).

24. Devine A, Karvelas M, Sundararajan V. Evaluation of a prison-based hepatitis B immunisation pilot project. Australian and New Zealand journal of public health. 2007;31(2):127-30.

25. Clarke J, Schwartzapfel B, Pomposelli J, Allen S, Spaulding A, Rich JD. Hepatitis B vaccination of incarcerated women: a pilot program. Journal of health care for the poor and underserved. 2003;14(3):318-23.

26. Beck CR, Cloke R, O'Moore E, Puleston R. Hepatitis B vaccination coverage and uptake in prisons across England and Wales 2003-2010: a retrospective ecological study. Vaccine. 2012;30(11):1965-71.

27. Gilbert RL, Costella A, Piper M, Gill ON. Increasing hepatitis B vaccine coverage in prisons in England and Wales. Communicable disease and public health / PHLS. 2004;7(4):306-11.

28. Awofeso N, Levy M, Harper S, Jones M, Hayes M, Douglas J, et al. Response to HBV vaccine in relation to vaccine dose and anti-HCV positivity: a New South Wales correctional facilities' study. Vaccine. 2001;19(30):4245-8.

29. Pisu M, Meltzer MI, Lyerla R. Cost-effectiveness of hepatitis B vaccination of prison inmates. Vaccine. 2002;21(3-4):312-21.

30. Vallabhaneni S, Macalino GE, Reinert SE, Schwartzapfel B, Wolf FA, Rich JD. Prisoners' attitudes toward Hepatitis B vaccination. Preventive medicine. 2004;38(6):828-33.

31. Costumbrado J, Stirland A, Cox G, El-Amin AN, Miranda A, Carter A, et al. Implementation of a hepatitis A/B vaccination program using an accelerated schedule among high-risk inmates, Los Angeles County Jail, 2007-2010. Vaccine. 2012;30(48):6878-82.

32. Herlihy EJ, Klein SJ, Newcomb ML, Blog DS, Birkhead GS. Expansion of adult hepatitis A and B vaccination in STD clinics and other settings in New York State. Public health reports (Washington, DC : 1974). 2007;122 Suppl 2:36-41.

33. Jacobs RJ, Saab S, Meyerhoff AS, Koff RS. An economic assessment of pre-vaccination screening for hepatitis A and B. Public health reports (Washington, DC : 1974). 2003;118(6):550-8.

34. Jacobs RJ, Rosenthal P, Meyerhoff AS. Cost effectiveness of hepatitis A/B versus hepatitis B vaccination for US prison inmates. Vaccine. 2004;22(9-10):1241-8.

35. Nijhawan AE, Salloway R, Nunn AS, Poshkus M, Clarke JG. Preventive healthcare for underserved women: results of a prison survey. Journal of women's health (2002). 2010;19(1):17-22.

36. Seib K, Gleason C, Richards JL, Chamberlain A, Andrews T, Watson L, et al. Partners in immunization: 2010 survey examining differences among H1N1 vaccine providers in Washington state. Public health reports (Washington, DC : 1974). 2013;128(3):198-211.

37. Robinson S. Center for Disease Control and Prevention. Influenza outbreaks at two correctional facilities -- Maine, March 2011. MMWR Morbidity and mortality weekly report. 2012;61(13):229-32.

38. Walkty A, Van Caeseele P, Hilderman T, Buchan S, Weiss E, Sloane M, et al. Mumps in prison: description of an outbreak in Manitoba, Canada. Canadian journal of public health = Revue canadienne de sante publique. 2011;102(5):341-4.

39. WHO position paper, WER 2017, 92, 369–39. http://www.who.int/wer/2017/wer9227/en/

40. WHO position paper on hepatitis a vaccines – June 2012. Weekly Epidemiological Record. No. 28-29, 2012, 87, 261–276 http://www.who.int/wer/2012/wer8728_29.pdf?ua=1

41. Carrillo-Santisteve P, Tavoschi L, Severi E, Bonfigli S, Edelstein M, Byström, Lopalco P; ECDC HAV Expert Panel. Seroprevalence and susceptibility to hepatitis A in the European Union and European Economic Area: a systematic review. Lancet Infect Dis. 2017 Oct;17(10):e306-e319.

