International Journal of Drug Policy 146 (2025) 105035

Contents lists available at ScienceDirect

International Journal of Drug Policy

journal homepage: www.elsevier.com/locate/drugpo

Research Paper

Prevalence and engagement with healthcare services for hepatitis B infection among people in prison in Australia: the AusHep study

Chloe Montague, Rugiatu Bah, Yumi Sheehan, Xiaoying Li, Gregory J Dore, Jason Grebely, Andrew R Lloyd, Behzad Hajarizadeh *, on behalf of the AusHep study group[1]

The Kirby Institute, University of New South Wales, Sydney, New South Wales, Australia

ARTICLE INFO

Keywords:
HBV
Vaccination
Testing
Treatment
People incarcerated
Jail
Epidemiology

ABSTRACT

Introduction: People in prison are at increased risk of bloodborne virus (BBV) infections, including hepatitis B virus (HBV). This study evaluated HBV prevalence, and history of testing, treatment and vaccination among people in Australian prisons.

Methodology: The AusHep study was a bio-behavioral survey (2022–23) among randomly selected individuals from 23 representative Australian prisons. Participants were tested for BBVs, including HBV surface antigen (HBsAg). Demographics, risk behaviors, and previous HBV testing, treatment and vaccination data were collected through interview-based surveys.

Results: Overall, 1599 participants were enrolled (89 % male; median age 35 years, 49 % First Nations people). National HBsAg prevalence (weighted estimate) was 0.52 % (95 %CI: 0.25–1.10), overall, including 1.03 % (95 %CI: 0.51–2.08) among First Nations people, 2.26 % (95 %CI: 0.44–10.75) among non-First Nations people born in moderate/high prevalence countries, and 0.02 % (95 %CI: 0.00–10.75) among non-First Nations people born in low prevalence countries (including Australia). The odds of HBV infection (i.e., HBsAg-positive) was greater among First Nations people [adjusted OR (aOR): 4.68, 95 %CI: 1.35–16.24], and lower among people with a history of injecting drug use (aOR: 0.15, 95 %CI: 0.04–0.54). Among all participants, 48.5 % (95 %CI: 45.3-51.7) reported a history of HBV testing (42.0 % in prison), with testing most likely among people with a history of injecting drugs (aOR: 3.82, 95 %CI: 2.80–5.23). Among 15 HBsAg-positive participants, four reported receiving HBV treatment. Among 1584 HBsAg-negative participants, 41.9 % (95 %CI: 38.8–45.1) reported receiving HBV vaccination (24.2 % received ≥3 doses, 28.9 % received their latest dose in prison).

Conclusion: HBsAg prevalence was low overall, but disproportionately higher among First Nations people and people born overseas. Lower likelihood of HBV in people injecting drugs might be explained by higher chance of spontaneous clearance in adulthood or high-coverage HBV vaccination programs for children and adolescents, and subsequent immunity in many people by the time they start injecting drugs. Prison-based HBV testing uptake and vaccination coverage were sub-optimal. Targeted, jurisdiction- and population-specific strategies are needed to improve prison-based HBV care.

Introduction

Hepatitis B virus (HBV) infection presents a significant public health concern globally. In 2022, an estimated 258 million people were living with chronic HBV infection worldwide (Polaris Observatory Collaborators, 2023), while 1.1 million global deaths were due to HBV (World Health Organization, 2024). Compared to those in the community, people in prison in most countries are at a greater risk of blood-borne virus (BBV) infections, including HBV. The increased risk of HBV infection among people in prison has been attributed to several factors, such as unsafe injecting drug use or tattooing during incarceration due to a lack of access to unsterile equipment, suboptimal HBV vaccination coverage and an over-representation of migrants from countries with high HBV prevalence (Bivegete et al., 2023). A systematic review in

* Corresponding author at: The Kirby Institute, Wallace Wurth Building, UNSW, NSW 2052, Australia.
E-mail address: bhajarizadeh@kirby.unsw.edu.au (B. Hajarizadeh).
[1] Members of the AusHep study group are listed in Acknowledgments.

https://doi.org/10.1016/j.drugpo.2025.105035

Available online 28 October 2025

2016 estimated that >491 thousand people were living with HBV in prisons globally (Dolan et al., 2016). Given the high burden of HBV and the opportunities for engagement in HBV care in prison, the World Health Organization (WHO) has identified people in prison as a "key population for HBV prevention, diagnosis, treatment and care" (World Health Organization, 2022).

In Australia, over 205 thousand individuals were estimated to be living with chronic HBV in 2022, representing a prevalence of 0.78 %, with a higher prevalence among people born in HBV-endemic countries, and Aboriginal and/or Torres Strait Islander people (hereafter referred to as First Nations people) (MacLachlan et al., 2024). In 2022, an estimated 32 % of the people in Australian prisons were First Nations people while 18 % were born overseas (Australian Bureau of Statistics, 2022b). Given an over-representation of First Nations and overseas-born people in Australian prisons, a higher HBV prevalence among people in prison compared to general population in Australia was hypothesised. Data on HBV prevalence and clinical care in Australian prisons has been limited, with the most recent national estimates generated by the National Prison Entrants' Bloodborne Virus Survey in 2016 (Butler & Simpson, 2017). In this study, 3 % of participants tested positive for HBV surface antigen (HBsAg), while 47 % self-reported a history of HBV vaccination (Butler & Simpson, 2017). However, this study had several limitations, including only recruiting individuals entering prison (no representation of those already incarcerated), limited participation (50 %), an insufficient sample size to generate reliable jurisdiction-level estimates, and no questions in the survey regarding history of HBV testing or treatment. Another Australian cohort study which ran from 2005 to 2014 amongst people in prison who reported injecting drug use revealed that upon imprisonment 63 % of individuals were HBV susceptible amongst whom only a minority were immunized while seven incident HBV infections were identified during follow-up (Li et al., 2020). This study highlighted the need for better engagement in HBV clinical care in the prisons.

The present study, therefore, aimed to provide a more recent and representative evaluation of HBV prevalence, as well as the history of HBV testing, treatment and vaccination among people in prison in Australia.

Methods

The detailed methodology of the Australian Hepatitis and Risk Survey in Prisons (the AusHep study) has been previously described (Bah et al., 2024; Bah et al., 2025). A summary of the methods, with a focus on the parts related to the objectives of this current study, is outlined below and reported following the STROBE guideline for cross-sectional studies ("Strengthening the reporting of observational studies in epidemiology (STROBE Checklist): cross-sectional studies,").

