National Surveillance for Hepatitis B Indicators

Measuring the progress towards the targets of the National Hepatitis B Strategy
Annual Report 2020

WHO Collaborating Centre for Viral Hepatitis, Doherty Institute for Infection and Immunity
Prepared by: Karen McCulloch, Nicole Romero, Jennifer MacLachlan and Benjamin Cowie

Contact Information

WHO Collaborating Centre for Viral Hepatitis
Victorian Infectious Diseases Reference Laboratory, Doherty Institute for Infection and Immunity
Contact: Jennifer MacLachlan
Level 5, 792 Elizabeth Street, Melbourne VIC 3000
Email: Jennifer.MacLachlan@vidrl.org.au

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Abbreviations

ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
CHB	Chronic hepatitis B
DC	Decompensated cirrhosis
DSS	Department of Social Services
FoI	Force of infection
GHSS	Global Health Sector Strategy
HCC	Hepatocellular carcinoma
LHS	Latin-hypercube sampling
MBS	Medicare Benefits Schedule
National Strategy	Australia's 3rd National Hepatitis B Strategy 2018-2022
NNDSS	National Notifiable Diseases Surveillance
NOM	Net overseas migration
NSW	New South Wales
NT	Northern Territory
PBS	Pharmaceutical Benefits Scheme
PR	Plausible range
QLD	Queensland
SA	South Australia
TAS	Tasmania
VIC	Victoria
WA	Western Australia
WHO	World Health Organization
COVID-19	Coronavirus disease of 2019

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Executive Summary

Number of people living with chronic hepatitis B:

- In 2020 an estimated 222,559 people were living with chronic hepatitis B (CHB) in Australia, representing 0.87% of the population.
- For the first time since 1994, it was estimated that the number of people living with CHB in Australia declined, highlighting the demographic impacts of restrictions on migration in response to the COVID-19 pandemic.
- A decrease in prevalence can be seen from 1991 onwards in children aged under 5 years, highlighting the impact of hepatitis B vaccination.
- The estimates for the number of people living with CHB in Australia have been comprehensively revised using more granular and updated migration data, which has led to changes in estimates for treatment and care uptake and attributable mortality.

Chronic hepatitis B diagnosis:

An estimated 162,480 people living with CHB in Australia in 2020 had been diagnosed, representing 73.0% of the total.

- While the proportion diagnosed is increasing, it remains below the National Strategy target of 80%, with 8,666[i] more people living with CHB requiring diagnosis to reach this target by 2022.
- At the current rate of progress, Australia will not reach the National Strategy 2022 target of 80% until 2023.

Chronic hepatitis B engagement in care:

- During 2020, an estimated 50,229 people were engaged in care for their CHB, receiving either antiviral treatment or monitoring, representing 22.6% of all people living with CHB.
- The proportion engaged in care in 2020 remains below the National Strategy target of 50%, with 56,737[i] more people required to be in care to reach this by 2022.
- At the current rate of progress, Australia will not reach the National Strategy 2022 target of 50% until 2045.

Chronic hepatitis B treatment:

- In 2020, 23,787 people were dispensed drugs for the treatment of hepatitis B through the Pharmaceutical Benefits Scheme, which is an estimated 10.7% of all people living with CHB.
- The proportion on treatment in 2020 remains below the National Strategy target of 20% with 19,000[i] more people requiring treatment to reach this target by 2022.
- The estimated proportion of people living with CHB in Australia who are eligible for treatment in 2020 was 29.5%.
- At the current rate of progress, Australia will not reach the National Strategy 2022 target of 20% until 2034.

Deaths attributable to chronic hepatitis B:

- The modelled number of deaths attributable to CHB in 2020 was estimated to be 364. Three quarters of these estimated deaths (272) were attributable to hepatocellular carcinoma (HCC), while 92 estimated deaths were due to decompensated cirrhosis (DC).

[i] Based on the projected modelled estimate of 213,932 people living with CHB in 2022.

Jurisdictional disparities:

- Substantial differences in estimated prevalence, access to care and burden of disease in 2020 were noted between states and territories:
    - Prevalence of CHB ranged from 0.28% (TAS) to 1.84% (NT).
    - The proportion diagnosed ranged from 53.1% (TAS) to 79.2% (NSW).
    - The proportion in care ranged from 10.2% (WA) to 27.0% (NSW), with the proportion of all those living with CHB receiving antiviral treatment ranging 6.9% (WA) to 12.9% (NSW).
    - With respect to trends over time, the estimated reduction in deaths due to CHB between 2011 and 2020 ranged from 13% (WA) to 43% (ACT) across jurisdictions – however, accurate estimation is difficult particularly in jurisdictions with relatively low numbers of people living with CHB.

Summary of trends against National Strategy 2022 targets:

In 2022 an estimated 213,932 people will be living with CHB in Australia. Australia is currently projected to reach the National Strategy target for proportion diagnosed of 80% in 2023. Furthermore, Australia is now projected to reach the WHO's 2030 target of 90% of people living with hepatitis B diagnosed one year later than the goal, in 2031. If current trends in engagement in care and treatment uptake continue, an estimated 23.5% and 11.1% of people living with CHB will be engaged in care and receiving treatment in 2022 respectively. Both of these estimates fall well short of the National Strategy targets of 50% of people living with CHB engaged in care and 20% of people living with CHB receiving treatment by 2022. The National Strategy target of a 30% reduction in attributable deaths (when compared to the end of 2017) by 2022 is estimated to be achieved in 2030 under the WHO 2030 future treatment uptake scenario. However, this requires substantial increases in future treatment uptake.

It is important to note that substantial changes to the number of people migrating into and out of Australia has had a profound impact on future projections of the number of people living with CHB. Given the unpredictability of future migration patterns and the long-term impacts of COVID-19 on the health system and usual care, these modelled projection estimates will be updated as new information becomes available.

Introduction

In Australia approximately 1% of the population are living with chronic hepatitis B (CHB) [1-3], with people born overseas and Aboriginal and Torres Strait Islander peoples representing three quarters of those affected[4]. CHB is a significant public health burden and is now the most prevalent blood-borne viral infection in Australia[4, 5]. CHB is a leading cause of liver cancer, the 6th most common cause of cancer mortality in Australia[6]. Substantial improvements in access to appropriate care, monitoring and treatment are required to address hepatitis B related mortality nationally.

Australia's National Hepatitis B Strategies have been fundamental to guiding the response to hepatitis B since 2010, with significant progress being achieved over this period. The 3rd National Hepatitis B Strategy 2018-2022[7] (National Strategy), released in 2018 sets goals to make significant progress towards eliminating hepatitis B as a public health threat, including reducing the burden of disease and eliminating the negative impact of stigma, discrimination, and legal and human rights issues on people's health. The National Strategy highlights priority areas and populations, and outlines targets to measure progress throughout the span of the strategy.

These targets are by the end of 2022 to:

1. Achieve and maintain hepatitis B childhood vaccination coverage of 95 per cent at 12 and 24 months
2. Reduce the number of newly acquired hepatitis B infections across all age groups by 50 per cent, with a focus on priority populations
3. **Increase the proportion of people living with chronic hepatitis B who are diagnosed to 80 per cent**
4. **Increase the total proportion of people living with chronic hepatitis B receiving care to 50 per cent**
5. **For people living with chronic hepatitis B, increase the proportion receiving antiviral treatment to 20 per cent**
6. **Reduce hepatitis B attributable mortality by 30 per cent** (when compared to the end of 2017)
7. Minimise the reported experience of stigma among people living with hepatitis B, and the expression of stigma, in respect to hepatitis B status.

Only bolded targets are reported in this report. For more information about other projects reporting on Strategy targets, see 'Report Background' section.

Measuring the progress towards the targets of the National Strategy will allow current gaps to be identified, and priority areas to be highlighted to help shape the public health and policy response to hepatitis B in Australia.

Australia has also endorsed the World Health Organization (WHO) Global Health Sector Strategy on Viral Hepatitis 2016 – 2021[8], which calls for the elimination of hepatitis B as a public health threat by

2030. Global targets for 2030 include 90% of people living with hepatitis B diagnosed, 80% of eligible persons with CHB treated and a 65% reduction in hepatitis B related deaths compared to 2015.

Report Background

This report summarises work undertaken by the WHO Collaborating Centre for Viral Hepatitis at the Doherty Institute on the Surveillance for Hepatitis B Indicators Project funded by The Australian Government Department of Health. The objective of this project is to develop disease burden estimation and mathematical modelling approaches to inform the surveillance, monitoring and evaluation of progress towards achieving the objectives of the 3rd National Hepatitis B Strategy 2018-2022 and reporting against Hepatitis B Indicators in the National Blood-Borne Viruses and Sexually Transmissible Infections Surveillance and Monitoring Plan 2018 - 2022. This report will not assess vaccination, reduction in local transmission or stigma targets specifically. Further reporting against these indicators can be found in the National Viral Hepatitis Mapping Reports[4], the Kirby Institute's Annual Surveillance Reports[9], and the Centre for Social Research in Health Stigma Indicators Monitoring Project Reports[10].

This report for the year 2020 is the fourth publicly available National Surveillance for Hepatitis B Indicators Annual Report. All reports can be accessed at: https://www.doherty.edu.au/whoccvh/centre-activities/research/blood-borne-viruses-and-sexually-transmissible-infections-surveillance-and-research-programme

Report Updates

Indicator data estimates have been derived using a mathematical model for the natural history of hepatitis B in Australia extending on previous work[2, 3, 11, 12]. The model accounts for diversity in prevalence and impact of overseas migration, incorporating detailed disease phase dynamics, and examining the impact of domestic and overseas vaccination programs, together with the impact of antiviral treatment on mortality attributable to CHB at a population level. Further information regarding the model can be found in the associated paper[2].

To ensure estimates most accurately reflect the current epidemiology and clinical pattern of CHB in Australia, data inputs and assumptions are updated annually to incorporate new information. For that reason historical indicator estimates provided in this report differ in some respects from previous outputs reported in the Kirby Institute's Annual Surveillance Reports,[9] the Doherty Institute's National Viral Hepatitis Mapping Project Reports[4, 5, 13], and the National Surveillance for Hepatitis B Indicators: 2019 Annual Report[14-16].

Updates from previously reported 2019 estimates include:

- Data for total net overseas migration (NOM) by jurisdiction were updated from 1972 - 2003[17].
- More granular NOM data (including breakdown by jurisdiction, country of birth and 5-year age groups) were supplied by the Australian Bureau of Statistics (ABS) from 2004 onwards[18]. Previously publicly available ABS data was utilised for NOM by country of birth and combined with the estimated age distribution of migrants derived from Department of Social Services (DSS) Settlement Data[19].
- Projected estimates of future NOM included in the model were updated to consider the impact of COVID-19[20]. However, given the recent changes in arrivals and departures due to the COVID-19 pandemic[21] and likely ongoing shifts in migration patterns, future estimates will be profoundly affected by these changes.

Deriving specific modelled indicator estimates for Aboriginal and Torres Strait Islander populations remains a priority of ongoing work and will be included in future reporting.

Due to previous methodological updates, estimates may differ from previous outputs reported in the Kirby Institute's Annual Surveillance Reports[9], the Doherty Institute's National Viral Hepatitis Mapping Project Reports[4], National Surveillance for Hepatitis B Indicators National Report[16], and publications.

A. National

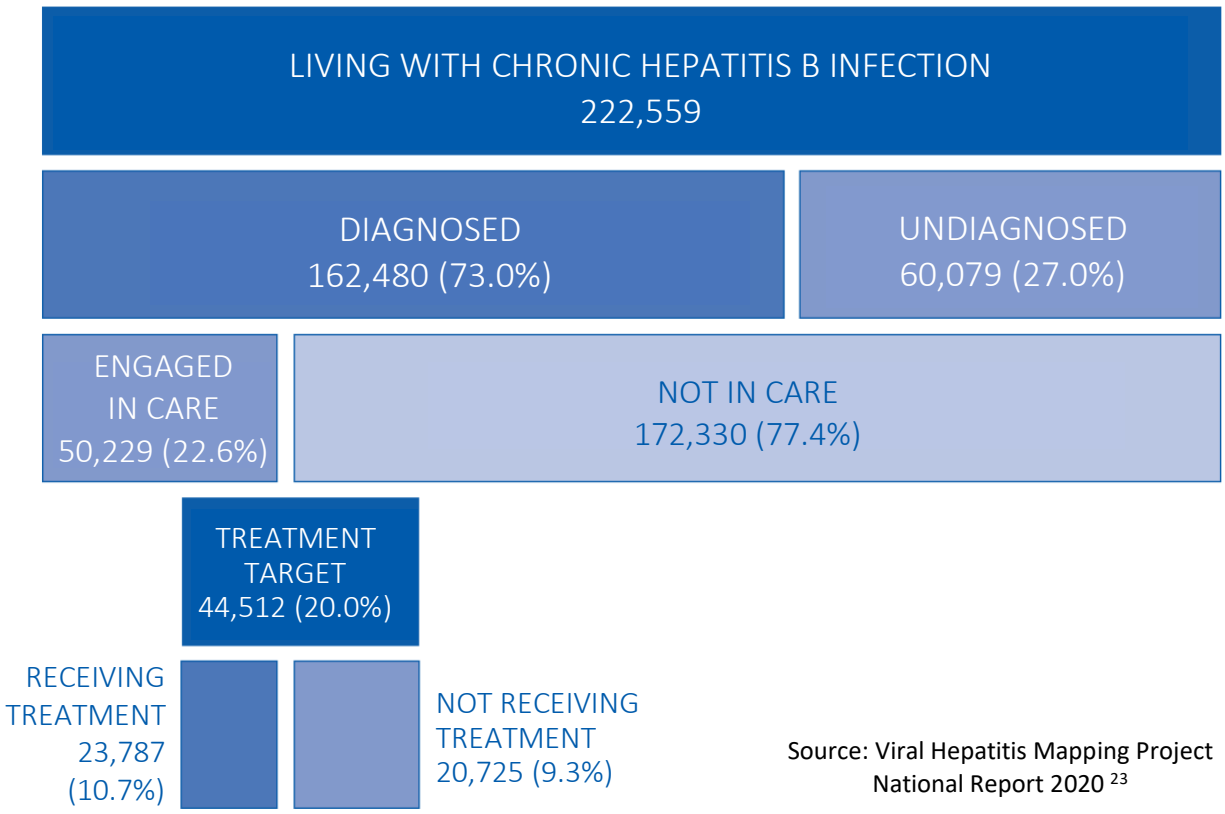
A.1 Summary National Estimates

Table 1. Australian summary for hepatitis B indicator estimates, 2020

Indicators	Point estimate	Plausible range	
		Minimum	Maximum
1. People living with CHB	222,559	205,376	240,364
2. Proportion of people living with CHB in Australia who have been diagnosed	73.0%	65.6%	80.9%
3. Proportion of people living with CHB in Australia who are receiving care	22.6%	20.9%	24.5%
4. Proportion of people living with CHB who are dispensed drugs for the treatment of hepatitis B	10.7%	9.9%	11.6%
5. Total number of attributable deaths due to CHB^	364	312	424
→ Number of deaths due to hepatocellular carcinoma attributable to CHB	272	235	316
→ Number of deaths due to decompensated cirrhosis attributable to CHB	92	77	108

^ The sum of deaths due to HCC and deaths due to DC

Figure 1. Chronic hepatitis B cascade of care, Australia, 2020



Source: Viral Hepatitis Mapping Project National Report 2020 [23]

A.1.1 Progress Towards National Cascade of Care Targets

Despite the continued increase in the number of people diagnosed with chronic hepatitis B, and in those receiving antiviral treatment, Australia did not reach the 2017 diagnosis and treatment uptake targets set in the 2nd National Hepatitis B Strategy 2014-2017[22]. Profound increases to existing levels of diagnosis, treatment and care will be required to achieve the 2022 targets contained in the current National Strategy.