42. Ndumbi P, Freidl GS, Williams CJ, Mårdh O, Varela C, Avellón A, Friesema I, Vennema H, Beebeejaun K, Ngui SL, Edelstein M, Smith-Palmer A, Murphy N, Dean J, Faber M, Wenzel J, Kontio M, Müller L, Midgley SE, Sundqvist L, Ederth JL, Roque-Afonso AM, Couturier E, Klamer S, Rebolledo J, Suin V, Aberle SW, Schmid D, De Sousa R, Augusto GF, Alfonsi V, Del Manso M, Ciccaglione AR, Mellou K, Hadjichristodoulou C, Donachie A, Borg ML, Sočan M, Poljak M, Severi E, Members Of The European Hepatitis A Outbreak Investigation Team. Hepatitis A outbreak disproportionately affecting men who have sex with men (MSM) in the European Union and European Economic Area, June 2016 to May 2017. Euro Surveill. 2018 Aug;23(33).Skarupski KA, Gross A, Schrack JA, Deal JA, Eber GB. The Health of America's Aging Prison Population. Epidemiol Rev. 2018 Jun 1;40(1):157-165.

43. PHE health and justice annual review 2017 to 2018. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/725776/Health_and_Justice_Annual_Review_2017-2018.pdf

44. Skarupski KA, Gross A, Schrack JA, Deal JA, Eber GB. The Health of America's Aging Prison Population. Epidemiol Rev. 2018 Jun 1;40(1):157-165.

45. Public Health England. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/463360/Guidance_on_seasonal_flu_for_prisons_2015_16_FINAL.pdf

46. WHO fact sheet. Seasonal Influenza. http://www.who.int/mediacentre/factsheets/fs211/en/

47. Commission of the European Communities. Proposal for a Council recommendation on seasonal influenza vaccination 2009. http://ec.europa.eu/health/ph_threats/com/Influenza/docs/seasonflu_rec2009_en.pdf

48. European Centre for Disease Prevention and Control. Seasonal influenza vaccination in Europe – Overview of vaccination recommendations and coverage rates in the EU Member States for the 2012–13 influenza season. Stockholm: ECDC; 2015. Available from: http://ecdc.europa.eu/en/publications/Publications/Seasonal-influenza-vaccination-Europe-2012-13.pdf.

49. Public Health England. Seasonal flu in prisons and detention centres in England: guidance for prison staff and healthcare professionals. 2013. Last updated 2017. Available at: https://www.gov.uk/government/publications/seasonal-flu-in-prisons-and-detention-centres-in-england-guidance-for-prison-staff-and-healthcare-professionals

50. Public Health England. Pandemic Influenza Strategic Framework; 2014. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/344695/PI_Response_Plan_13_Aug.pdf

51. WHO. WHO recommendations for routine immunization - summary tables. Available at: http://www.who.int/immunization/policy/Immunization_routine_table1.pdf?ua=1 (accessed on 27th July 2018)

52. WHO. Global Vaccine Action Plan 2011-2020. http://www.who.int/immunization/global_vaccine_action_plan/GVAP_doc_2011_2020/en/

53. Public Health England;2014. Health and Justice Health Needs Assessment Toolkit for Prescribed Places of Detention. Availablel at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/331622/Health_Needs_Assessment_Toolkit_for_Prescribed_Places_of_Detention_Part_1.pdf

54. Higgins JPT, Green, S. (editors). Cochrane Handbook for Systematic Reviews of Interventions. The Cochrane Collaboration; 2011.

55. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Int J Surg. 2010;8(5):336-41.