Study design and setting

The AusHep study was a cross-sectional bio-behavioural survey which evaluated the epidemiology and clinical care of BBV infections in prisons, including HBV, HIV and hepatitis C virus (HCV). The study was designed as a repeated survey, with the first round conducted from April 2022 to June 2023 in 23 representative prisons across six jurisdictions (i.e., New South Wales, Queensland, Western Australia, South Australia, Northern Territory and Tasmania). These jurisdictions collectively housed 83 % of people in Australian prisons during this period (Australian Bureau of Statistics, 2022b). In most jurisdictions, a minimum of one-quarter of the prisons were selected using a strategy that considered the available infrastructure in each prison for feasibility and ensured representation of all types of prisons (e.g., different security classifications) and demographic groups of people in prison (e.g., female prisons, and prisons with large First Nations populations). The study received ethics approval from the UNSW Human Research Ethics Committees (HC190778) and corresponding jurisdictional ethics bodies (Bah et al., 2024; Bah et al., 2025).

Participants

All people in prison were eligible to participate, although participation was voluntary. In each prison, the study population was randomly selected using computer-generated random numbers from a list of prison identifier numbers of all individuals currently in the facility, who were then invited to participate. Individuals who declined were replaced by other randomly selected individuals.

Study procedures and measurements

All participants provided written informed consent. Participants provided saliva and fingerstick whole blood samples for point-of-care testing for HBsAg, HIV antibody, HCV Ab and HCV RNA. For HBsAg testing, fingerstick whole blood samples were tested using Alere Determine™ II HBsAg test (Alere International, Ireland), with results available after 20 min. Trained study nurses conducted an interview-administered survey with each participant. The survey included questions regarding demographics, security classification, duration of current incarceration, previous imprisonment, potential risk behaviours for BBV (e.g. injecting drugs), and history of engagement in BBV clinical care. HBV clinical care included history of previous HBV testing, treatment and vaccination, either in prison or in the community. After the interview, test results were discussed with participants, and those who required further assessments or clinical care were referred to prison health services.

Variables and analysis outcomes

For each participant, HBsAg serostatus was identified based on study-conducted blood test results and used to estimate HBV prevalence as the primary analysis outcome. To evaluate engagement in various stages of the HBV clinical care pathway, self-reported data on history of prison- or community-based HBV testing, diagnosis, treatment and vaccination was used. The analysis outcomes included: proportion of participants who self-reported HBV testing (any test; among total participants); proportion of participants who self-reported ever being diagnosed with chronic HBV (among those HBsAg positive based on study-conducted testing); proportion of participants who self-reported receiving HBV treatment (among those HBsAg positive based on study-conducted testing); and proportion of participants who self-reported receiving HBV vaccination (among those HBsAg negative based on study-conducted testing).

Statistical methods

HBsAg prevalence and corresponding 95 % confidence intervals (95 %CI) were calculated nationally, by jurisdiction and among First Nations people. The proportion of participants engaged in each stage of HBV clinical care pathway and corresponding 95 %CI were also calculated. For national estimates, the study population from each jurisdiction was weighted by the size of the prisoner population of that jurisdiction and the distribution of gender and First Nations identity among people in prison in 2022. For jurisdiction estimates, the study population from each jurisdiction was weighted by the distribution of gender and First Nations identity among people in prison in that jurisdiction in 2022 (Australian Bureau of Statistics, 2022b).

Logistic regression analyses were conducted to evaluate factors associated with HBsAg positivity and history of HBV testing among all participants. In the regression models, evaluating factors associated with HBV infection, the hypothesized covariates included age, gender, education, region of birth, First Nations identity, sexual identity and injecting drug use. These models were first developed for all participants and then repeated among First Nations people. In the models evaluating factors associated with HBV testing, we also hypothesized the contribution of prison-related variables and therefore included security

classification, duration of current incarceration, and previous imprisonment as additional covariates. In unadjusted models, covariates with a p-value <0.20 were included in adjusted analyses, with adjusted odds ratio (aOR) as the measure of association.

In the analysis among First Nations people, only unadjusted models were reported given small number of HBsAg-positive individuals (as the analysis outcome). Fisher's exact test was used for categorical variables with no HBsAg-positive individual in one of the categories (i.e., zero event cell) instead of logistic regression. In the logistic regression analysis evaluating factors associated with HBV infection, age was used as both continuous and binary variable (i.e., older than 24 vs. younger than 24). This age cut-off in the binary variable was selected given introduction of universal HBV vaccination for infants in the Australian Immunisation Program in 2000, assuming most individuals aged 24 or younger were vaccinated (Australian Immunisation Handbook, 2023). Duration of incarceration was used as a binary variable (i.e., greater vs. less than two months) in the models to reflect the approximate time taken for people in prison to receive elective clinical care (e.g., BBV testing) by prison-based health services after entering. For region of birth, countries with a HBV prevalence close to Australia (≤1 %) were grouped ('low-prevalence countries') and compared with countries with higher HBV prevalence (>1 %; 'moderate/high-prevalence countries') (Polaris Observatory Collaborators, 2023). Robust variance estimates were used in all models, with prison sites specified as the groups (clusters) to adjust for potential correlation of participants within each prison. Statistical significance was assessed at $p < 0.05$ (two-sided p-values). All analyses were conducted utilising Stata 17.0 (StataCorp, College Station, TX, US).

Results

Description of participants

A total of 1599 people were recruited from six jurisdictions, including New South Wales ($n = 327$), Queensland ($n = 248$), Western Australia ($n = 299$), South Australia ($n = 300$), Northern Territory ($n = 254$) and Tasmania ($n = 171$). A large majority of those invited (98 %) agreed to participate. Baseline characteristics of the participants are summarised in Table 1. Most participants (89 %) were male and born in Australia (90 %). The median age was 35 years, and 49 % identified as First Nations. The median incarceration duration was eight months, with 84 % of participants incarcerated for longer than two months at the time of the survey. The age and sex distribution among study participants were comparable to the population in Australian prison in 2022 (93 % male, median age: 36) (Australian Bureau of Statistics, 2022b).