Figure 2. Progress towards the 3rd National Hepatitis B Strategy 2018 – 2022 targets.

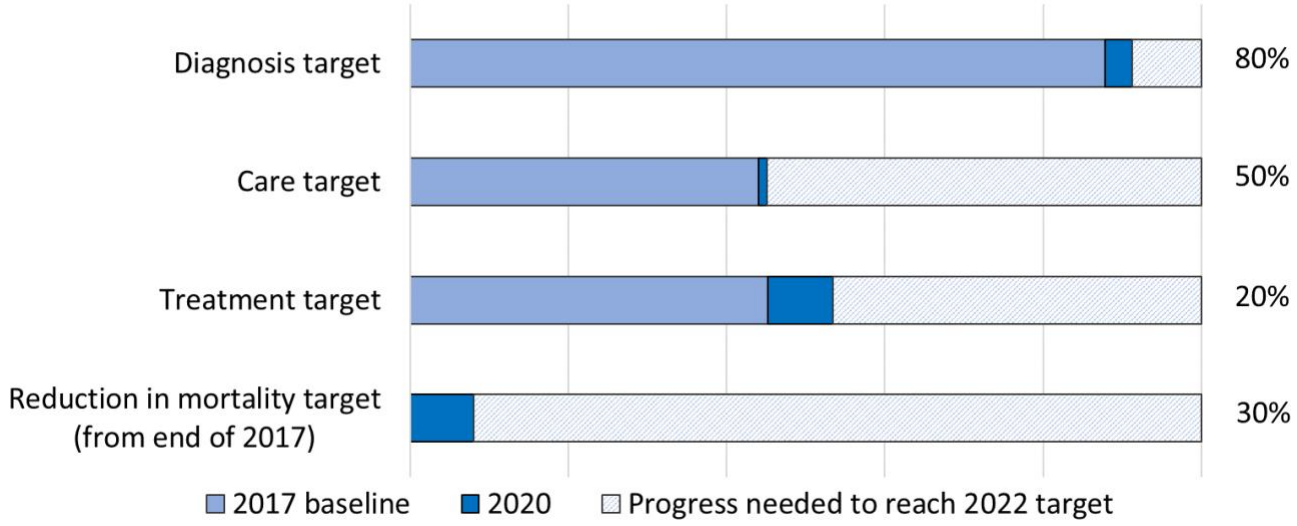


Table 2. Tracking the 3rd National Hepatitis B Strategy 2018-2022 targets.

Indicator	2018	2019	2020	2022 Target
Proportion of people living with CHB who have been diagnosed	70.9%	71.3%	73.0%	80.0%
Proportion of people living with CHB who are in care	22.8%	23.2%	22.6%	50.0%
Proportion of people living with CHB who have been treated	9.7%	10.2%	10.7%	20.0%
Reduction of hepatitis B attributable mortality (from end of 2017)	2.1%	2.7%	2.4%	30.0%

A.1.2 Progress Towards Global Health Sector Strategy Targets

We also measure progress towards the WHO's 2030 targets outlined in the Global Health Sector Strategy (GHSS) on Viral Hepatitis 2016 – 2021[8] targets, which are to:

- diagnose 90% of people living with hepatitis B by 2030,
- treat 80% of eligible persons with CHB and
- achieve a 65% reduction in hepatitis B related deaths when compared to 2015.

To achieve WHO's 2030 targets outlined in the GHSS on Viral Hepatitis 2016 – 2021, and taking into account future trends*, Australia must:

- Increase the number of people diagnosed from 162,480 in 2020 to 196,573^ by 2030
- Increase the number of people treated from 23,787 in 2020 to 55,774^ by 2030
- Decrease the number of deaths attributable to CHB from 364 in 2020 to 143 by 2030

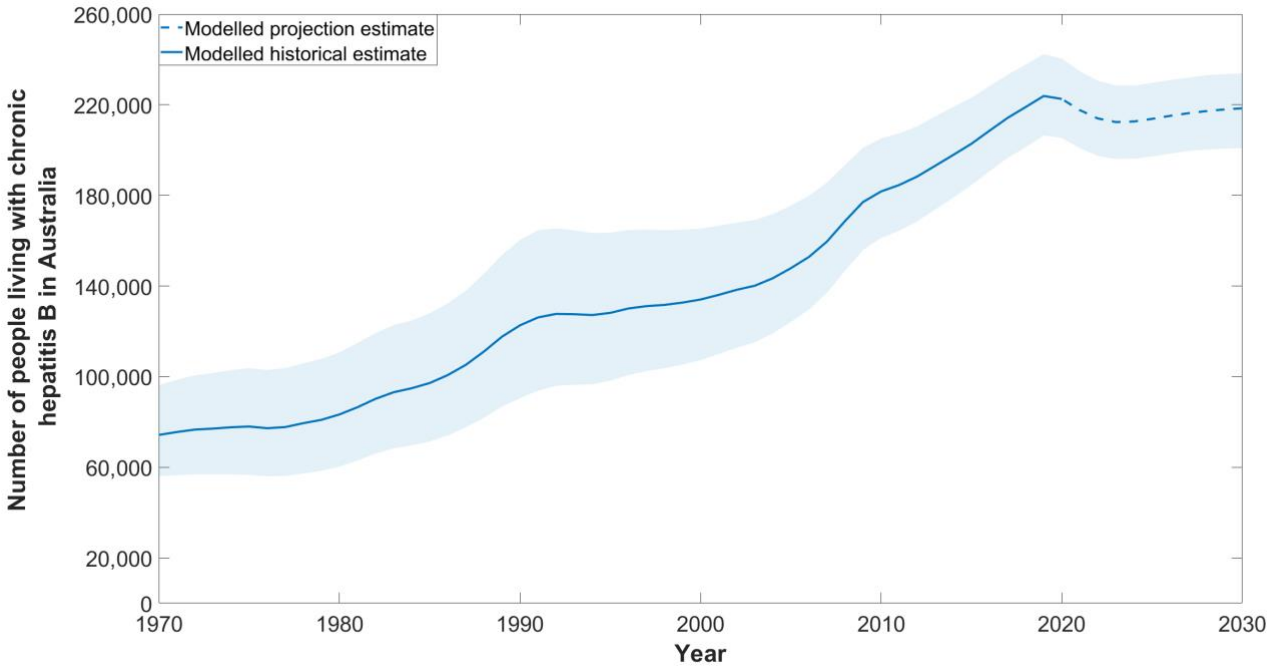
*Estimates based on modelled future projections which assume that future migration numbers follow the moderate impact scenario and our underlying assumptions about diagnosis trends, the composition of migrants by country of birth and age distribution remain constant, which may not be the case due to the impacts of COVID-19 (see section A.2.1.2 for details).
^ Based on the projected modelled estimate of 218,414 people living with CHB in 2030.

A.2 National Estimates for Hepatitis B Indicators

A.2.1 Number of people living with chronic hepatitis B in Australia.

During 2020, an estimated 222,559 (plausible range (PR) 205,376 to 240,364) people were living with CHB in Australia, representing 0.87% of the population. Modelled estimates show that the number of people living with CHB has increased over time in Australia, with an additional 88,524 people living with CHB in 2020 when compared to 2000 (Figure 3, Appendix Table A1). Following current trends (see section A.2.1.2 for details), including migration, treatment uptake and historical and current vaccination uptake both in Australia and overseas, an estimated 218,414 (PR 200,877 to 233,854) people will be living with CHB in Australia by 2030 (Figure 3).

Figure 3. Estimated number of people living with chronic hepatitis B in Australia, 1970-2030.

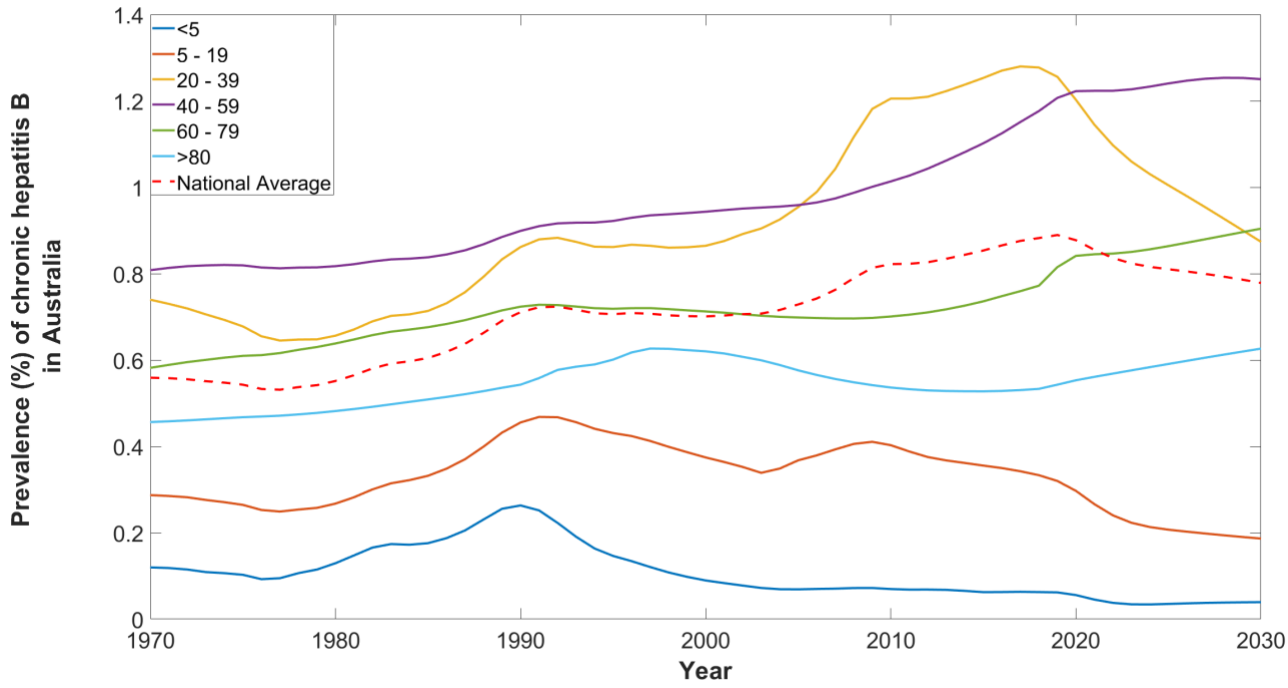


Shaded areas show plausible ranges of estimates determined by the 10th and 90th percentiles of simulations.

The prevalence of CHB has increased substantially over time, from 0.59% in 1970 to 0.87% in 2020 (Figure 4). Changes in prevalence vary across age groups, with a decrease in prevalence observed from 1991 onwards in the under 5-year age group. The increase in prevalence of CHB in people aged 5 – 19 observed from 2004 – 2008 (Figure 4) is due to an increase in the numbers of migrants from countries with endemic CHB when compared to previous years. The decreasing trends observed (from 1991 onwards in the under 5-year age group, and from 2009 onwards in the 5 – 19 years age group) highlights the impact of childhood hepatitis B vaccination programs both domestically and internationally, with vaccination mediated reductions in CHB prevalence extending to older age groups over time. The majority of people living with CHB in Australia were born overseas and acquired hepatitis B in childhood prior to migration, and therefore changes in total numbers, countries of origin and age distributions of Australia's migrant population will

affect the projections of hepatitis B in Australia, especially in light of the COVID-19 pandemic. Further detailed information on the epidemiology of CHB in Australia according to priority groups can be found in the Viral Hepatitis Mapping Project National Report[4, 5, 23].