Figure 1. Flowchart selection process peer-reviewed literature

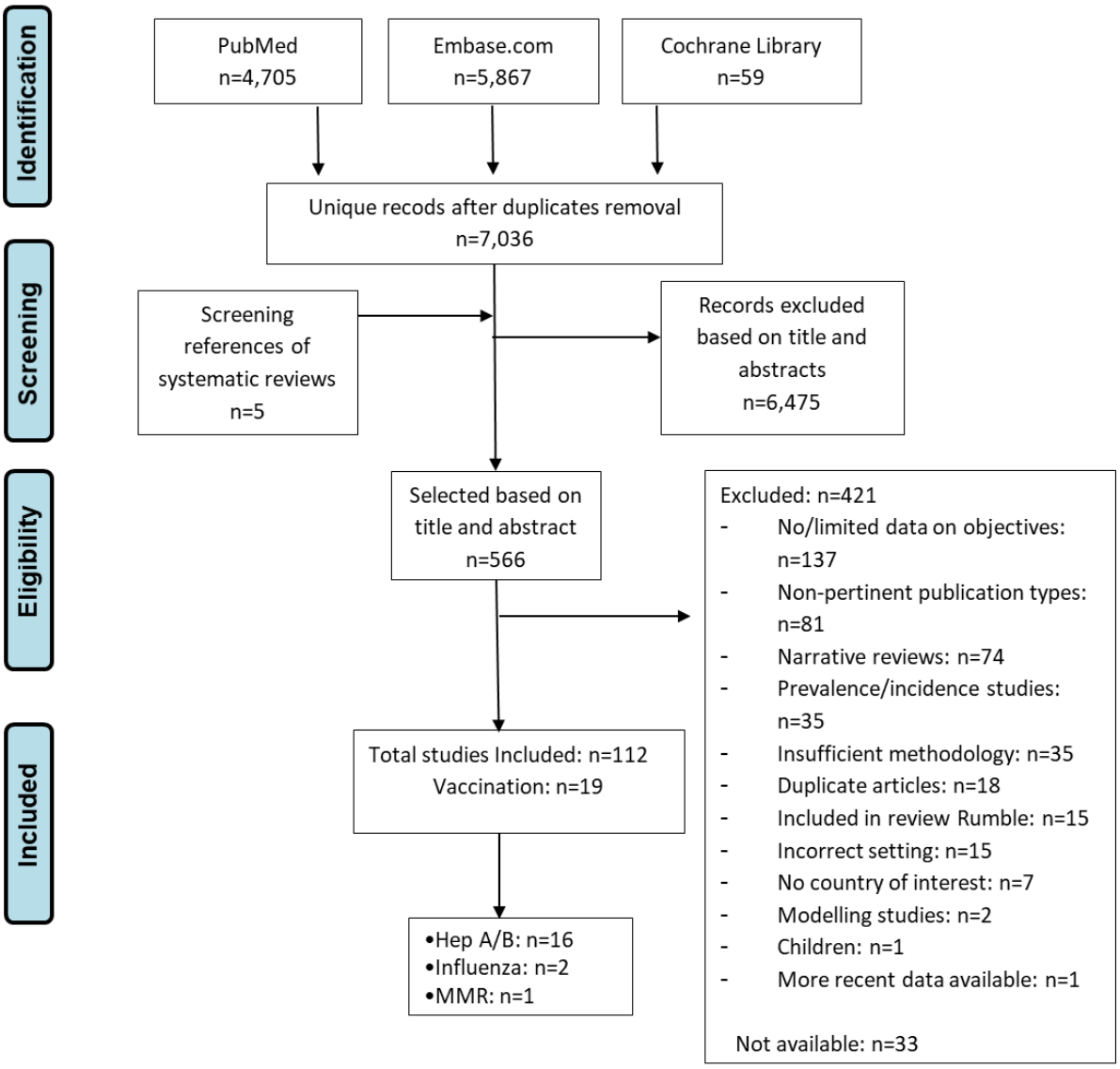


Figure 2. Flowchart selection process for the grey literature

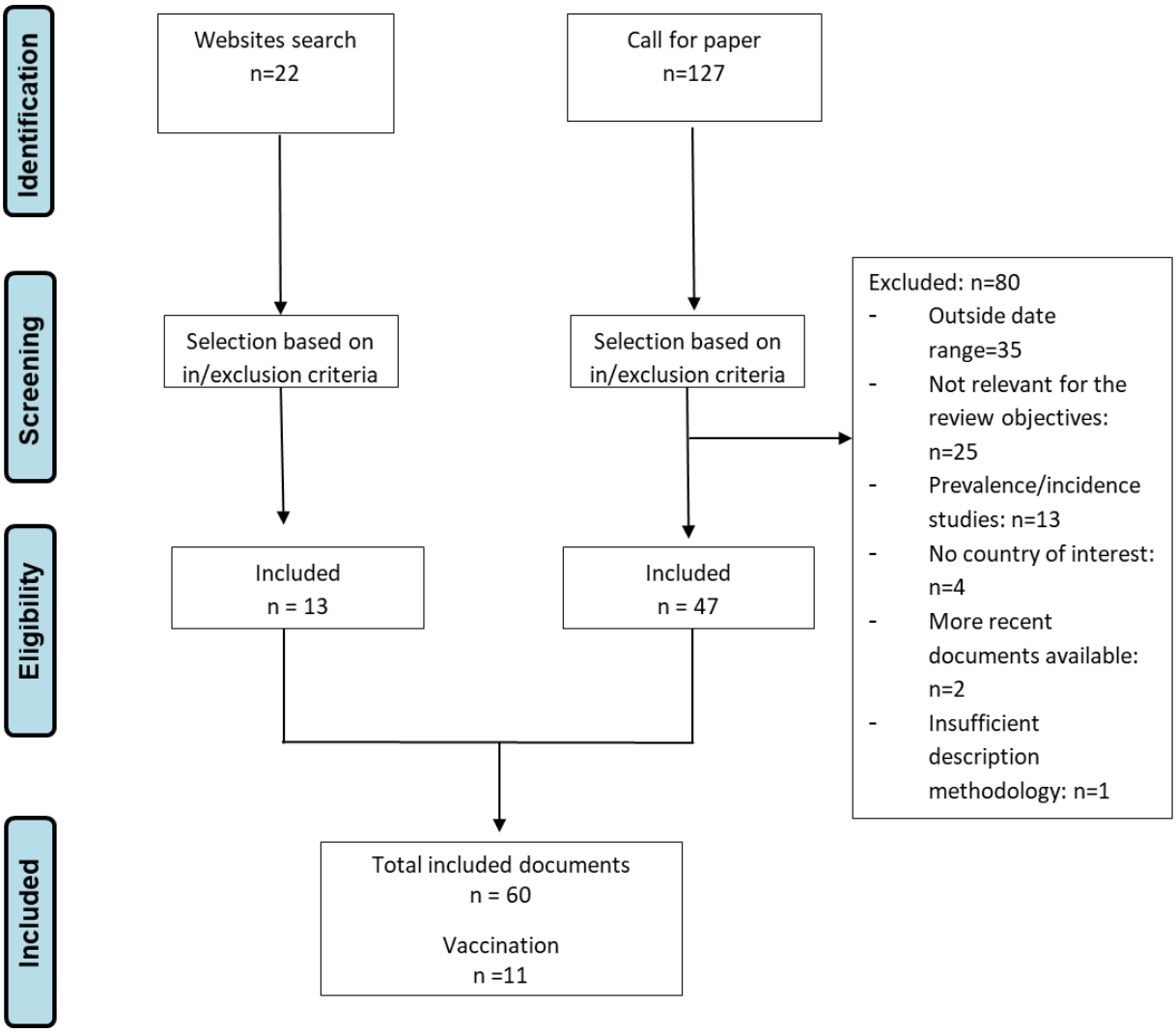


Table 1: Characteristics of included studies

Reference	Country	Source - study design	Sample size	Vaccine (schedule/dose)	Effectiveness outcomes	Acceptability/barriers outcomes/	Level of evidence
Gilbert, 2004 [18]	UK	PRL - Cross-sectional study	1,363 inmates	Hepatitis A (single dose)	Acceptance, uptake, effectiveness	Refusal + reasons No vaccine offer + reasons	Very low
Gabbuti, 2014 [19]	Italy	GL – Cross-sectional study	2,376 inmates	Hepatitis A (single dose)	Acceptance, uptake	Reasons for non completion of schedule	Unpublished research report
Christensen, 2004 [20]	Denmark/Estonia	PRL - RCT - Open label extension	72 inmates in Denmark and 566 in Estonia	Hepatitis B (very rapid vs. standard)	Acceptance, uptake seroconversion, seroprotection	No vaccine offer + reasons	Low
Gilbert, 2004 (27)	UK	PRL - Cross-sectional study	42 prisons in England and Wales	Hepatitis B (very rapid schedule)	Effectiveness	-	Very low
Awofeso, 2001 [28]	Australia	PRL – Cross-sectional study	1,037 inmates	Hepatitis B (rapid)	Seroconversion, seroprotection	-	Very low