HBV prevalence

In Australian prisons, the national prevalence estimate for HBsAg was 0.52 % (95 %CI: 0.25–1.10), overall. The prevalence was 1.03 % (95 %CI: 0.51–2.08) among First Nations people, 2.26 % (95 %CI: 0.44–10.75) among non-First Nations people born in moderate/high prevalence countries, and 0.02 % (95 %CI: 0.00–10.75) among non-First Nations people born in low prevalence countries (including Australia). The jurisdictional prevalence was highest in Northern Territory (3.34 %, 95 %CI: 1.74–6.34), and lowest in Tasmania (0 %, 95 %CI: 0.00–0.02) and Queensland (0 %, 95 %CI: 0.00–1.48). In other jurisdictions, HBsAg prevalence was 0.60 % (95 %CI: 0.14–2.55) in New South Wales, 0.59 % (95 %CI: 0.12–2.78) in South Australia and 0.53 % (95 %CI: 0.13–2.10) in Western Australia. Among 15 HBsAg-positive participants, two individuals had HIV co-infection while none had HCV co-infection. It is important to note that the reported weighted HBsAg prevalence estimates reflected the prisoner population size and the distribution of gender and First Nations identity among people in prison in each jurisdiction, which resulted in apparent discrepancies between the crude number of HBsAg-positive individuals and the prevalence estimates reported.

Table 1
Baseline characteristics of participants.

	Number (%) Total $n = 1599$
Age, median (Q1, Q3)	35 (28, 44)
Age	
≤24 years	215 (13)
>24years	1384 (87)
Sex	
Male	1418 (89)
Female	181 (11)
Education	
Less than tertiary	1326 (83)
Tertiary	273 (17)
Region of birth	
Australia	1444 (90)
New Zealand	16 (1)
Europe/North America	45 (3)
East/South-East Asia	36 (2)
South Asia/Middle East	23 (1)
Africa	24 (2)
Pacific	7 (<1 %)
Other countries	4 (<1 %)
First Nations	
Yes	776 (49)
No	823 (51)
Security classification	
Sentenced	1245 (78)
Remand	354 (22)
Duration of current incarceration, median (Q1, Q3), months	8 (3, 24)
Duration of current incarceration	
≤2 months	258 (16)
>2 months	1341 (84)
Previously imprisoned	
Yes	1215 (76)
No	384 (24)
Sexual identity	
Heterosexual	1510 (94)
Homosexual/Bisexual	89 (6)
Injecting drug use history*	
Never injected	812 (51)
History of injecting drugs, not past month	197 (12)
Injecting drug use in the past month	589 (37)

Q1, Q3: Quartiles 1 and 3.
*Data was not available for $n = 1$.

Factors associated with HBV infection (HBsAg-positive)

Table 2 summarizes factors associated with HBV infection. The likelihood of HBV infection was higher among First Nations people (aOR: 4.68, 95 %CI: 1.35–16.24), and lower among people who reported a history of injecting drug use (aOR: 0.15, 95 %CI: 0.04–0.54).

Among First Nations people, decreased likelihood of HBV infection was associated with a history of injecting drug use (OR 0.18, 95 %CI: 0.05–0.67); Table 3.

History of HBV testing and treatment

Overall, 48.5 % (95 %CI: 45.3–51.7) of participants reported a past history of any HBV testing (either prison- or community-based, prior to this current study), 46.0 % (95 %CI: 42.8, 49.2) reported never being tested, and 5.5 % (95 %CI: 4.2, 7.1) did not know about their HBV testing history. Of all participants, 42.0 % (95 %CI: 38.9–45.2) reported a history of HBV testing in prison.

Participants who reported a history of HBV testing ($n = 756$) were asked about the type of HBV tests they had ever received, among whom 92 % mentioned HBsAg (indicating active infection), 93 % mentioned HBV surface antibody (indicating immunity against HBV) while 7 % were unsure of the testing type received.

The results of the analysis evaluating factors associated with HBV

Table 2
Factors associated with HBV infection (HBsAg-positive) among all participants.

		Unadjusted		Adjusted	
	HBsAg+ *n* / Total *n* (%)	OR (95 %CI)	*p*	OR (95 %CI)	*p*
Age, year		1.00 (0.96, 1.03)	0.820		
Age					
≤24 years	1/215 (0.47)	1.00			
>24 years	14/1384 (1.01)	2.19 (0.63, 7.62)	0.219		
Sex					
Male	14/1418 (0.99)	1.00			
Female	1/181 (0.55)	0.56 (0.09, 3.43)	0.528		
Education					
Less than tertiary	12/1326 (0.90)	1.00			
Tertiary	3/273 (1.10)	1.22 (0.41, 3.63)	0.725		
Region of birth					
Low HBV prevalence countries (incl Australia)	13/1505 (0.86)	1.00			
Moderate/high HBV prevalence countries	2/94 (2.13)	2.49 (0.45, 13.71)	0.293		
First Nations					
No	3/823 (0.36)	1.00		1.00	
Yes	12/776 (1.55)	4.29 (1.03, 17.82)	0.045	4.68 (1.35, 16.24)	0.015
Sexual identity					
Heterosexual	14/1510 (0.93)	1.00			
Homosexual/ Bisexual	1/89 (1.12)	1.21 (0.15, 9.78)	0.855		
Injecting drug use history*					
Never injected drugs	13/812 (1.60)	1.00		1.00	
Past or current history of injecting drugs	2/787 (0.25)	0.16 (0.04, 0.68)	0.014	0.15 (0.04, 0.54)	0.004

OR: Odds Ratio; 95 %CI: 95 % Confidence Interval; *Data was not available for $n = 1$.

testing (any test) are summarized in Table 4. The highest likelihood of prior HBV testing was observed among participants with a past or current history of injecting drugs (aOR: 3.82, 95 %CI: 2.80, 5.23). Other factors associated with HBV testing included tertiary education (vs. less than tertiary; aOR: 1.75, 95 %CI: 1.30, 2.35), incarceration duration to date longer than two months (aOR: 1.51, 95 %CI: 1.16, 1.97) and history of previous imprisonment (aOR: 1.52, 95 %CI: 1.09, 2.12).