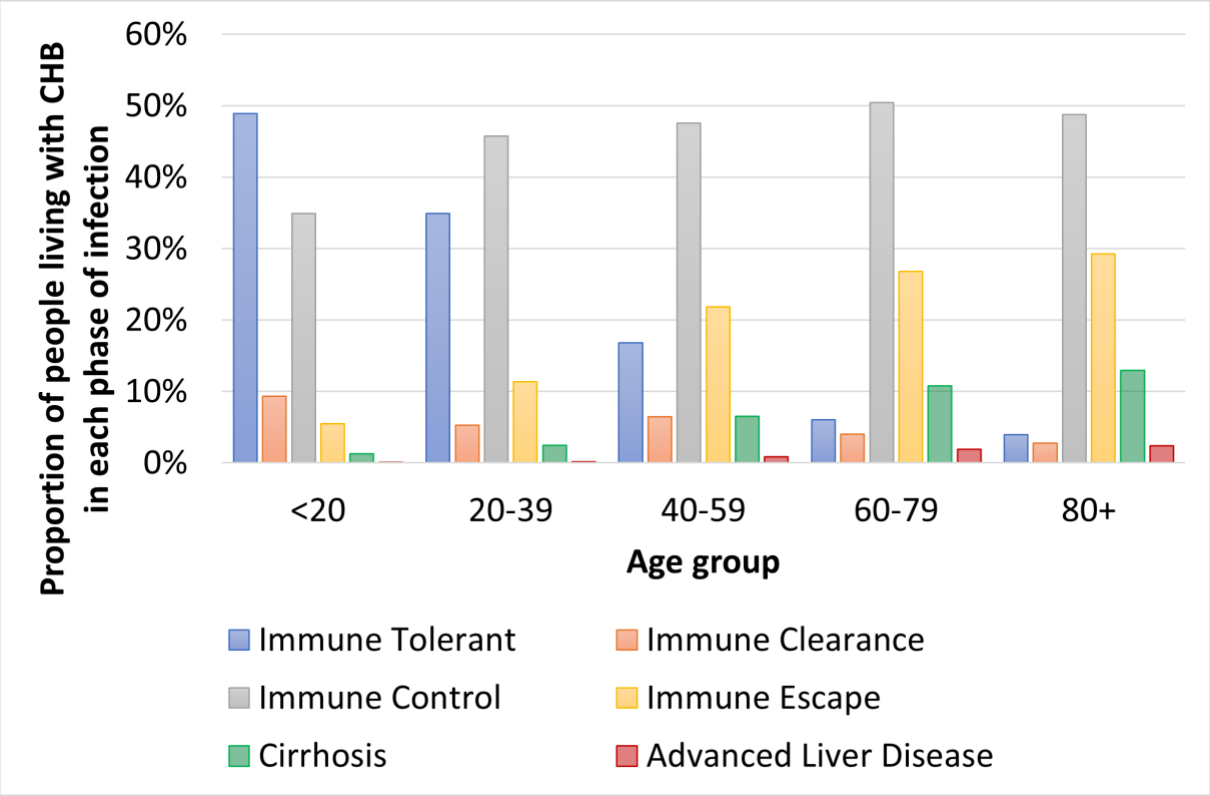
Figure 4. Estimated prevalence of chronic hepatitis B in Australia by age group, 1970-2030.



A.2.1.1 Phases of infection for people living with chronic hepatitis B

People living with CHB can transition in and out of different phases over time, so it is important to estimate the distribution of phases at a population level. During 2020, the distribution of people living with CHB in each disease phase (excluding those who had cirrhosis) was estimated to be 24.0% in immune tolerant, 5.7% in immune clearance, 46.1% in immune control and 17.6% in immune escape phase. In addition, an estimated 5.8% of people living with CHB had cirrhosis and 0.8% had advanced liver disease (hepatocellular carcinoma or decompensated cirrhosis). The proportion of people living with CHB in each disease phase varies by age group (Figure 5) with the majority of people under 20 years old in the immune tolerant phase (49.9%). For all other age groups, the majority of people living with CHB were in immune control, and this was generally seen to increase with age. The proportion of people with CHB living with cirrhosis in 2020 also increases with age from 1.3% in those under 20 years old to 12.9% in those aged above 80 years. Similarly, the proportion of people living with advanced liver disease increases from 0.1% in those under 20 years to 2.4% in those aged above 80. These estimates have implications for public health messaging and policy around CHB management and treatment eligibility to prevent liver disease and the importance of engaging particular populations, allowing prioritisation of those at greatest risk of disease progression.

Figure 5. Estimated proportion of people living with chronic hepatitis B in each phase of infection by age group, 2020.



A.2.1.2 Uncertainty in estimated future number of people living with CHB in Australia due to impacts of COVID-19 on migration

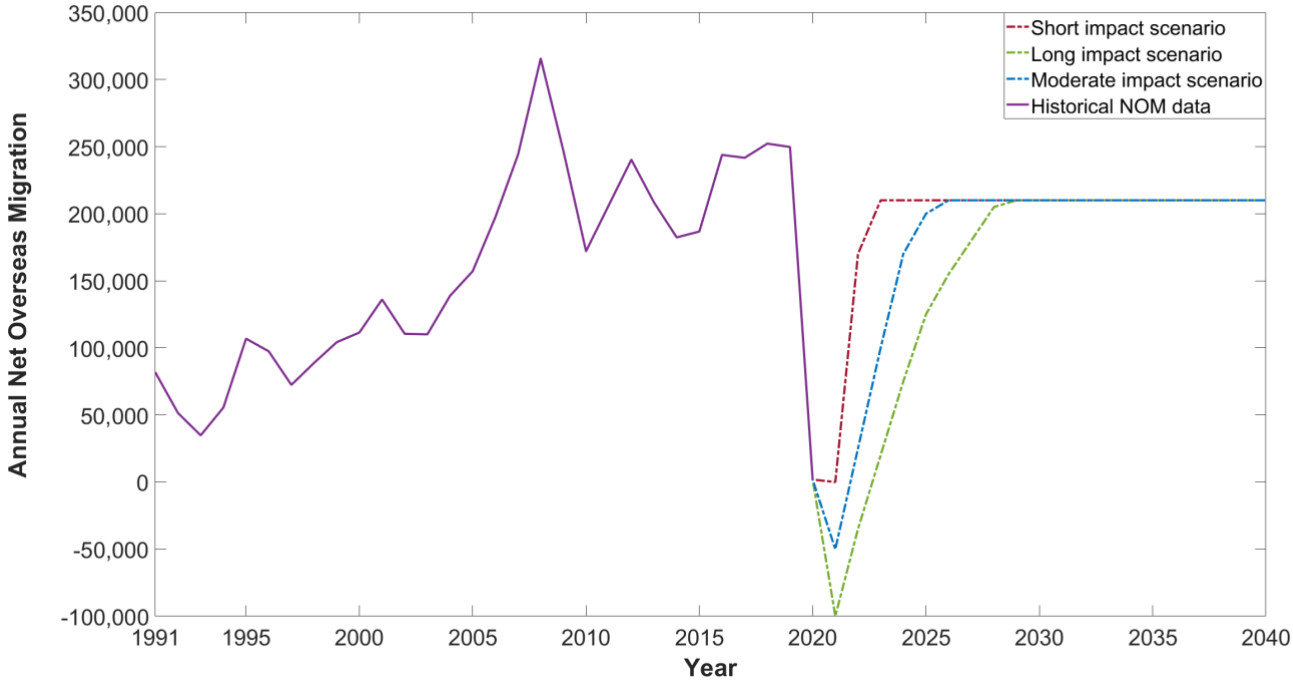
Changing patterns of migration to Australia, and the impact of infant hepatitis B vaccination programs in countries with high prevalence of CHB have a significant impact on projections of the number of people living with CHB in Australia. These future migration patterns are dependent on various factors including local and international economic conditions, government policy, and of particular relevance currently, the impact of restrictions in travel to Australia in response to the COVID-19 pandemic. Substantial changes to the number of people migrating into Australia[21] has had a profound impact on future projections of the number of people living with CHB. In our previously reported model-based estimates, the future migration projections of the Australian Bureau of Statistics (ABS) were used for our model calculations[24]. However, these estimates were generated prior to the COVID-19 pandemic and now do not accurately capture the current migration trends.

New data sourced from the ABS highlights the huge impact of restrictions on international travel in response to COVID-19[18], as shown in Figure 6, with a severe decline in net overseas migration (NOM), dropping from an estimate of 249,750 in 2019 to just 1,830 in 2020. Given the drastic

changes in migration numbers due to international borders closing, limits on the number of international arrivals accepted into Australia every week and the ongoing nature of the pandemic, it is unknown if and when migration will return to pre-pandemic levels.

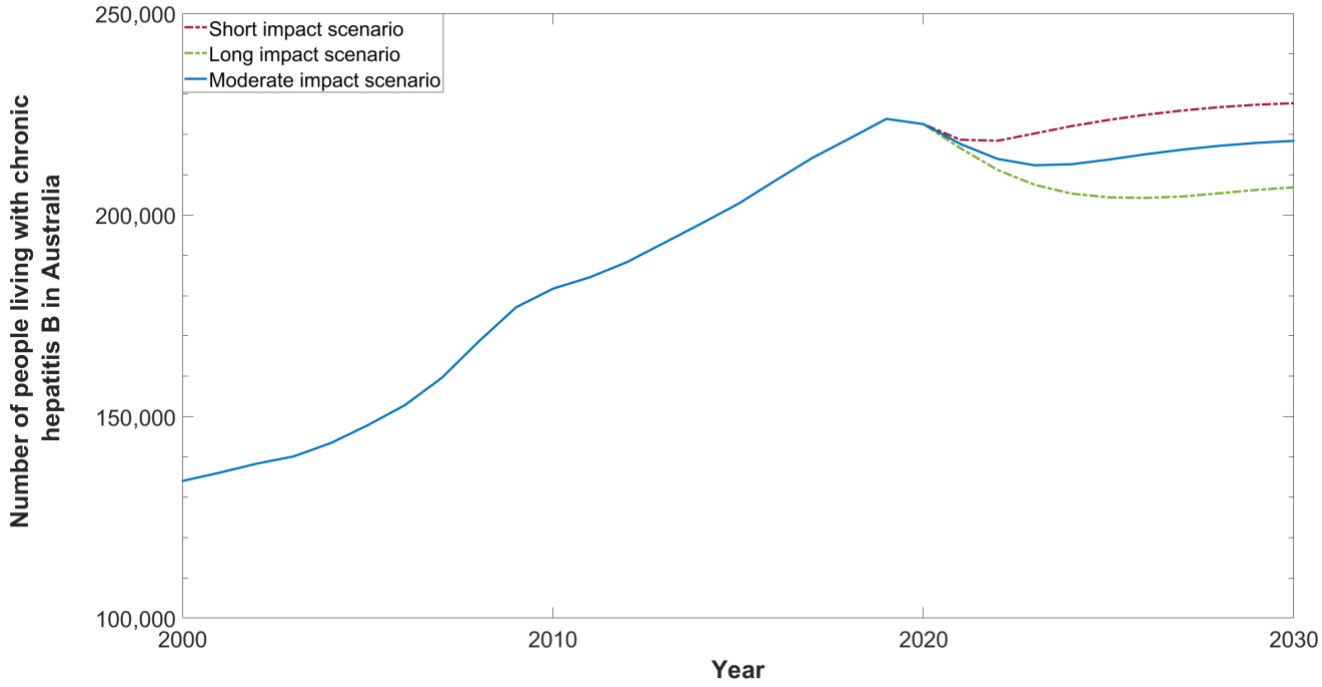
We explored the effect this would have on the future projected number of people living with CHB by investigating different possible scenarios of future net overseas migration. Wilson and colleagues[20] considered the impact of the COVID-19 pandemic on Australia's future population by modelling future population increases based on available ABS data and using 2019 as the starting point for projecting estimates forward to 2041. They derived three scenarios including: (i) a **short impact** scenario where economic and demographic trends bounce back strongly over 2 – 3 years; (ii) a **moderate impact** scenario where the effects are felt for about 5 years; and (iii) a **longer impact** scenario with an extended economic depression of up to a decade (Figure 6).

Figure 6: Historical and projected national net overseas migration (NOM) numbers 1991 – 2040.



Within this report we have assumed that future net overseas migration would follow the **moderate impact** scenario for our future projections. The impact of varying the total number of people migrating into Australia as generated by Wilson et al.[20] is substantial (Figure 7), with estimates of the number of people living with CHB in Australia in 2030 ranging between 206,894 and 227,758 when using the long impact and the short impact scenarios, respectively.

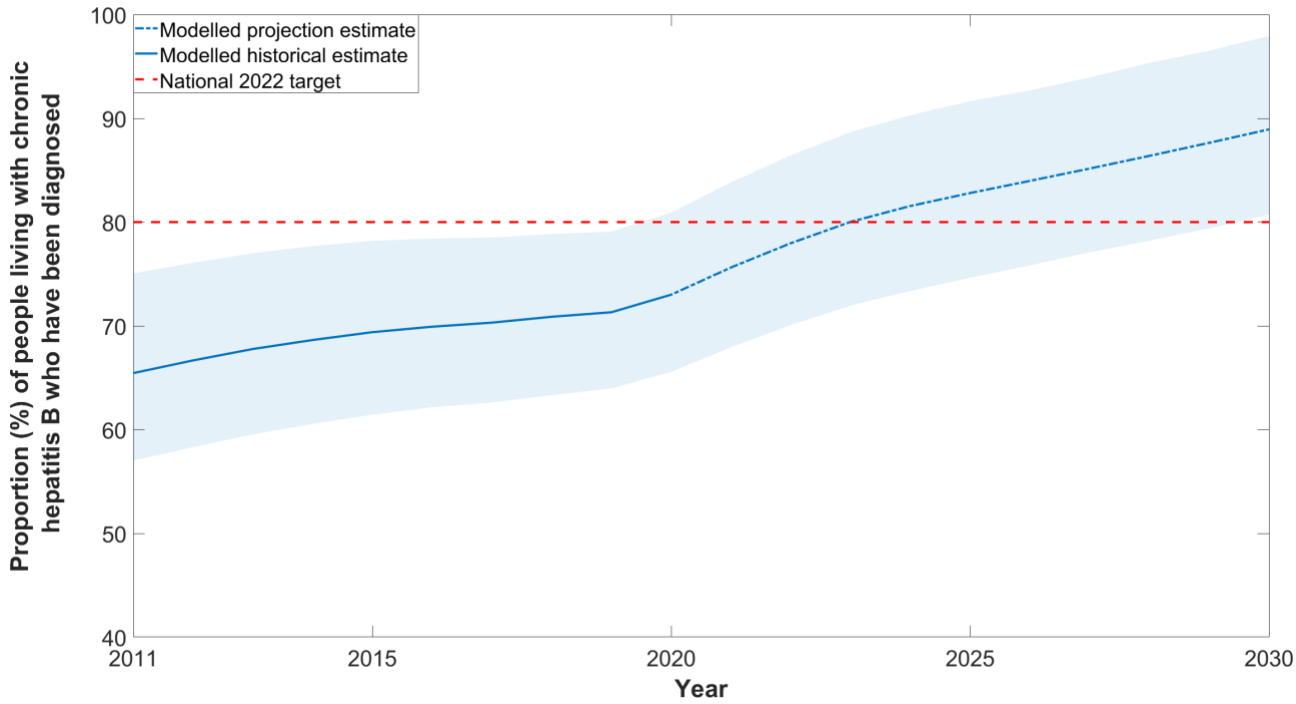
Figure 7: Impact of future migration numbers on estimated number of people living with CHB in Australia.