Devine, 2007 [24]	Australia	PRL – Cross-sectional study	391 inmates	Hepatitis B (standard)	Acceptance, uptake	No vaccine offer + reasons	Very low
Clarke, 2003 [25]	USA	PRL - Cross-sectional study	236 inmates	Hepatitis B (3 doses)	Acceptance, uptake	No vaccine offer + reasons	Very low
Gabbuti, 2014 [23]	Italy	GL - Retrospective study	12,143 inmates	Hepatitis B (standard)	Acceptance, uptake	-	Unpublished research report
Jacomet, 2016 [22]	France	PRL – Cross-sectional study	357 inmates	Hepatitis B (schedule NR)	Acceptance, uptake	No vaccine offer + reasons	Very low
Beck, 2012 [26]	UK	PRL - Surveiilance study	147 prisons in England and Wales	Hepatitis B (schedule NR)	Uptake	-	Very low
Pisu, 2002 [29]	USA	PRL - Mathematical model	NA	Hepatitis B (schedule NR)	Cost-effectiveness	-	Low
Bayas, 1993 [21]	Spain	PRL – Cross-sectional study	705 inmates	Hepatitis B (standard)	Acceptance, uptake	No vaccine offer + reasons	Very low
Vallabanheni, 2004 [30]	USA	PRL - Cross-sectional study	153 inmates	Hepatitis B (schedule NR)	-	Acceptability Refusal + reasons	Very low