Among 15 HBsAg-positive participants, eight individuals reported having been previously diagnosed (i.e., informed about their chronic HBV infection by a health professional), three individuals reported having a history of HBV viral load testing (HBV DNA test), and four individuals reported receiving HBV antiviral treatment. Regarding prison-based HBV clinical care, of 15 HBsAg-positive participants, six individuals reported receiving HBV clinical services during their current incarceration, including liver fibrosis assessment ($n = 3$), antiviral treatment ($n = 2$), and liver cancer screening ($n = 1$).

Table 3
Factors associated with HBV infection (HBsAg-positive) among First Nations people.

		Unadjusted	
	HBsAg+ *n*/ Total *n* (%)	OR (95 %CI)	*p*
Age			
≤24 years	1/150 (0.67)	1.00	
>24 years	11/626 (1.76)	2.66 (0.84, 8.42)	0.095
Sex			
Male	12/697 (1.72)		
Female	0/79 (0.00)		0.623*
Education			
Less than tertiary	11/715 (1.54)	1.00	
Tertiary	1/61 (1.64)	1.06 (0.30, 3.82)	0.921
Sexual identity			
Heterosexual	12/748 (1.60)		
Homosexual/Bisexual	0/28 (0.00)		1.000*
Injecting drug use history ±			
Never injected drugs	10/373 (2.68)	1.00	
Past or current history of injecting drugs	2/403 (0.50)	0.18 (0.05, 0.69)	0.012

OR: Odds Ratio; 95 %CI: 95 % Confidence Interval; *Fisher's exact test was used in the analysis; ± Data was not available for $n = 1$.

Vaccination

Among HBsAg-negative participants ($n = 1584$), 41.9 % (95 %CI: 38.8, 45.1) reported a history of HBV vaccination. The proportion of participants who reported receiving three or more doses, only two doses and only one dose of vaccine was 24.2 % (95 %CI: 21.5, 27.1), 8.7 % (95 %CI: 7.1, 10.7) and 5.2 % (95 %CI: 3.90, 6.94), respectively. However, 3.8 % of participants reported not knowing how many doses they had received.

Among HBsAg-negative participants, the proportion receiving their last dose of vaccine in prison was 28.9 % (95 %CI: 26.07, 31.90). Among HBsAg-negative participants who had ever injected drugs ($n = 785$), 52.5 % (95 %CI: 48.1, 56.9) reported a history of HBV vaccination, while 39.9 % (95 %CI: 35.7, 44.3) reported receiving their last dose of vaccination in prison.

Discussion

This study provided nationally representative estimates of HBV prevalence and the history of HBV testing, treatment, and vaccination among people in Australian prisons. The overall estimate of HBV prevalence was relatively low, but higher among First Nations people and those born in countries with moderate/high HBV prevalence. We also identified suboptimal uptake of HBV testing and vaccination coverage among people in prison. These findings can inform policies and strategies to improve access to HBV clinical care services for people in prison, a priority population for the HBV elimination goals specified by WHO and the Australian Fourth National HBV Strategy (Australian Government Department of Health & Aged Care, 2024; World Health Organization, 2022).

This study found a HBsAg-positive prevalence of 0.5 % among people in prison, with higher prevalence among First Nations people (1.0 %) and those born in moderate/high prevalence countries (2.3 %). Across jurisdictions, the highest prevalence was identified in Northern Territory prisons (3.3 %), most likely due to the larger proportion of First Nations people. In 2022, 87 % of people in Northern Territory prisons identified as First Nations, compared to the national average of 32 % (Australian Bureau of Statistics, 2022b).

In 2016, a global review identified wide variation in HBV prevalence among incarcerated populations across countries, with highest prevalence in West and Central Africa (23.5 %), and lowest in North America

Table 4
Factors associated with HBV testing (any test) among all participants.

		Unadjusted		Adjusted	
	Tested for HBV *n* / Total *n* (%)	OR (95 %CI)	*p*	OR (95 %CI)	*p*
Age, year		1.00 (0.99, 1.02)	0.579		
Sex					
Male	674/1418 (47.53)	1.00			
Female	82/181 (45.30)	0.91 (0.55, 1.52)	0.728		
Education					
Less than tertiary	611/1326 (46.08)	1.00		1.00	
Tertiary	145/273 (53.11)	1.33 (0.89, 1.97)	0.164	1.75 (1.30, 2.35)	<0.001
Region of birth					
Low HBV prevalence countries (incl Australia)	724/1505 (48.11)	1.00		1.00	
Moderate/high HBV prevalence countries	32/94 (34.04)	0.56 (0.28, 1.12)	0.099	0.9 (0.46, 1.64)	0.658
First Nations					
No	408/823 (49.57)	1.00			
Yes	348/776 (44.85)	0.83 (0.49, 1.41)	0.484		
Security classification					
Remand	151/354 (42.66)	1.00		1.00	
Sentenced	605/1245 (48.59)	1.27 (0.94, 1.71)	0.117	1.2 (0.92, 1.61)	0.168
Duration of current incarceration					
≤2 Months	103/259 (39.92)	1.00		1.00	
>2 Months	653/1341 (48.70)	1.43 (1.12, 1.83)	0.004	1.51 (1.16, 1.97)	0.002
Previously imprisoned					
No	132/384 (34.38)	1.00		1.00	
Yes	624/1215 (51.36)	2.02 (1.45, 2.79)	<0.001	1.52 (1.09, 2.12)	0.013
Sexual identity*					
Heterosexual	708/1510 (46.89)	1.00			
Homosexual/ Bisexual	48/89 (53.93)	1.33 (0.81, 2.18)	0.266		
Injecting drug use history*					
Never injected drugs	251/812 (30.91)	1.00		1.00	
Past or current history of injecting drugs	505/787 (64.17)	4.00 (2.94, 5.45)	<0.001	3.82 (2.80, 5.23)	<0.001

OR: Odds Ratio; 95 %CI: 95 % Confidence Interval.
* Data was not available for $n = 1$.

(1.4 %) and West Europe (2.4 %) (Dolan et al., 2016). Although these estimates require updating, more recent country- or region-specific studies have also shown this variation, with HBV prevalence ranging from <1 % in Spain, Belgium and United Kingdom to >13 % in Taiwan and Nigeria (Abdo Sanmartino et al., 2023; Bivegete et al., 2023; Buschots et al., 2021; Dan-Nwafor et al., 2021; Lu et al., 2021). In many countries, HBV prevalence among people in prison is higher than in the general population. A systematic review of HBV epidemiology in European countries found a median HBV prevalence of 2.1 % among people in prison, compared to 0.5 % in the general population (Bivegete et al., 2023). In our study, although the national HBV prevalence estimate among people in prison was comparable to the national prevalence in the community (0.78 %) (MacLachlan et al., 2024), the estimated prevalence in Northern Territory prisons was higher than the Northern Territory general population (3.34 % vs 1.72 %)(MacLachlan et al., 2024). This difference is primarily attributable to the higher proportion of First Nations people in Northern Territory prisons compared to the community (87 % vs 26 %) (Australian Bureau of Statistics 2022a, 2022b).