A.2.2 Proportion of people living with chronic hepatitis B in Australia who have been diagnosed

In 2020, an estimated 162,480 people living with CHB in Australia had been diagnosed, representing 73.0% (PR 65.6% to 80.9%) of all Australians living with CHB. Historical trends show modest improvements in this proportion, having increased from 65.4% diagnosed in 2011 (Figure 8, Appendix Table A2). Although thousands of individuals are diagnosed with CHB in Australia each year, the population living with CHB also continued to increase until 2019. The year 2020 represented the first estimated decline in the number of people living with CHB in Australia since 1994 (Figure 3). This has resulted in a higher annual increase in the proportion diagnosed of 1.7% from 2019 to 2020, compared with an average annual increase of 0.5% seen from 2016 to 2019 (Figure 8).

Figure 8. Estimated proportion of people living with chronic hepatitis B in Australia who have been diagnosed, 2011-2030.



Shaded areas show plausible ranges of estimates determined by the 10th and 90th percentiles of simulations.

The proportion diagnosed in 2020 remains below the National Strategy target of 80%, with 8,666[ii] more people living with CHB requiring diagnosis to reach this target by 2022, which assumes the number of people living with CHB in Australia continues to decline according to modelled future projections (Figure 3). Since 2010 the annual number of national notifications has been fluctuating, but followed a decreasing trend[25]. During the COVID-19 pandemic the number of total viral hepatitis serology tests performed declined by 19.1% during April to December 2020 compared to the same period in 2019[26]. This is likely due to the health system impacts of the pandemic and the interruption to usual care observed for many aspects of health care. In parallel with this decrease in serologic testing, a 14.8% decline in notifications of CHB was observed. By combining this information with modelled outputs, we estimate the proportion diagnosed will reach 88.9% diagnosed in 2030 (Figure 8), and Australia is projected to reach the National Strategy target for proportion diagnosed of 80% in 2023. These projections assume that our underlying assumptions about migration, diagnosis trends, the composition of migrants by country of birth and age distribution remain constant, which is far from certain. Given the unpredictability of future migration patterns and the long-term impacts of COVID-19 on the health system and usual care, it will become increasingly important to understand disparities in the rates of diagnoses among priority populations.

Taking into consideration notification and future migration trends (under the moderate impact

[ii] Based on the projected modelled estimate of 213,932 people living with CHB in 2022, to reach the 80% diagnosis target we need to have diagnosed 171,146 people by 2022.

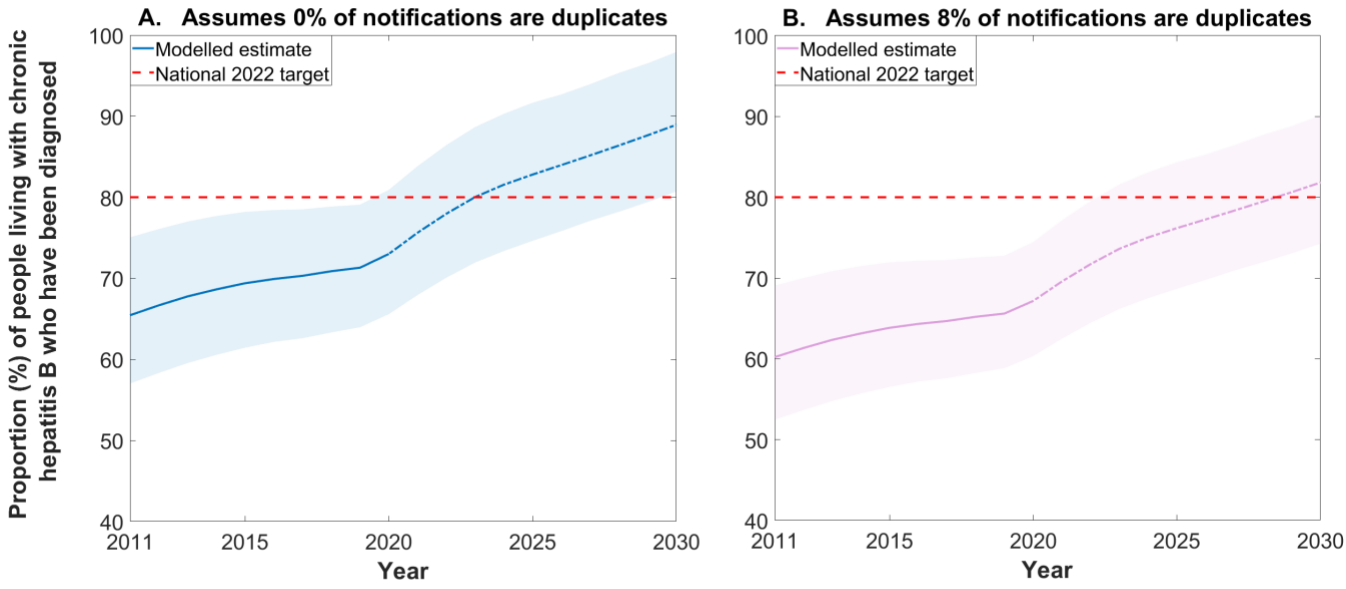
scenario), **Australia is now projected to reach the WHO's 2030 target of 90% of people living with hepatitis B diagnosed one year later than the goal, in 2031.**

Considering the plausible range, the proportion diagnosed in 2020 could be as small as 65.6% and as large as 80.9% - which in the latter case would mean that Australia has already reached the 2022 diagnosis target. However, the likelihood that the 2022 diagnosis target has been achieved in 2020 is low, as the target was not achieved in 86.9% of model simulations. These estimates may be considered optimistic and further analysis below highlights the impact of uncertainties in source data on the proportion diagnosed.

A.2.2.1 Sensitivity Analysis for duplicate notifications

The number of people living with CHB who have been diagnosed is calculated by using the number of notifications, which is sourced from the National Notifiable Diseases Surveillance (NNDSS) system[25]. However, NNDSS data may contain duplicates if individuals have been diagnosed in multiple jurisdictions, inflating the number of people diagnosed. Data linkage projects in New South Wales and Victoria estimated that approximately 8% of notifications were duplicates, occurring in both jurisdictions. While we do not yet know what the proportion of duplicate notifications will be nationally, we conducted a sensitivity analysis to consider the impact this could have on the estimated proportion diagnosed nationally (Figure 9). Assuming 8% of national notifications are duplicates reduces the estimated proportion diagnosed in 2020 from 73.0% (PR 65.6% to 80.9%) to 67.2% (PR 60.3% to 74.4%).

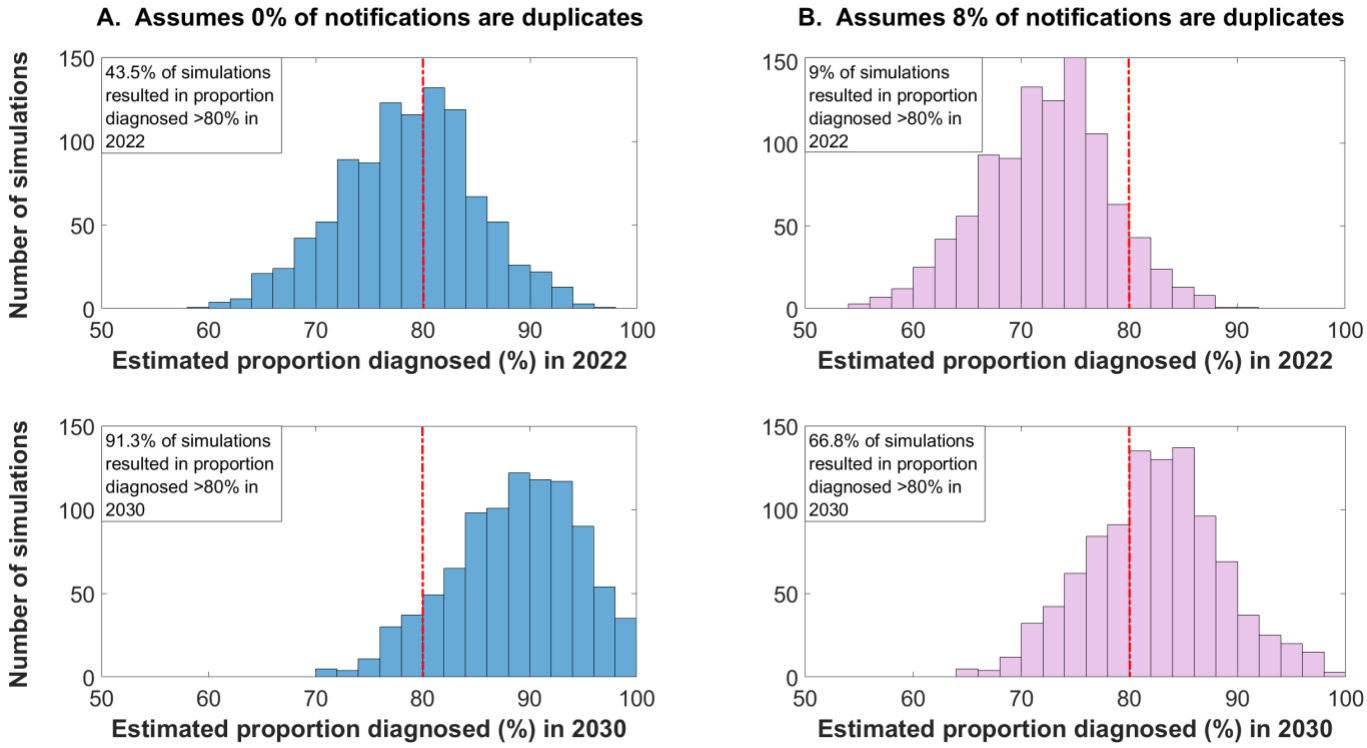
Figure 9. Comparison of estimated proportion diagnosed when assuming none of the national notifications are duplicates (Panel A) and when assuming 8% of national notifications are duplicates (Panel B), 2011-2030, comparison with assuming 8% of notifications are duplicates.



Shaded areas show plausible ranges of estimates determined by the 10th and 90th percentiles of simulations.

Furthermore, only 9% of model simulations estimated the 2022 diagnosis target could be reached in 2022 when assuming 8% of notifications are duplicates, compared to 43.5% of simulations if we assumed no duplicate notifications (Figure 10).

Figure 10: Distribution of estimated proportion diagnosed in 2022 and 2030 based on model output of 1,000 simulations. Panel A graphs assume no duplicate notifications, Panel B assumes 8% of national notifications are duplicates.

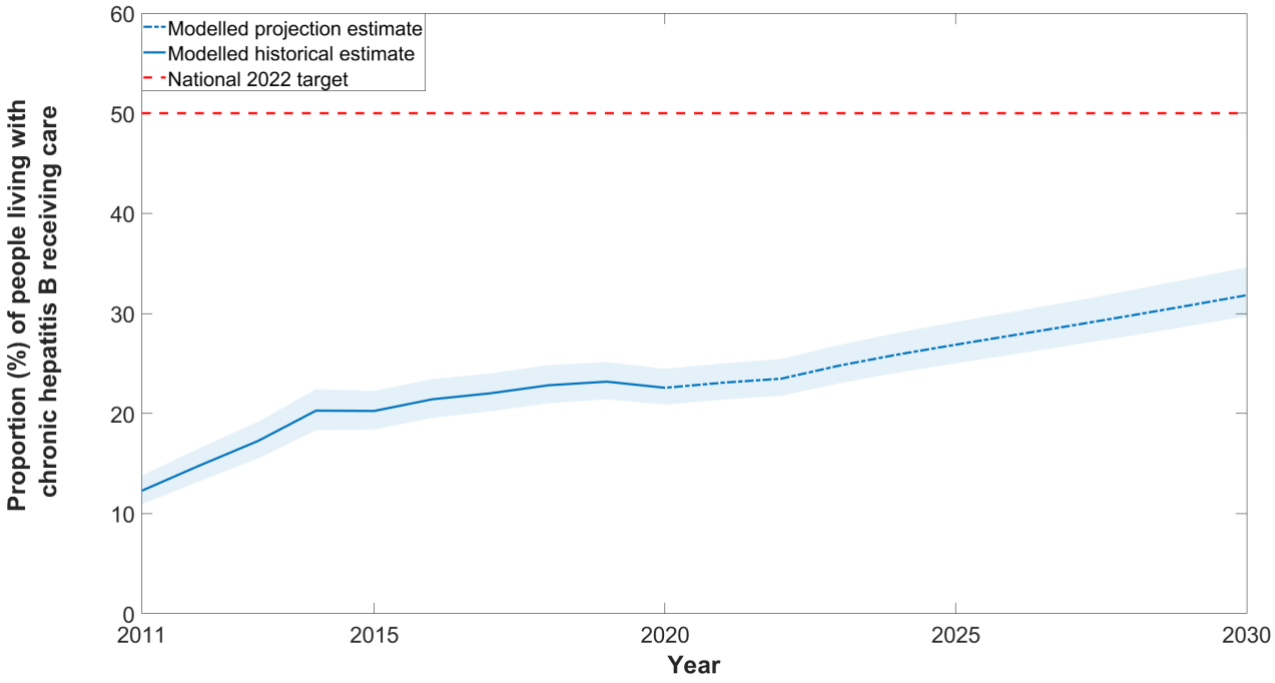


This sensitivity analysis highlights the importance of estimating the proportion of duplicate notifications for accurately estimating the true proportion of people diagnosed, particularly across states and territories.