Costumbrado, 2012 [31]	USA	PRL – Cross-sectional study	4,719 inmates	Hepatits A + B combined (very rapid schedule)	Acceptance, uptake	Refusal + reasons No vaccine offer + reasons	Very low
Herlihy, 2007 [32]	USA	PRL - Prospective study	NR	Hepatits A + B combined (schedule NR)	Number of county jails offering vaccine	-	Very low
Jacobs, 2003 [33]	USA	PRL - Mathematical model	NA	Hepatits A + B combined (schedule NR)	Cost-effectiveness	-	NA
Jacobs, 2004 [34]	USA	PRL - Mathematical model	NA	Hepatits A + B combined (schedule NR)	Cost-effectiveness		NA
Nijhawan, 2010 [35]	USA	PRL - Cross-sectional study	52 inmates	Hepatits A + B combined (schedule NR)	-	Acceptability	Very low
Robinson, 2012 [37]	USA	PRL - Outbreak report	995 inmates 235 staff	Infuenza vaccine (single dose)	Uptake	No vaccine offer + reasons	Very low

Seib, 2013 [36]	USA	PRL - Outbreak report	25 correctional facilities in Washington State	Influenza vaccine (single dose)	-	Acceptability, feasibility and accessibility	Very low
Walkty, 2011[38]	Canada	PRL Outbreak report	135 inmates 187 staff	MMR combined vaccine (schedule/dose NR)	Acceptance, uptake	No vaccine offer + reasons	Very low

UK: United Kingdom; USA: United States of America; PRL: peer-reviewed literature; GL: grey literature; NR: not reported; NA: not applicable.