The estimated national HBV prevalence in our study (0.5 %) was lower than the 3 % reported in the 2016 National Prison Entrants' Bloodborne Virus Survey (NPEBBVS) (Butler & Simpson, 2017). The primary factor explaining this discrepancy is the difference in methodologies used to generate the estimates. Our study employed weighted estimates that accounted for jurisdictional prison population size and the distribution of gender and First Nations identity among people in prison. In the 2016 survey, raw estimates were reported, with 52 of 260 participants tested (20 %) were from Northern Territory prisons (Butler & Simpson, 2017), a significantly higher proportion than 5 % in the national people in prison population (Australian Bureau of Statistics, 2022b). The over-representation of people in Northern Territory prisons in the NPEBBVS study population, coupled with the lack of adjustment for jurisdictional population size in the analysis, skewed the national prevalence estimate towards the higher prevalence observed in Northern Territory prisons. Lower prevalence estimate in our study could be also attributable to actual decreased HBV prevalence compared to 2016, given inclusion of HBV vaccination in the National Immunisation Program in 2000 (National Centre for Immunisation Research and Surveillance, 2018) and the adult HBV catch-up vaccination programs for priority populations, including First Nations people (Graham et al., 2019).

In addition to the higher prevalence of HBV infection among First Nations people, our data also showed high prevalence among participants born in moderate/high-prevalence countries. These findings are consistent with the national community-based HBV epidemiology in Australia, where the prevalence is disproportionately higher among people born overseas and First Nations people (MacLachlan et al., 2024).

Our study identified a decreased likelihood of HBV infection among people with a history of injecting drugs. Although this finding is inconsistent with some other international studies that identified injecting drug use as a risk factor for HBV infection in prisons (Macalino et al., 2004; Moradi et al., 2018; Wirtz et al., 2018), several more recent prison-based studies have not found any association between injecting drug use and HBV infection in prisons (Abdo Sanmartino et al., 2023; Dan-Nwafor et al., 2021; Lu et al., 2021; Marques et al., 2023; Metanat et al., 2024; Tadesse et al., 2024). Two hypotheses may explain these findings. First, an estimated 95–98 % of adults spontaneously clear HBV after exposure (Jeng et al., 2023). Given that HBV exposure through injecting drugs is more likely to occur in adulthood, a higher chance of spontaneous clearance is anticipated. Second, with the implementation of HBV vaccination programs for children and adolescents in many countries, more people in recent years are likely to have vaccine-conferred immunity by the time they start injecting drugs. The HCV epidemic in Australian prisons differs from that of HBV. Based on data from the AusHep study, the estimated prevalence of HCV infection (HCV RNA positive) observed among those with recent injecting drug use was 23.8 % (Bah et al., 2024). In contrast, HIV prevalence in Australian prisons has historically been low, with the AusHep study reporting an estimated prevalence of 0.8 % (Bah et al., 2024). This is likely attributable to the distribution of the HIV epidemic in Australia,

which is primarily among men who have sex with men rather than people who inject drugs, explaining the low HIV prevalence among people in prison.

In our study, 49 % of participants reported a history of HBV testing, with 42 % tested in prison, reinforcing the importance of prisons in delivering HBV screening services. This study provides the first national estimate of HBV testing uptake among people in Australian prisons. The data indicated suboptimal uptake despite Australian, global, and WHO guidelines recommending universal opt-out testing on reception (Lubel et al., 2022; Sheehan et al., 2024; World Health Organization, 2022). In Australia, although HBV screening services are available in all prisons, screening strategies vary across jurisdictions or prisons. Some jurisdictions (or prisons) implement universal opt-out HBV testing in prisons (i.e., people are offered testing at reception with the option to decline), while HBV testing is opt-in or risk factor-guided in some jurisdictions. Among 25 European countries, only eight countries implemented opt-out testing in 2016–17 (Duffell et al., 2021). Although opt-out screening on prison reception aims to increase testing uptake, several barriers can affect implementation and effectiveness of this strategy. At a provider level, the main barrier is delayed testing due to limited capacity of prison health services or prioritization of security and prison processes (Francis-Graham et al., 2019). Other barriers to HBV testing uptake by people in prison also exist, such as stigma, concerns about confidentiality, and fear of needles (Francis-Graham et al., 2019). A prison in the Caribbean employed a universal opt-out BBV screening strategy (including HBV testing) for all prison entrants, where people were tested in a median of 20 days after reception, and those tested were notified of their test results at a median of 33 days (Abel et al., 2018). This lengthy process resulted in several people missing out on testing given typically short stays in prison (e.g., due to transferring to court or other prisons, or release to the community), and was a main factor contributing to suboptimal outcomes, with 59 % of prison entrants tested and 50 % were informed of their BBV status (Abel et al., 2018). Utilizing point-of-care fingerstick HBsAg testing (<20 mins to results) could streamline the testing process and also address other barriers such as fear of needles associated with phlebotomy sampling, thereby enhancing testing uptake among people in prison.

In our study, 42 % of HBsAg-negative participants reported a history of HBV vaccination (receiving vaccination either in prison or in the community), with 24 % receiving ≥3 doses. Since the introduction of universal infant HBV vaccination program in Australia in 2000, uptake has been high, with 95 % of children fully vaccinated by 24 months in 2024-25 (Australian Government Department of Health and Aged Care, 2025). Self-reported vaccination data, reported in our study, may underestimate actual vaccination coverage, as participants may not recall vaccinations received at birth or during childhood.