A.2.3 Proportion of people living with chronic hepatitis B who are engaged into care, receiving either treatment or monitoring

During 2020, 50,229 people were engaged in care for their CHB, receiving either antiviral treatment or monitoring (defined as receiving hepatitis B viral load testing according to clinical guidelines) without antiviral treatment. As a result, total uptake of care is an estimated 22.6% (PR 20.9% to 24.5%) of all people living with CHB. Modelled trends show substantial improvement in this proportion over time, increasing from 12.3% in 2011 (Figure 11, Appendix Table A3). Although this increase was relatively rapid between 2011 to 2014, the rate of increase has been substantially slower since 2015. Due to the COVID-19 pandemic a reduction in the proportion of people engaged in care for their CHB was seen in 2020, with data showing an 8.7% decline in viral load tests performed while not on treatment during April to December 2020 compared to April to December 2019[26].

Figure 11. Estimated proportion of people living with chronic hepatitis B in Australia who were engaged in care (receiving either treatment or monitoring), 2011-2030.



Shaded areas show plausible ranges of estimates determined by the 10th and 90th percentiles of simulations.

Clinical guidelines recommend that all people living with CHB should be engaged in care, and Australia currently falls well short of meeting these clinical recommendations. The proportion engaged in care also remains below the National Strategy target of 50%, with 56,737[iii] more people required to be in care to reach this target by 2022. Assuming the number of people

[iii] Based on the projected modelled estimate of 213,932 people living with CHB in 2022, we estimate that 106,966 people living with CHB are required to be engaged in care to reach the target of 50%.

engaged in care for their CHB remains stable in 2021 – 2022 and then increases based on trends seen in 2016 – 2019, Australia will not reach the 50% target until 2045. Noting that these projections incorporate our inherently uncertain underlying assumptions about future migration, composition of migrants by country of birth and age distribution as detailed in section A.2.1.2.

A.2.4 Proportion of people living with chronic hepatitis B who are dispensed drugs for the treatment of hepatitis B through the Pharmaceutical Benefits Scheme

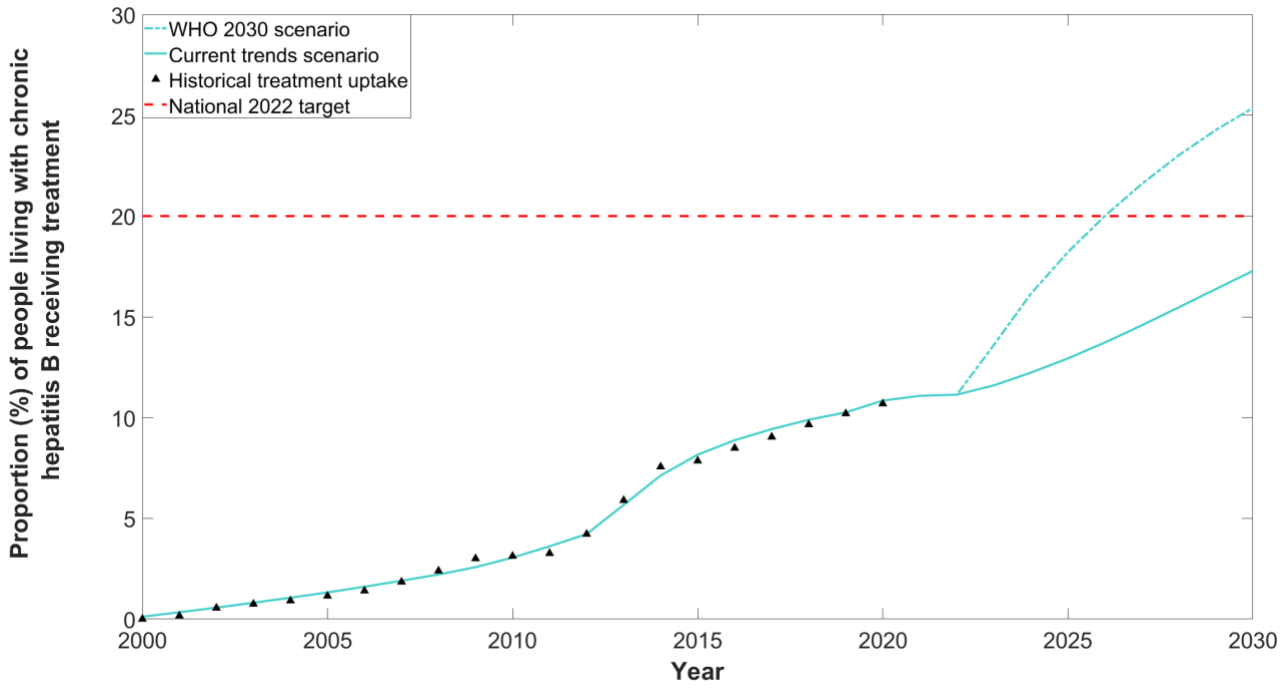
During 2020, 23,787 people were dispensed drugs for the treatment of hepatitis B through the Pharmaceutical Benefits Scheme (PBS), which is an estimated 10.7% (PR 9.9% to 11.6%) of people living with CHB. The number of hepatitis B treatment scripts dispensed during Apr-Dec 2020 increased by 3.6% compared to 2019, however this increase was substantially smaller than the magnitude of increase in the previous year (9.7%), likely due to the impact of the COVID-19 pandemic on routine health care delivery[26].

For Australia to achieve the National Strategy target of 20% of people receiving antiviral treatment, rapid increases in treatment uptake need to be seen, with an additional 19,000[iv] people living with CHB needing to receive antiviral treatment by 2022. Two treatment uptake scenarios were modelled to consider the impact of future treatment uptake on future mortality: (i) Current trends scenario: Assumes the number of people receiving treatment in 2021 & 2022 remain the same as in 2020, due to the impact of COVID-19. From 2023 onwards this scenario assumes the average annual increase follows 2016 – 2019 trends; and (ii) WHO 2030 scenario: Assumes the number of people receiving treatment in 2021 & 2022 remain the same as in 2020, due to the impact of COVID-19. From 2023 onwards future treatment uptake was modelled at the level of increase required to meet the WHO GHSS 2030 treatment target (80% of eligible people receiving treatment). Based on estimates of the proportion of people who are eligible for antiviral treatment developed through this modelling project (29.5% in 2021), the target of 80% of eligible people (see section A.2.4.1 below) receiving treatment equates to approximately 25% of all people living with CHB.

The National Strategy target of 20% receiving treatment by 2022 is not reached under the future treatment uptake scenarios (due to the projected impact of the COVID-19 pandemic) (Figure 12). Reaching this target would require an average annual treatment increase of 4.7% from 2020 to 2022, compared to the current increase of 0.49% from 2019 to 2020. Furthermore, to reach the WHO target of 80% of eligible people living with CHB receiving treatment by 2030 would require a significant average annual treatment increase of 1.7% from 2023 to 2030.

[iv] Based on the projected modelled estimate of 213,932 people living with CHB in 2022, we estimate that 42,787 people living with CHB require treatment to reach the target of 20%.

Figure 12. Estimated proportion of people living with chronic hepatitis B in Australia who were dispensed drugs for the treatment of hepatitis B through the Pharmaceutical Benefits Scheme, 2000-2030.



A.2.4.1 Treatment eligibility

Although the number of people dispensed drugs for treatment of CHB through the PBS is usually reported as a proportion of the total number of people living with CHB, it is important to highlight not all people living with CHB are eligible for treatment. This is because the dynamic natural history of hepatitis B and the various phases of infection mean the minority of people living with CHB require treatment. Current guidelines recommend antiviral therapy only for those in an immune active phase of CHB (immune clearance, immune escape) or those living with cirrhosis with detectable HBV replication irrespective of phase[27]. These guidelines emphasise the importance of generating estimates of the proportion of people living with CHB by phase (refer to section A.2.1.1 on page 13)[2].

Estimates of the proportion of people living with CHB who are eligible for treatment range from approximately 10% to 31% [2, 28-32]. The true proportion of people living with CHB who require treatment will vary by hepatitis B genotype, age group, sex, and other factors, and prior to this project had not previously been estimated for Australia. The modelling undertaken for this project, which incorporates the phase of CHB and the proportion of people living with cirrhosis, enabled estimation of the number of people living with CHB eligible for antiviral treatment in Australia for the first time. We are able to track this over time in response to population changes.

In 2020, an estimated 65,658 (PR 62,796 to 68,409) people living with CHB were eligible for antiviral treatment, representing 29.5% (PR 28.2% to 30.7%) of the total. This suggests the National Strategy target of 20% of people living with CHB receiving antiviral treatment by 2022

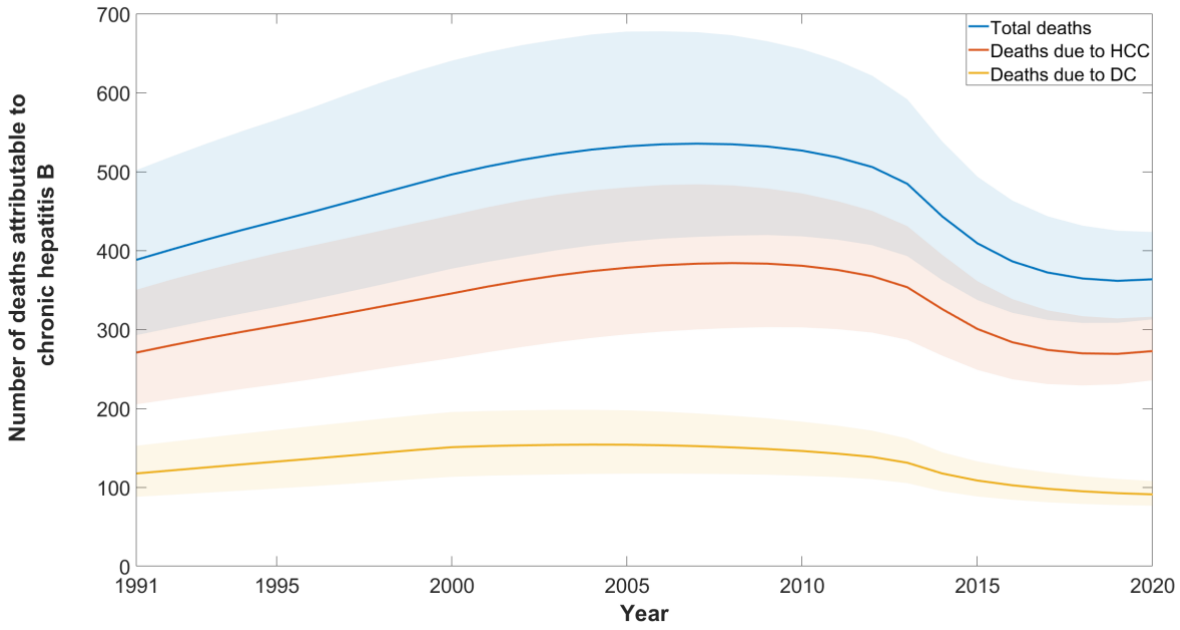
remains conservative (Figure 12). Based on this modelling, Australia treated a third of those estimated to require treatment in 2020 and would have needed to treat an additional 41, 871 people to reach everyone who was eligible.

To reach the WHO Global Health Sector Strategy of 80% of eligible people with CHB treated by 2030, the number of people receiving antiviral treatment in Australia will need to increase from 23,787 in 2020 to 55,774 in 2030. Since 2015, an average annual increase of 1.7% in treatment uptake for eligible people was observed; if this trend were to remain stable, Australia will not reach the WHO 2030 elimination target until 2046.

A.2.5 Burden of disease attributable to chronic hepatitis B in Australia

In 2020, an estimated 364 people (PR 312 to 424) died due to complications of CHB in Australia. The total number of estimated attributable deaths has changed over time, increasing from 387 in 1991 to a peak of 535 deaths in 2007 followed by a gradual decline (Figure 13, Appendix Table A5). This decrease in estimated deaths is due to the introduction and scaling up of effective antiviral treatment in Australia during the last two decades, and the resulting reduction in CHB-associated mortality in those at greatest risk of adverse outcomes. In recent years the number of deaths has plateaued instead of continuing to decrease, in part due to an increasing aging population and treatment uptake not increasing sufficiently.

Figure 13. Estimated number of deaths attributable to chronic hepatitis B in Australia over time, 1991-2020.



Shaded areas show plausible ranges of estimates determined by the 10th and 90th percentiles of simulations.