Table 2. Summary of retrieved studies on Hepatitis A, B and combined A+B vaccination in prison setting

Reference, country, study design	Prison setting, sample	Schedule	Who, when, offer, promotion	Acceptance*	Uptake**	Seroconversion	Seroprotection	Change prevalence/incidence	Level of evidence
Hepatitis A vaccine									
Gilbert, 2004 [18] UK Cross-sectional study PRL	Large local prison serving mostly remands or those with short sentences n=1,363	Single dose	All inmates on the mass vaccination day and all entrants the subsequent 4 weeks, without vaccination history One-day mass vaccination and at entry (timing NR) the subsequent 4 weeks Voluntary Information letter, information leaflets, active promotion by nurses	91%	NR	NR	NR	NR	Very low
Gabbuti A 2014 [19] Italy Cross-sectional study GL	Regional prison (Florence) n=2376	Single dose	All detainees After serological screening (timing of screening NR) Voluntary 2 sanitary assistants dedicated to prisoners vaccination from 2010	1/20 (5%) in 2010 5/39 (12.8%) in 2011 22/82 (26.8%) in 2012 40/98 (40.8%) in 2013	Vaccinated: -62.9% in 2012 -70.5% in 2013	NR	NR	NR	Unpublished research report
Hepatitis B vaccine									
Christensen, 2004 [20] Denmark RCT PRL	One prison center for remands and convicts n=72	d0, d7, d21, booster d210 (very rapid)	Prison entrants known to HBV positive or ever vaccinated against HBV At entry (timing NR) Voluntary NR	100%	Dose 3: 63%	NR	NR	NR	Low
		d0, d30, d180, booster d210 (standard)		100%	Dose 3: 20% Very rapid vs. standard schedule p=0.017[$]	NR	NR	NR	

Christensen, 2004 [20] Estonia Open-label trial PRL	One prison for remands and convicts n=566	d0, d7, d21, booster d210 (very rapid)	All inmates known to have had hepatitis B During study period Voluntary NR	100%	Dose 1: 100% Dose 2: 92% Dose 3: 81% Booster: 42%	*Seroconversion (anti-HBs ≥1 IU/l):* At median 209 days: 91%	*Seroprotection (anti-HBs ≥10 IU/l):* At median 209 days: 67%	NR	Low
Awofeso, 2001 [28] Australia Cross-sectional study PRL	State correctional facilities n=1,037	Engerix-B (20 µg/dose) d0-1-2 months (rapid)	Full-time inmates who agreed to participate in the screening program, serologically negative for HBV surface antigen, HBV surface antibody, and HBV core antibody During study period Voluntary NR	NR	NR	*Seroconversion (definition not given):* - HCV+ inmates: 79.7% - HCV- inmates: 85.2% - OR HCV+ vs - =0.69 (p=0.37)	*Seroprotection (anti-HBs ≥10IU/l):* After dose 3: 82.5%	NR	Very low
		H-B-Vax II (10 µg/dose) d0-1-2 months (rapid)		NR	NR	*Seroconversion (definition not given):* - HCV+ inmates: 73.7% - HCV- inmates: 67.6% - OR HCV+ vs - =1.3 (p=0.64)	*Seroprotection (anti-HBs ≥10IU/l):* After dose 3: 69.6% OR Engerix-B vs. H-B-Vax II =2.1 (p=0.04)[$]	NR	
Devine, 2007 [24] Australia Cross-sectional study PRL	Two female prisons n=391	H-B-Vax II d0, d30, d180 (standard)	New entrants and already sentenced female inmates with no/incomplete HBV vaccination history Entrants: at same time as serological screening (timing of screening NR) Voluntary NR	83%	Dose 1: 43% Dose 2: 48% Dose 3: 19%	NR	NR	NR	Very low
Bayas, 1993 [21] Spain Cross-sectional study PRL	Three prisons (1 for young offenders awaiting trial, 1 long-sentence, 1 intermediate situation) n=705	Engerix-B d0, d(1-90), d(50-360)	Inmates negative for all hepatitis B markers or with positive anti-HBs As soon as possible after the serological screening (timing of screening NR)	76%	Dose 1: 31% Dose 2: 81% Dose 3: 43%	*Seroconversion (anti-HBs ≥1 IU/l):* After dose 2: 44% After dose 3: 80%	*Seroprotection (anti-HBs ≥10IU/l):* After dose 2: 33% After dose 3: 6%	NR	Very low