Moreover, 29 % of overall HBsAg-negative participants and 40 % of HBsAg-negative participants who reported injecting drugs had received HBV vaccination in prison, which may have occurred during the current or a previous incarceration. In most Australian prisons, universal HBV vaccination is offered to susceptible individuals. A cohort study of people who inject drugs in New South Wales prisons found that 62 % of participants who were HBV susceptible at the begining of the study received at least one dose of HBV vaccine during their time in prison, with 42 % receiving three (Li et al., 2020). Although global and WHO guidelines have recommended HBV vaccination for all susceptible people in prison (Sheehan et al., 2024; World Health Organization, 2022), many countries, including Australia, are not fully compliant to these recommendations yet, particularly given mandated HBV screening to determine susceptible status prior to vaccination. In 2023–24, among 20 European countries investigated, prison-based HBV vaccination was available in 17 countries, but only in 11 countries was it offered to all susceptible people in prison (Cocco et al., 2024). Although universal access to HBV vaccine is an important facilitator for increasing uptake, it may not be sufficient as a sole solution. Studies in the United Kingdom prisons, where a universal access strategy is in place, still report suboptimal uptake, ranging between 19 % to 59 % (Arif, 2018; Perrett et al., 2019). Additional interventions, such as an accelerated vaccination program, enhancing provider capacity and implementing HBV educational programs for people in prison, have been shown to increase vaccination uptake (Stasi et al., 2022, 2019; Winter et al., 2016).

This study had several limitations. Self-reported HBV testing, treatment and vaccination may have been influenced by low health literacy and possible recall bias. To mitigate this bias, trained study nurses administered questionnaires, allowing them to clarify questions for participants. This study did not include prisons from two Australian jurisdictions (Australian Capital Territory and Victoria, collectively housing 16 % of the Australian prisoner population). Although this may affect the representativeness of the findings, minimal impact is anticipated given the comparability of the study population to the national prison population. The small number of HBsAg-positive individuals limited some of our analyses. For example, the analysis of factors associated with HBV among non-First Nations people, would have had limited power and hence was not conducted. This small number has limited the generalisability of our estimates for the proportion of people in prison diagnosed with chronic HBV and those receiving treatment. Lastly, this study did not include testing for HBV core antibody and HBV surface antibody due to the absence of reliable point-of-care tests for these sero-markers, limiting our ability to assess previous HBV exposure and immunity.

In conclusion, this study identified a relatively low overall HBsAg prevalence among people in Australian prisons, yet a disproportionate burden remains among First Nations people and people born overseas. This study also revealed suboptimal uptake of HBV testing and vaccination coverage among people in prison. These findings suggest that the current strategies and programs for HBV clinical care in prisons need to be revised to address existing barriers to access and to incorporate evidence-based interventions that have proven effective in improving access and service delivery in the prison setting. While our findings can inform prison-based HBV prevention and care programs in Australia to achieve national elimination goals, the next rounds of the study will help evaluate temporal changes in HBV prevalence and access to clinical care.

CRediT authorship contribution statement

Chloe Montague: Writing – original draft, Formal analysis. **Rugiatu Bah:** Writing – review & editing, Project administration, Investigation, Data curation. **Yumi Sheehan:** Writing – review & editing, Resources, Project administration, Methodology, Investigation, Conceptualization. **Xiaoying Li:** Writing – review & editing, Resources, Project administration. **Gregory J Dore:** Writing – review & editing, Data curation. **Jason Grebely:** Writing – review & editing, Data curation. **Andrew R Lloyd:** Writing – review & editing, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization. **Behzad Hajarizadeh:** Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Behzad Hajarizadeh, Gregory J Dore, and Jason Grebely report financial support was provided by the National Health and Medical Research Council.

Behzad Hajarizadeh reports financial support was provided by the Australian Government Department of Health Disability and Ageing.

Rugi Bah reports financial support was provided by the Australian Government Research Training Program.

Andrew Lloyd reports a relationship with Gilead, AbbVie, Bristol-Myers Squibb and Sequiris that includes: funding grants.

Greg J Dore reports a relationship with AbbVie and Gilead Sciences

that includes: funding grants.

Jason Grebely reports a relationship with AbbVie, bioLytical, Cepheid, Gilead Sciences, Hologic, Roche that includes: consulting or advisory, funding grants, and speaking and lecture fees.

Yumi Sheehan reports a relationship with Gilead Sciences that includes: funding grants.

Given Jason Grebely's role as Editor-in-Chief, Yumi Sheehan and Andrew Lloyd's role as Special Issue Guest Editor, they had no involvement in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another journal editor.

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

Acknowledgements

The Kirby Institute was funded by the Australian Government Department of Health, Disability and Ageing. The AusHep study was funded by an NHMRC Partnership Grant (2042295) and the Australian Government Department of Health and Aging (E25-141660). The views expressed in this article are authors' views and do not necessarily represent the position of the Australian Government. BH (2026968), GJD (2008276) and JG (1176131, 2034002) are supported by NHMRC Investigator Grants. RB is supported by the Australian Government Research Training Program. For the purposes of open access, the author has applied a CC BY public copyright licence to any Author Accepted Manuscript version arising from this submission.

The authors thank all participants who took part in the AusHep study. The AusHep study group includes: Andrew Lloyd, Behzad Hajarizadeh, Yumi Sheehan, Rugi Bah, Charlotte Li, Marianne Byrne, Tony Butler, Bridget Musarurwa, Elmira Hooshmand, Annabeth Simpson, Meya Alrayyani, Jason Grebely, Greg Dore (The Kirby Institute); Nikki Price and Melissa Groom (Ascott). We gratefully acknowledge the support we received from all our jurisdictional collaborators: New South Wales - Colette McGrath, Tracey Brown (Justice Health NSW); Luke Grant (CSNSW); Tasmania- Deb Siddall, Barry Nicholson, David Onu (Correctional Primary Health Service), Ian Thomas (Tasmania Prison Service); South Australia: Andrew Wiley, Tom Turnbull, Dan Pronk, Adam Spicer (SAPHS), Tom Rees (South Australia Health), John Strachan (DCS); Queensland - Graham Kraak, Robert Kemp (Queensland Health), Jenny Bell (QCS); Western Australia - Joy Rowland, Holly Beasley, Peter Illich (Dept of Justice); Northern Territory- Priscilla Moore, Dy Kelaart (Northern Territory Health), Bill Carroll, David Gordon (NTCS); Victoria - Teri van Geelen, Helen Meyer-Tinning (Justice Health); Australian Capital Territory - Cameron Edgell, Alex Misev, Katerina Lagios (Justice Health ACT). We also thank all of the on-the-ground staff at the participating sites, including the general managers/governors, nursing staff, and correctional staff.