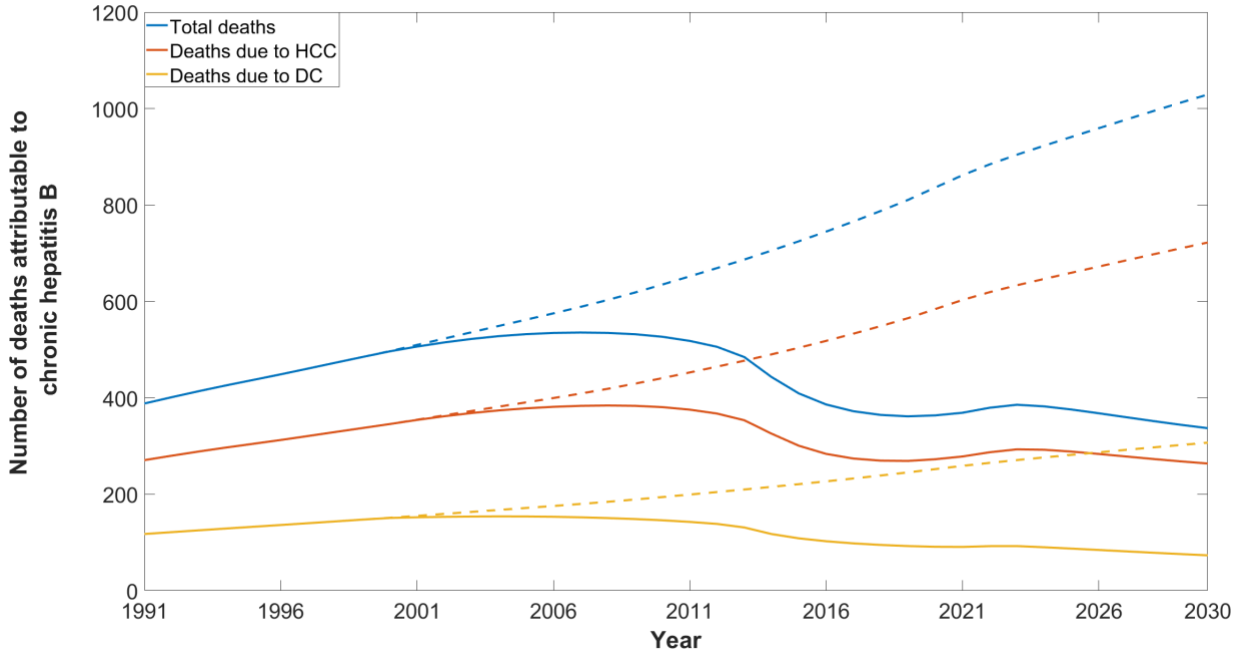
Deaths due to CHB are caused by the development of decompensated cirrhosis (DC) and/or hepatocellular carcinoma (HCC), the most common form of liver cancer. In Australia, 75% of

estimated deaths due to CHB were attributable to HCC, which was responsible for 272 (PR 235 to 316) deaths in 2020, while 92 (PR 77 to 108) people were estimated to have died due to DC. Deaths due to both causes have decreased over the last decade, however the decline has been more pronounced for DC (40.3% reduction, from peak of 165 in 2006, Figure 13) than for HCC (29.2% reduction, from the peak of 384 in 2007, Figure 13).

The impact of treatment in reducing the risk of death due to CHB may be more pronounced for DC compared to HCC due to the underlying clinical factors in relation to treatment impact. While antiviral treatment has been demonstrated to substantially reduce the risk of development of HCC, this effect is not immediate and antiviral therapy has limited impact on survival once HCC has already been diagnosed. In contrast, antiviral treatment not only prevents progression to cirrhosis and then to DC, but additionally can be effective even when provided late in the disease course, resulting in re-compensation of liver disease. In coming years, increasing the uptake of timely treatment in people living with CHB (i.e. before the development of cirrhosis) can be expected to accelerate the reduction in HCC attributable deaths.

The results of the modelling undertaken for this project suggest that without the availability of antiviral treatment in Australia, the number of attributable deaths would have continued to increase over time, to 834 CHB attributable deaths estimated in 2020 (Figure 14). Our assessment estimates that in 2020, 470 lives were saved due to treatment, with a total of 3,601 lives saved since the year 2000 following the introduction of antiviral treatment for CHB in Australia.

Figure 14. Estimated number of deaths attributable to chronic hepatitis B in Australia, current trends treatment scenario vs no treatment, 1991 – 2030.



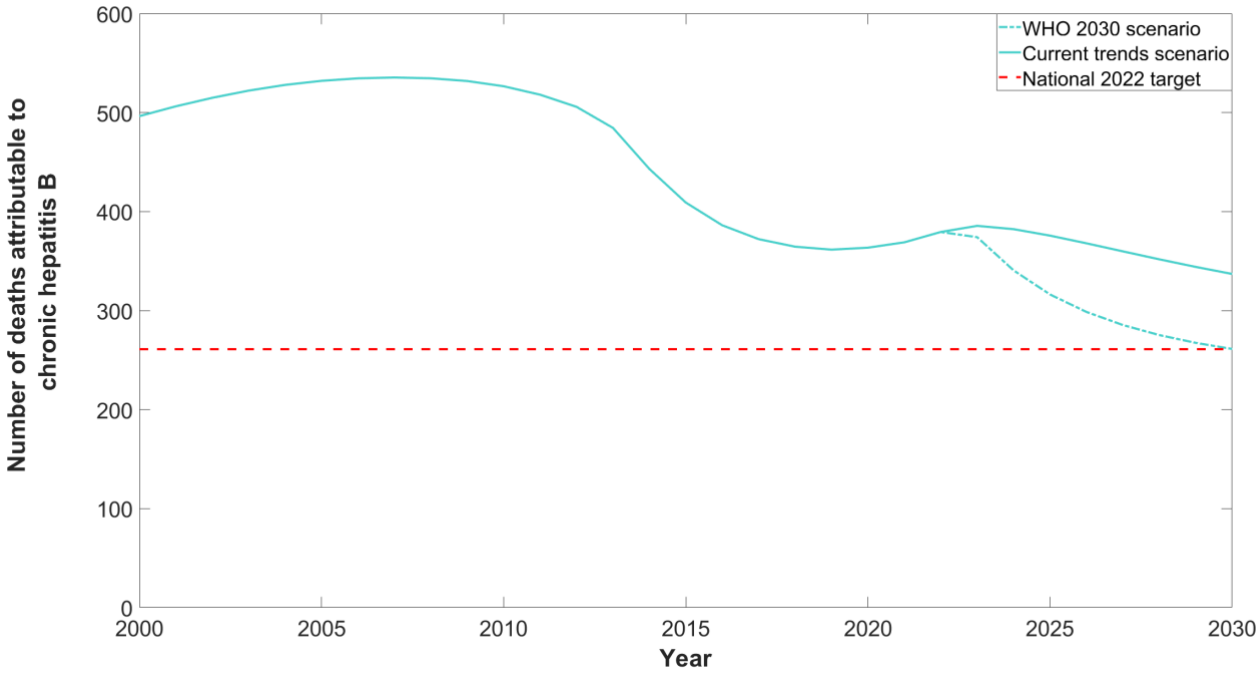
Dotted lines show estimated deaths per year without treatment for CHB

A.2.5.1 Impact of treatment on mortality

The reduction in deaths attributable to CHB at the end of 2020 relative to the end of 2017 was 2.4%, with substantial progress still needed to reach the National Strategy target of a 30% reduction in hepatitis B attributable mortality by 2022. To reach this target, the total number of CHB attributable deaths must fall to 262 deaths. Although the reduction in deaths has been pronounced since the introduction of antiviral treatment, future reductions depend on future treatment uptake. In 2022, the estimated change in attributable deaths in Australia when compared to 2017 under the current trends and WHO 2030 scenarios (Figure 12) will be a 1.9% *increase* (Figure 15). However, in 2030, the estimated reduction in attributable deaths in Australia when compared to 2017 is 9.8% and 30% under the current trends and WHO 2030 scenarios respectively (Figure 15).

To reach the WHO Global Health Sector Strategy 2030 target of a 65% reduction in hepatitis B related deaths compared to 2015, the total number of CHB attributable deaths must fall to 143 deaths by 2030.

Figure 15: Impact of future treatment uptake on estimated number of deaths attributable to chronic hepatitis B in Australia, 2000 – 2030.



B. State and Territories

B.1 Summary State and Territory Estimates

Table 3. Australian summary for hepatitis B indicator point estimates by jurisdiction, 2020

State/ Territory	People living with CHB	Diagnosed (%)	In care (%)	Treatment uptake (%)	Total deaths attributable to CHB	HCC deaths attributable to CHB	DC deaths attributable to CHB
ACT	3,211	69.3%	25.7%	12.5%	<10	<10	<10
NSW	79,522	79.2%	27.0%	12.9%	119	91	28
NT	4,538	70.0%	24.8%	9.1%	10	<10	<10
QLD	33,987	73.4%	18.8%	8.3%	56	41	15
SA	11,507	67.2%	16.7%	8.8%	20	15	<10
TAS	1,513	53.1%	17.3%	8.5%	<10	<10	<10
VIC	64,632	63.0%	24.4%	11.0%	105	79	26
WA	23,649	57.3%	10.2%	6.9%	47	34	13
Australia	222,559	73.0%	22.6%	10.7%	364	272	92

Note: Jurisdictional estimates were standardized to ensure the sum of indicator variables across the jurisdictions aligns with the modelled national estimate.

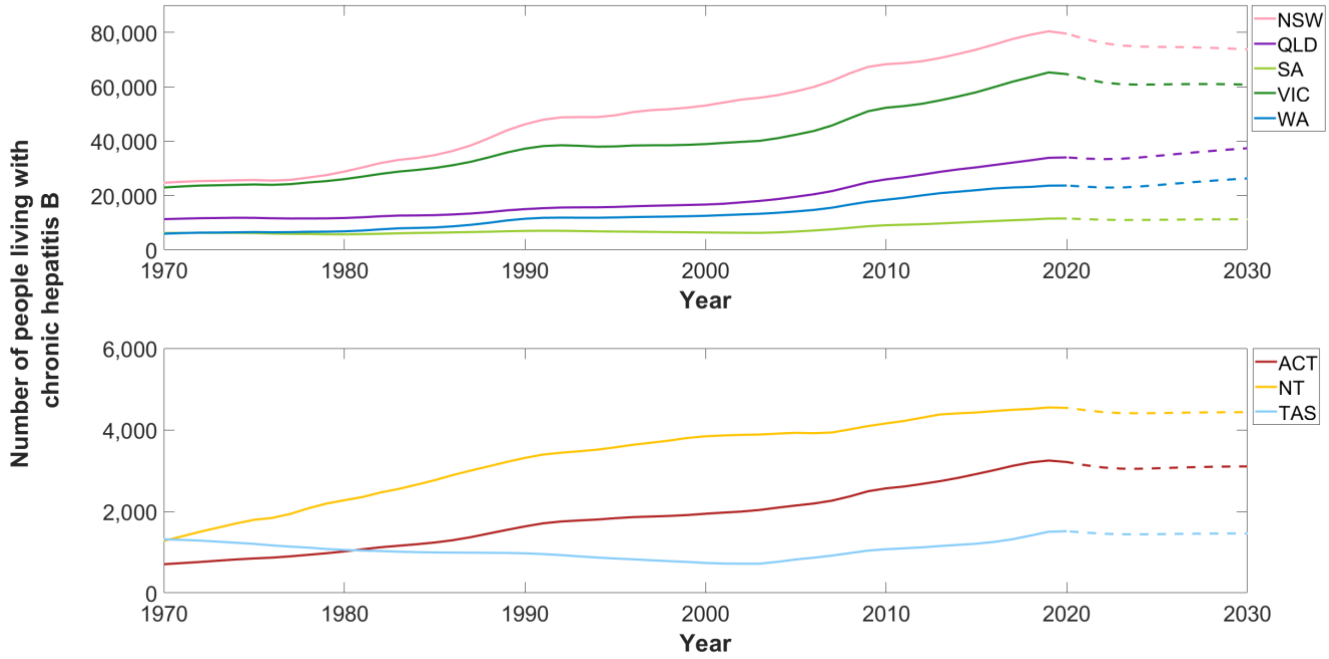
B.2 State and Territory Estimates for Hepatitis B Indicators

B.2.1 Number of people living with chronic hepatitis B in Australia.

Modelled estimates show that the number of people living with CHB has generally increased over time in all jurisdictions, however due to changes in migration patterns due to the COVID-19 pandemic, ACT, NSW, NT, and VIC all saw a drop in the estimated number in 2020 (Figure 16, Appendix Table A1). Similar to national estimates, differences in overseas migration patterns affect the epidemiology and future projections of hepatitis B across jurisdictions and is demonstrated in differential changes over time. This is particularly highlighted in TAS, which is the only jurisdiction to historically show a gradual decline in the number of people living with CHB (Figure 16). Despite steady increases in this number after 2003, TAS still had the lowest estimate in 2020 with 1,513 number of people living with CHB. The effect of migration has also been seen in NSW and VIC which had the highest estimates of people living with CHB in 2020 (79,522 and 64,632 respectively), and historically saw relatively high increases after increased migration from 1990 (Table 4, Appendix Table A1).

Prevalence across jurisdictions varies according to differing population demographics, with the highest prevalence in 2020 estimated in NT (1.84%) and the lowest was in TAS (0.28%). Among other jurisdictions, VIC (0.97%) and NSW (0.97%) had estimated prevalence above the national average (0.87%) in 2020, WA (0.89%) was equivalent, and ACT (0.74%), SA (0.64%) and QLD (0.65%) were below (Table 4).

Figure 16. Estimated number of people living with chronic hepatitis B by jurisdiction, 1970-2030



Dotted lines represent modelled projection estimates.

Table 4. Estimated number of people living with chronic hepatitis B and prevalence by jurisdiction, 2020

State/Territory	People living with CHB	Plausible range		Prevalence (%)
		Minimum	Maximum	
ACT	3,211	2,966	3,502	0.74%
NSW	79,522	73,348	86,002	0.97%
NT	4,538	4,327	4,739	1.84%
QLD	33,987	31,818	35,429	0.65%
SA	11,507	10,601	12,425	0.65%
TAS	1,513	1,370	1,655	0.28%
VIC	64,632	59,314	71,023	0.97%
WA	23,649	21,632	25,589	0.89%
Australia	222,559	205,376	240,364	0.87%

Note: Jurisdictional estimates were standardized to ensure the sum of indicator variables across the jurisdictions aligns with the modelled national estimate.