			Voluntary Each inmate personally informed about aims of the program						
Jacomet, 2016 [22] France Cross-sectional study PRL	Two prisons n=357	NR NR	Adult inmates who were HBV free and exhibited no HBs antibodies After the serological screening at entry/relea-se (timing of screening NR) Voluntary NR	Dose 1: 54%	Dose 1: 23%	NR	NR	NR	Very low
Clarke, 2003 [25] USA Cross-sectional study PRL	One state correctional facility serving both as jail and prison n=236	NR 3 doses, not further specified	Female inmates at entry, and for the last 4 days of the study all other female inmates, all with no/unknown HBV vaccination/ infection history At entry (timing NR) and for the last 4 days any time during imprisonment Voluntary Called in small groups to vaccination area, information about hepatitis B, due date cards, contact details of local hospital clinic for free vaccine doses	93%	Dose 1: 67% Dose 2: 73% Dose 3: 40%	NR	NR	NR	Very low
Gabbuti A 2014 [23] Italy 2009-2015 Retrospective study GL	Regional prison (Florence) -2303 prisoners in 2009 -2376 prisoners in 2010 -2198 prisoners in 2011 -2015 prisoners in 2012 -1843 prisoners	HBV, not further specified d0, d30, d180 (standard)	All detainees with negative HBV serology At prison entry. After serological screening. Voluntary 2 sanitary assistants dedicated to prisoners vaccination from 2010	12.9% in 2009 13.1% in 2010 14.2% in 2011 15.2% in 2012 23.2% in 2013 24.3% in 2014	Vaccination completion (all doses): -35/46 (76.1%) in 2009 -40/50 (80%) in 2010 -52/67 (77.6%) in 2011 -110/187	NR	NR	NR	Unpublished research report

	in 2013 -1408 prisoners in 2014				(58.8%) in 2012 -192/402 (47.8%) in 2013 -185/358 (51.7%) in 2014				
Combined Hepatitis A and B vaccine									
Costumbrado, 2012 [31] USA Cross-sectional study PRL	County jail MSM dorm n=4,719	d0, 7, 21-30, booster 12 months (very rapid schedule)	All MSM dorm inmates Vaccine offered once a week during study period Voluntary A next-dose card: record administered vaccine doses, due date next dose, sexual health clinics, website and helpline, and message "It is never too late to complete the vaccine series"	34%	Dose 1: NR Dose 2: 77% Dose 3: 58% Booster: 11%	NR	NR	NR	Very low

HAV: hepatitis A virus, NR: not reported, USA: United States of America, MSM: Man who have Sex with Men, HCV=hepatitis C virus, OR=odds ratio

PRL: Peer-review literature, GL: Grey literature.

**Of all subjects eligible for vaccination at d0*

***Of total study sample of inmates; % dose 2 and 3 are of the number of inmates that received first dose (Hepatitis B vaccine only)*

$post-vaccination titer ≥100 IU/l: OR=1.89, p=0.04.

Table 3. Summary of retrieved studies on Measles-Mumps-Rubella and Influenza vaccination in prison setting

Reference, country, study design	Prison setting, sample	Vaccine, schedule	Who, when, offer, promotion	Acceptance*	Uptake**	Seroconversion	Seroprotection	Change prevalence/ incidence	Level of evidence
Robinson S CDC, 2012 [37] USA Outbreak report PRL	One minimum to maximum and one minimum security prison n=995 inmates n=235 staff	influenza vaccine NR	All inmates and staff of the two prisons Shortly after influenza outbreak identification of ILI cases NR Temporary clinics were set up to identify ILI cases and offer vaccination	NR	*Prison A:* Inmates: 42% Staff: 37% *Prison B:* Inmates: 46% Staff: 25%	NR	NR	NR	Very low
Walkty, 2011 [38] Canada Outbreak report PRL	One minimum-security prison n=135 inmates n=187 staff	MMR combination vaccine NR	All inmates and staff During mumps outbreak Voluntary NR	Inmates: 80% Staff: NR	Inmates: 74% Staff: 36%	NR	NR		Very low

CDC=Centers for Disease Control and Prevention, ILI=influenza-like illness, NR=not reported, RCT=randomised controlled trial, MMR=measles-mumps-rubella, PRL: Peer-review literature

**Of all subjects eligible for vaccination at d0*

***Of total study sample of inmates*

Supplemental Files

Click here to download Supplemental Files: Manuscript Vaccination Prisons_Appendix.docx