References

Abdo Sanmartino, I. J., Guerrero-Moreno, R. A., & Mouriño, A. M. (2023). Changes in the epidemiological pattern of chronic B hepatitis amongst inmates in Catalonia: Current prevalence and predictive variables. *Revista Espanola de Sanidad Penitenciaria, 25*, 89–97.

Abel, S., Cuzin, L., Da Cunha, S., Bolivard, J.-M., Fagour, L., Miossec, C., Pircher, M., Thioune, M., Césaire, R., & Cabié, A. (2018). Reaching the WHO target of testing persons in jails in prisons will need diverse efforts and resources. *PLoS One, 13*, Article e0202985.

Arif, T. (2018). Hepatitis service provision at HMP Birmingham: Progressing a previous service improvement plan. *BMJ Open Quality, 7*, Article e000192.

Australian Bureau of Statistics. (2022a). *Northern territory: Aboriginal and Torres Strait Islander population summary*, 13 October 2024 from https://www.abs.gov.au/articles/northern-territory-aboriginal-and-torres-strait-islander-population-summary#cite-window1.

Australian Bureau of Statistics. (2022b). *Prisoners in Australia*, 13 October 2024 from https://www.abs.gov.au/statistics/people/crime-and-justice/prisoners-australia/2022.

Australian Government Department of Health and Aged Care. (2024). *Fourth National Hepatitis B strategy 2023-2030*. Canbera: Australian Government Department of Health and Aged Care.

Australian Immunisation Handbook. Hepatitis B. (2023) from https://immunisationhandbook.health.gov.au/contents/vaccine-preventable-diseases/hepatitis-b.

Australian Government Department of Health and Aged Care. (2025). *Current coverage data tables for all children*. from. https://www.health.gov.au/topics/immunisation/immunisation-data/childhood-immunisation-coverage.

Bah, R., Sheehan, Y., Li, X., Dore, G. J., Grebely, J., Lloyd, A. R., & Hajarizadeh, B. (2024). Prevalence of blood-borne virus infections and uptake of hepatitis C testing and treatment in Australian prisons: The AusHep study. *The Lancet Regional Health - Western Pacific, 53*, Article 101240.

Bah, R., Sheehan, Y., Li, X., Price, N., Butler, T., Dore, G. J., Grebely, J., Lloyd, A. R., & Hajarizadeh, B. (2025). Challenges and facilitators in repeated bio-behavioural surveys for blood-borne virus infections in Australian prisons. *International Journal of Drug Policy, 144*, Article 104401.

Bivegete, S., McNaughton, A. L., Trickey, A., Thornton, Z., Scanlan, B., Lim, A. G., Nerlander, L., Fraser, H., Walker, J. G., Hickman, M., Vickerman, P., Johnson, H., Duffell, E., Brooks-Pollock, E., & Christensen, H. (2023). Estimates of hepatitis B virus prevalence among general population and key risk groups in EU/EEA/UK countries: A systematic review. *Eurosurveillance, 28*, Article 2200738.

Busschots, D., Kremer, C., Bielen, R., Koc, Ö. M., Heyens, L., Brixko, C., Laukens, P., Orlent, H., Bilaey, P., De Smet, F., Hellemans, G., Muyldermans, G., Van Baelen, L., Hens, N., Van Vlierberghe, H., & Robaeys, G. (2021). A multicentre interventional study to assess blood-borne viral infections in Belgian prisons. *BMC Infectious Diseases, 21*, 708.

Butler, T., & Simpson, M. (2017). *National prison entrants' blood-borne virus survey report 2004, 2007, 2010, 2013, and 2016*. Sydney, Australia: Kirby Institute, UNSW Sydney.

Cocco, N., Tramonti Fantozzi, M. P., Ihuthia, J. N., Moazen, B., Merouehi, F., Barbîroș, I., Mavrou, J., Bardelli, A., De Vita, E., Plugge, E., Tavoschi, L., Ranieri, R., Petri, D., Stoever, H., Murauer, E., Mieuset, A., Edge, C., & Yiasemi, I. (2024). Cancer-preventing vaccination programs in prison: Promoting health equity in Europe. *The Lancet Regional Health - Europe, 43*, Article 100958.

Dan-Nwafor, C. C., Adeoye, I., Aderemi, K., Onuoha, M., Adedire, E., Bashorun, A., Osunkwo, D., Gidado, S., Balogun, M., Idris, S., Ade-Yusuf, I., Udom, E., & Nguku, P. (2021). Serological markers and risk factors associated with Hepatitis B virus infection among Federal Capital Territory prison inmates, Nigeria: Should we be concerned? *PLoS One, 16*, Article e0248045.

Dolan, K., Wirtz, A. L., Moazen, B., Ndeffo-mbah, M., Galvani, A., Kinner, S. A., Courtney, R., McKee, M., Amon, J. J., Maher, L., Hellard, M., Beyrer, C., & Altice, F. L. (2016). Global burden of HIV, viral hepatitis, and tuberculosis in prisoners and detainees. *The Lancet, 388*, 1089–1102.

Duffell, E., Montanari, L., Mozalevskis, A., Nakitanda, A. O., & Tavoschi, L. (2021). Hepatitis B virus infection in EU/EEA and United Kingdom prisons: A descriptive analysis. *Epidemiology and Infection, 149*, e59.

Francis-Graham, S., Ekeke, N. A., Nelson, C. A., Lee, T. Y., Haj, S. E., Rhodes, T., Vindrola, C., Colbourn, T., & Rosenberg, W. (2019). Understanding how, why, for whom, and under what circumstances opt-out blood-borne virus testing programmes work to increase test engagement and uptake within prison: A rapid-realist review. *BMC Health Services Research, 19*, 152.

Graham, S., MacLachlan, J. H., Gunaratnam, P., & Cowie, B. C. (2019). Chronic hepatitis B prevalence in Australian aboriginal and Torres Strait Islander people before and after implementing a universal vaccination program: A systematic review and meta-analysis. *Sexual Health, 16*, 201–211.

Jeng, W.-J., Papatheodoridis, G. V., & Lok, A. S. F. (2023). Hepatitis B. *The Lancet, 401*, 1039–1052.