B.2.2 Proportion of people living with chronic hepatitis B in Australia who have been diagnosed

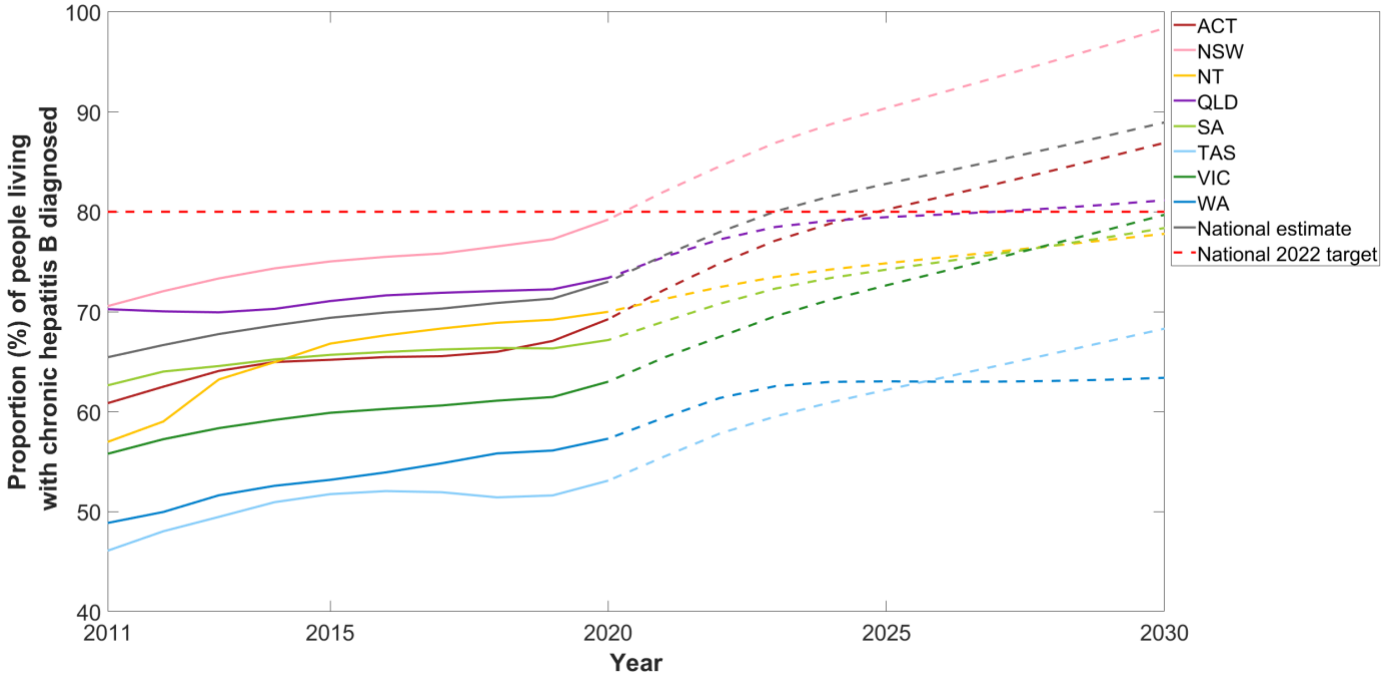
Since 2011 modest increases in the estimated proportion of people living with CHB who have been diagnosed have been observed in all jurisdictions (Figure 17, Appendix Table A2). The estimated

proportion diagnosed varied greatly between jurisdictions, with NSW (79.2%) and QLD (73.4%) having the highest proportion diagnosed in 2020 (Table 5). Estimates for all other states and territories were below the national average of 73.0%, with NT (70.0%), ACT (69.3%), SA (67.2%), VIC (63.0%), WA (57.3%) and TAS (53.1%) exceeding 50%.

No jurisdiction has yet reached the 2022 National Strategy target of 80% of people living with CHB being diagnosed. Following trends in notifications since 2016, the only jurisdiction due to reach the 80% diagnosed target by 2022 is NSW, which is estimated to reach the target in 2021 (Figure 17). The ACT and QLD are estimated to reach the target in 2025 and 2027 respectively, while all other jurisdictions would reach the target after 2030. Similar to the national model, it is important to note that these projections assume our underlying assumptions about migration, diagnosis trends, the composition of migrants by country of birth and age distribution remain constant, which may not be the case. A significantly increased rate of diagnosis is required in all these jurisdictions to reach the National Strategy target by 2022.

As the proportion diagnosed is dependent on routinely collected surveillance data, disparities between states and territories will be impacted by variations in screening practices, underlying population differences in each jurisdiction and duplicate notifications. Please see section *A.2.2.1 Sensitivity analysis for duplicate notifications* for more information.

Figure 17. Estimated proportion of people living with chronic hepatitis B who have been diagnosed by jurisdiction, 2011-2030.



Dotted lines represent modelled projection estimates.

Table 5. Estimated proportion of people living with chronic hepatitis B who have been diagnosed by jurisdiction, 2020

State/Territory	Proportion diagnosed	Plausible range	
		Minimum	Maximum
ACT	69.3%	63.4%	80.7%
NSW	79.2%	74.4%	90.8%
NT	70.0%	68.0%	77.4%
QLD	73.4%	71.6%	81.9%
SA	67.2%	61.5%	79.2%
TAS	53.1%	50.6%	60.6%
VIC	63.0%	57.5%	74.3%
WA	57.3%	53.4%	66.3%
Australia	73.0%	65.6%	80.9%

B.2.3 Proportion of people living with chronic hepatitis B who are engaged into care, receiving either treatment or monitoring

Since 2011, the proportion of people living with CHB who are engaged in care varied greatly between state and territories (Figure 18, Appendix Table A3). Despite some fluctuations, generally the proportion of people living with CHB who are engaged into care increased in most states and territories during 2011 - 2019.

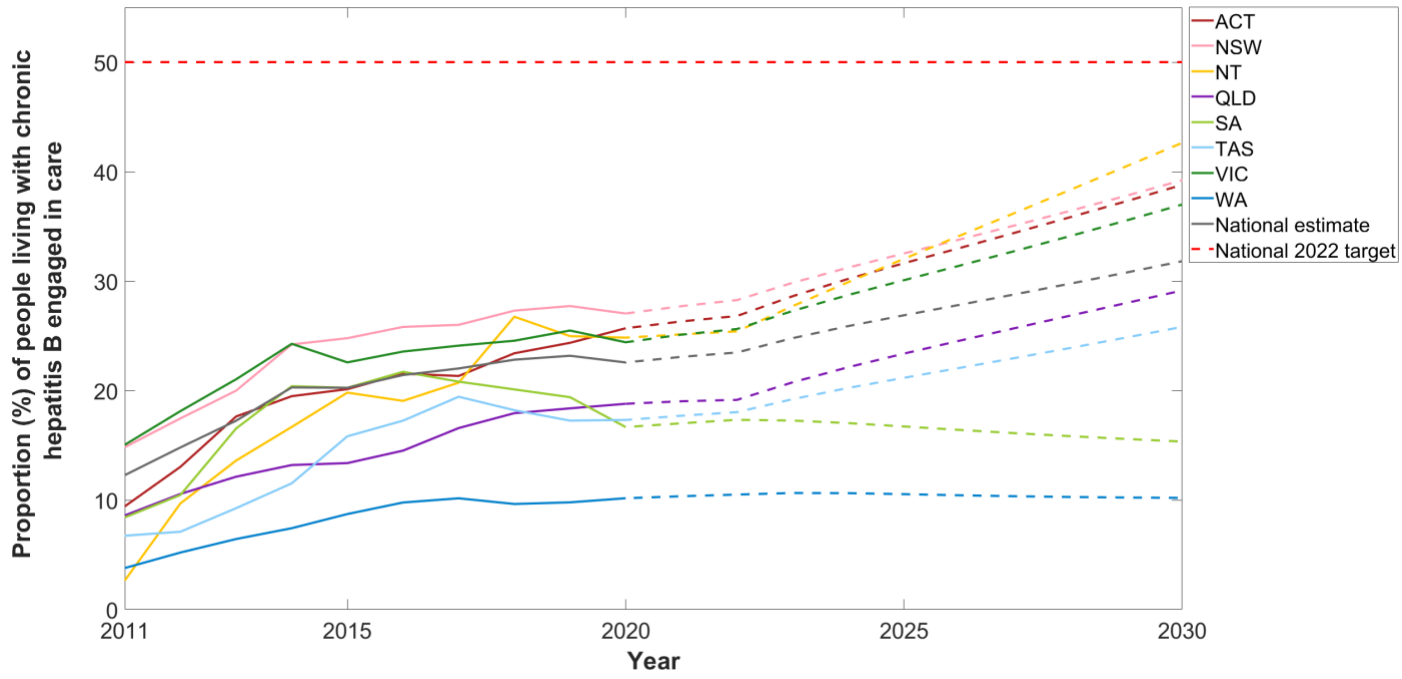
However, since 2017 there has been a decreasing trend in the proportion receiving care in SA, TAS, WA, NT, NSW and VIC (Figure 18). This may be partly attributable to data reporting, as anomalies in the expected number of viral load tests performed in some jurisdictions have been observed in the Viral Hepatitis Mapping Project National Report[4, 5]. In 2020, due to the impact of COVID-19, the proportion of people living with CHB who are engaged into care declined or remained stable, with the exception of the ACT which had a 1.3% increase from 2019 to 2020.

It can be observed that jurisdictions with a higher proportion of people living with CHB diagnosed did not always have a higher proportion engaged in care, indicating that jurisdictions likely encounter different challenges in improving the cascade of care for CHB. In 2020 NSW (27.0%), ACT (25.7%), NT (24.8%) and VIC (24.4%) had the highest proportions of people living with CHB engaged in care (Table 6). All other jurisdictions fell under the national average of 22.6% engagement in care: QLD (18.8%), SA (16.7%), TAS (17.3%), WA (10.2%).

No jurisdiction has yet reached the 2022 National Strategy target of 50% of people living with CHB engaged in care. Following current trends since 2016, NT, ACT, NSW and VIC will not reach this target until 2034, 2037, 2037 and 2038 respectively. All other jurisdictions will reach the 2022 target after the national estimate, in 2045.

Although the National Strategy target is set to 50%, clinical guidelines recommend that all people living with CHB should be engaged in care, so drastic improvements need to be made across all jurisdictions to engage all people living with CHB.

Figure 18. Estimated proportion of people living with chronic hepatitis B who were engaged into care, receiving either treatment or monitoring by jurisdiction, 2011-2030



Dotted lines represent modelled projection estimates.

Table 6. Estimated proportion of people living with chronic hepatitis B who were engaged in care by jurisdiction, 2020

State/Territory	Proportion in care	Plausible range	
		Minimum	Maximum
ACT	25.7%	23.6%	27.8%
NSW	27.0%	25.0%	29.3%
NT	24.8%	23.8%	26.0%
QLD	18.8%	18.0%	20.1%
SA	16.7%	15.4%	18.1%
TAS	17.3%	15.8%	19.1%
VIC	24.4%	22.2%	26.6%
WA	10.2%	9.4%	11.1%
Australia	22.6%	20.9%	24.5%

B.2.4 Proportion of people living with chronic hepatitis B who are dispensed drugs for the treatment of hepatitis B through the Pharmaceutical Benefits Scheme

As previously described in the Viral Hepatitis Mapping Project National Report[4, 5], the proportion of people living with CHB receiving antiviral treatment has increased over time in all states and territories (Figure 19, Appendix Table A4). Treatment uptake varied greatly between jurisdictions, with NSW (12.9%), ACT (12.5%) and VIC (11.0%) estimated to have the highest proportion of people with CHB receiving treatment in 2020 (Table 7). All other states and territories were below the national average (10.7%) for treatment uptake, including NT (9.1%), SA (8.8%), TAS (8.5%), QLD (8.3%) and WA (6.9%). A relatively rapid increase in treatment uptake was observed in most jurisdictions until 2014 to 2015, when the rate of increase slowed.

Uniquely, NT has seen the opposite pattern over time, with substantial treatment uptake seen in more recent years compared to other jurisdictions. Due to the impact of COVID-19, most jurisdictions saw marginal increases in the proportion of people receiving treatment for their CHB, with the exception of TAS and ACT which saw a 1.1% and 1.4% increase in the proportion receiving treatment in 2020 when compared to 2019 respectively (Figure 19). In 2020, no jurisdiction had reached the 2022 National Strategy target of 20% treatment uptake.

Figure 19. Estimated proportion of people living with chronic hepatitis B who were dispensed drugs for the treatment of hepatitis B through the PBS by jurisdiction, 2011-2020.