Li, H., Cameron, B., Douglas, D., Stapleton, S., Cheguelman, G., Butler, T., Luciani, F., & Lloyd, A. R. (2020). Incident hepatitis B virus infection and immunisation uptake in Australian prison inmates. *Vaccine, 38*, 3255–3260.

Lu, M.-Y., Chen, C.-T., Shih, Y.-L., Tsai, P.-C., Hsieh, M.-H., Huang, C.-F., Yeh, M.-L., Huang, C.-I., Wang, S.-C., Tsai, Y.-S., Ko, Y.-M., Lin, C.-C., Chen, K.-Y., Wei, Y.-J., Hsu, P.-Y., Hsu, C.-T., Jang, T.-Y., Liu, T.-W., Liang, P.-C., Hsieh, M.-Y., Lin, Z.-Y., Chen, S.-C., Huang, J.-F., Dai, C.-Y., Chuang, W.-L., Yu, M.-L., & Chang, W.-Y. (2021). Changing epidemiology and viral interplay of hepatitis B, C and D among injecting drug user-dominant prisoners in Taiwan. *Scientific Reports, 11*, 8554.

Lubel, J. S., Strasser, S. I., Thompson, A. J., Cowie, B. C., MacLachlan, J., Allard, N. L., Holmes, J., Kemp, W. W., Majumdar, A., Iser, D., Howell, J., & Matthews, G. V. (2022). Australian consensus recommendations for the management of hepatitis B. *Medical Journal of Australia, 216*, 478–486.

Macalino, G. E., Vlahov, D., Sanford-Colby, S., Patel, S., Sabin, K., Salas, C., & Rich, J. D. (2004). Prevalence and incidence of HIV, Hepatitis B Virus, and Hepatitis C virus infections among males in Rhode Island prisons. *American Journal of Public Health, 94*, 1218–1223.

MacLachlan, J. H., Romero, N., Purcell, I., & Cowie, B. C. (2024). *Viral hepatitis mapping project: Hepatitis B national report 2022*. Sydney, Australia: Australasian Society for HIV, Viral Hepatitis, and Sexual Health Medicine (ASHM).

Marques, J. M.d. S., Matos, M. A., Silva, Á. M. C., Freitas, N. R., Okita, M. T., Souza, S. d. O., Carneiro, M. A.d. S., Martins, R. M. B., & Matos, M. A. D. (2023). Prevalence of overt and occult hepatitis B virus infection among an incarcerated population of Central-western Brazil. *Acta Tropica, 241*, Article 106886.

Metanat, M., Almasi, S. Z., Sepehri Rad, N., Tabatabaee, S. M., & Rezaei, K. (2024). Seroepidemiological investigation of hepatitis B and C prevalence and associated factors among people in custody at Zahedan Central Prison. *Archives of Iranian Medicine, 27*, 298–304.

Moradi, G., Gouya, M.-M., Azimizan Zavareh, F., Mohamadi Bolbanabad, A., Darvishi, S., Aghasadeghi, M. R., Nabavi, M., Alasvand, R., Tashakorian, M., Nouri, B.,

Rahmani, K., & Molaei, L. (2018). Prevalence and risk factors for HBV and HCV in prisoners in Iran: A national bio-behavioural surveillance survey in 2015. *Tropical Medicine & International Health, 23*, 641–649.

National Centre for Immunisation Research and Surveillance. (2018) Significant events in hepatitis B vaccination practice in Australia. from https://ncirs.org.au/sites/default/files/2024-04/Hepatitis%20Bpdf.

Perrett, S. E., Cottrell, S., & Shankar, A. G. (2019). Hepatitis B vaccine coverage in short and long stay prisons in Wales, UK 2013–2017 and the impact of the global vaccine shortage. *Vaccine, 37*, 4872–4876.

Polaris Observatory Collaborators. (2023). Global prevalence, cascade of care, and prophylaxis coverage of hepatitis B in 2022: A modelling study. *The Lancet Gastroenterology & Hepatology, 8*, 879–907.

Sheehan, Y., Garg, A., Sheehan, J., Maduka, N., Altice, F. L., Costa, F. A.d., Cox, S., Elsharkawy, A. M., Salah, E., Stoové, M., Tavoschi, L., Thompson, A. J., Thornton, K., Lloyd, A. R., Cabezas, J., Akiyama, M. J., Kronfli, N., & on behalf of INHSU Prisons. (2024). *Global guidelines for viral hepatitis service delivery in prisons*. In.

Stasi, C., Monnini, M., Cellesi, V., Salvadori, M., Marri, D., Ameglio, M., Gabbuti, A., Celmi, R., Di Fiandra, T., Voller, F., & Silvestri, C. (2022). Ways to promote screening for hepatitis B virus and accelerated vaccination schedule in prison: Training, information, peer education. *Revue d'Épidémiologie et de Santé Publique, 70*, 25–30.

Stasi, C., Monnini, M., Cellesi, V., Salvadori, M., Marri, D., Ameglio, M., Gabbuti, A., Di Fiandra, T., Voller, F., & Silvestri, C. (2019). Screening for hepatitis B virus and accelerated vaccination schedule in prison: A pilot multicenter study. *Vaccine, 37*, 1412–1417.

Strengthening the reporting of observational studies in epidemiology (STROBE Checklist): Cross-sectional studies. Retrieved April 7 2024 from https://www.strobe-statement.org/checklists/.

Tadesse, K., Ayalew, G., Million, Y., & Gelaw, A. (2024). Hepatitis B and hepatitis C virus infections and associated factors among prisoners in Gondar City, Northwest Ethiopia. *PLoS One, 19*, Article e0301973.

Winter, R. J., White, B., Kinner, S. A., Stoové, M., Guy, R., & Hellard, M. E. (2016). A nurse-led intervention improved blood-borne virus testing and vaccination in Victorian prisons. *Australian and New Zealand Journal of Public Health, 40*, 592–594.

Wirtz, A. L., Yeh, P. T., Flath, N. L., Beyrer, C., & Dolan, K. (2018). HIV and viral hepatitis among imprisoned key populations. *Epidemiologic Reviews, 40*, 12–26.

World Health Organization. (2022). *Consolidated guidelines on HIV, viral hepatitis and STI prevention, diagnosis, treatment and care for key populations*. Geneva: World Health Organization.

World Health Organization. (2024). *Global hepatitis report 2024: Action for access in low- and middle-income countries*. Geneva: World Health Organization.