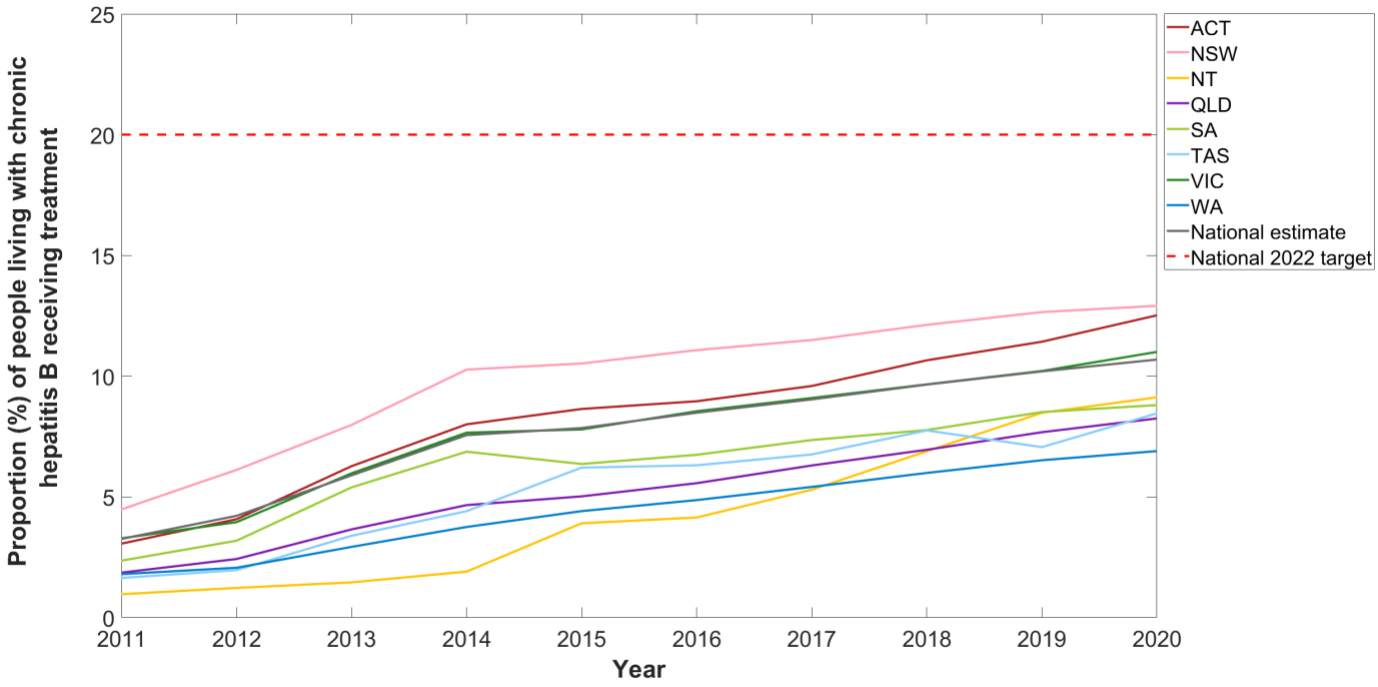


Table 7. Estimated proportion of people living with chronic hepatitis B who were dispensed drugs for the treatment of hepatitis B through the PBS by jurisdiction, 2020

State/Territory	Proportion receiving treatment	Plausible range	
		Minimum	Maximum
ACT	12.5%	11.5%	13.6%
NSW	12.9%	11.9%	14.0%
NT	9.1%	8.7%	9.6%
QLD	8.3%	7.9%	8.8%
SA	8.8%	8.2%	9.6%
TAS	8.5%	7.7%	9.3%
VIC	11.0%	10.0%	12.0%
WA	6.9%	6.4%	7.5%
Australia	10.7%	9.9%	11.6%

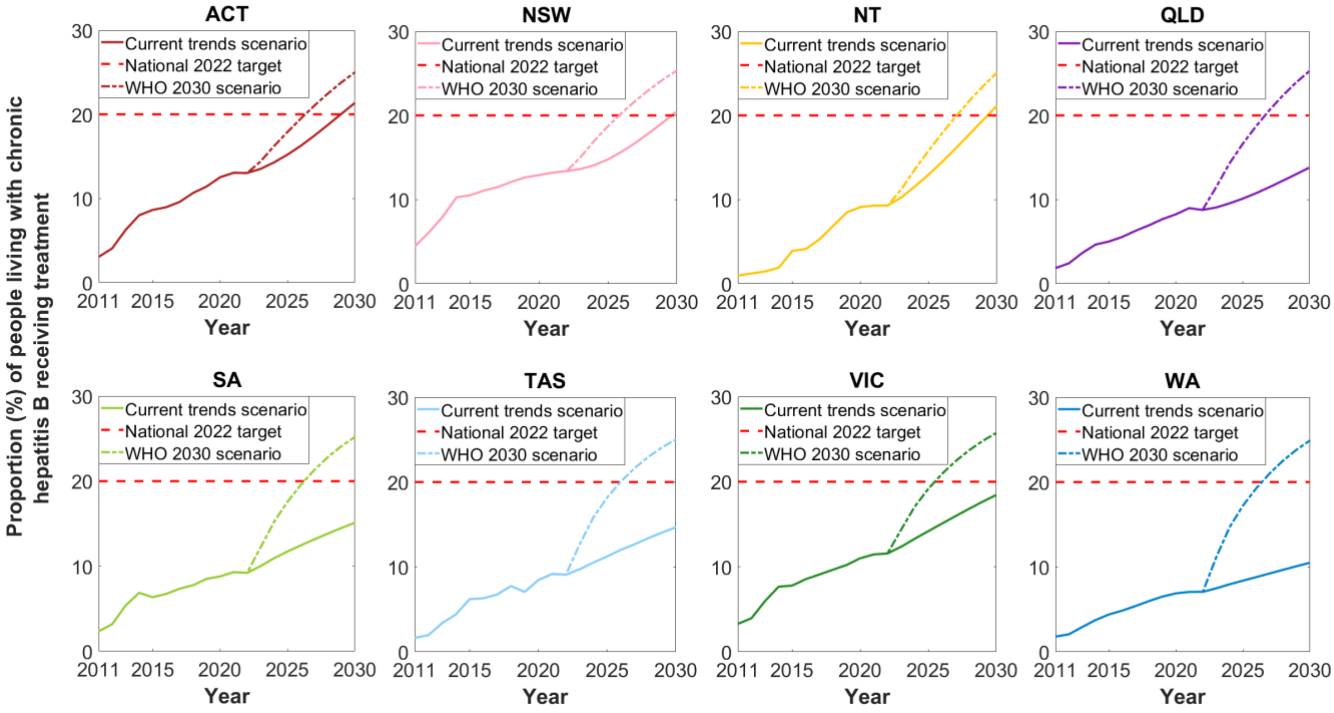
To explore future treatment uptake, two scenarios were modelled for each jurisdiction:

i. Current trends scenario: Assumes the number of people receiving treatment in 2021 & 2022 remain the same as in 2020, due to the impact of COVID-19. From 2023 onwards this scenario assumes the average annual increase follows 2016 – 2019 trends

ii. WHO 2030 scenario: Assumes the number of people receiving treatment in 2021 & 2022 remain the same as in 2020, due to the impact of COVID-19. From 2023 onwards future treatment uptake was modelled to ensure the WHO GHSS 2030 treatment target (80% of eligible people receiving treatment) was reached. From modelled estimates 80% of eligible people (see section A.2.4.1) receiving treatment equates to approximately 25% of all people living with CHB (Figure 20).

Under the current trends scenario, no jurisdiction reached the 2022 treatment target with ACT, NT and NSW estimated to have the highest proportion of people living with CHB receiving treatment in 2030, 21.4%, 21.2% and 20.5% respectively. Under the WHO 2030 scenario, jurisdictions only reach the 2022 target of 20% treatment uptake between 2026 and 2028, however this requires a substantial increase in uptake from 2023 onwards (Figure 20).

Figure 20: Estimated proportion of people living with chronic hepatitis B in Australia receiving treatment by jurisdictions, current trends vs WHO 2030 future treatment uptake scenarios



B.2.4.1 Treatment eligibility

As described in the National Estimates section of this report (section A.2.4.1), not all people living with CHB are eligible for treatment due to the dynamic natural history of hepatitis B. Estimates of the proportion of people living with CHB who are eligible for treatment range from approximately 10% to 31% [2, 28-32]. The true proportion of people living with chronic hepatitis B who require treatment will vary by hepatitis B genotype or country of birth as a proxy, age group, sex, and other factors. This has been highlighted when comparing the proportion eligible for treatment in each state and territory. In 2020, NT (32.0%), NSW (29.8%) and VIC (29.7%) were estimated to have the highest proportion of people living with CHB who are eligible for treatment, followed by WA (29.2%), SA (29.1%), QLD (28.8%), ACT (28.3%) and TAS (26.5%).

B.2.5 Burden of disease attributable to chronic hepatitis B in Australia

While national estimates demonstrated a gradual decline in deaths attributable to CHB from 2006 to 2019, this was largely driven by those jurisdictions with the largest number of people living with CHB receiving treatment (NSW and VIC), with this trend not being observed in all states and territories (Figure 21, Appendix Table A5).

NSW and VIC were estimated to have the highest burden of CHB attributable deaths in 2020 (119 and 105 deaths respectively, Table 8). Although burden is currently similar in NSW and VIC, this has not always been the case, with NSW historically having the highest numbers of deaths and experiencing a larger and earlier peak (199 in 2005) compared to VIC (163 in 2006). The more profound decline in total estimated deaths in NSW reflects the relatively higher treatment uptake in NSW when compared with VIC. In NT, SA and TAS, jurisdictions with lower treatment uptake, the total number of deaths attributable to CHB has only marginally declined. Similar trends can be seen for both HCC (Figure 22, Appendix Table A5) and DC (Figure 23, Appendix Table A6) attributable deaths.

The reduction in deaths attributable to CHB at the end of 2020 relative to the end of 2017 was variable between jurisdictions and is difficult to reliably estimate in states and territories with smaller populations of people living with CHB. Some jurisdictions with larger populations showed a higher reduction in deaths when compared to the national estimate of 2.4%, with QLD and VIC estimated to have reductions of 5.1% and 3.7%, respectively. WA showed a similar reduction in deaths of 2.1% when compared to the national estimate. However, in 2020, NSW was estimated to have a 1.7% increase in deaths when compared to the end of 2017, this is in part due to an aging population of people living with CHB and the plateauing of treatment uptake in recent years. With the impact of COVID-19, similar trends are likely to be seen in other jurisdictions over the next few years unless treatment uptake can be substantially increased.

Figure 21. Estimated number of deaths attributable to chronic hepatitis B by jurisdiction, 1991-2020.

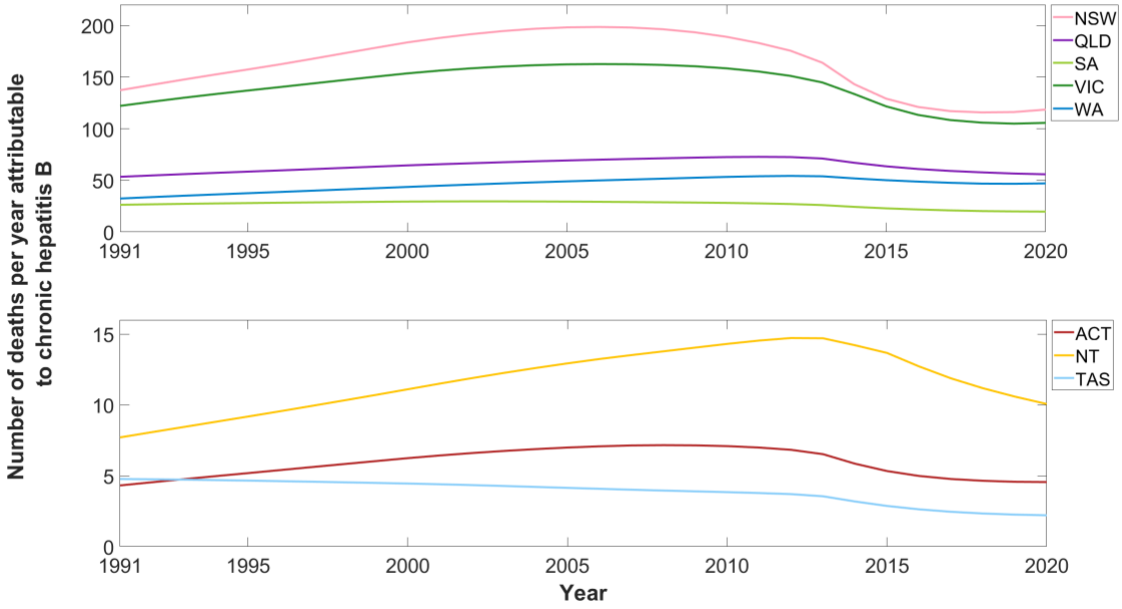


Table 8. Estimated number of total deaths attributable to chronic hepatitis B and population numbers by jurisdiction, 2020

State/Territory	Total deaths attributable to CHB	Plausible range		People living with CHB
		Minimum	Maximum	
ACT	<10	<10	<10	3,211
NSW	119	103	137	79,522
NT	10	10	11	4,538
QLD	56	51	61	33,987
SA	20	16	23	11,507
TAS	<10	<10	<10	1,513
VIC	105	87	128	64,632
WA	47	40	56	23,649
Australia	364	312	424	222,559

Figure 22. Estimated number of HCC deaths attributable to chronic hepatitis B across jurisdictions, 1991-2020.

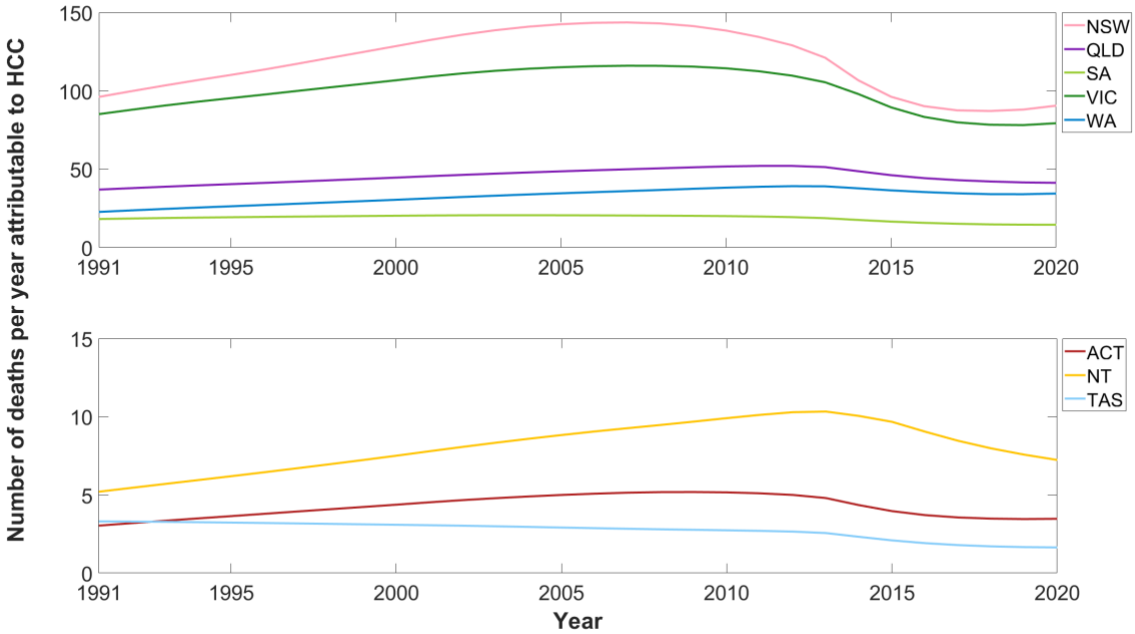


Figure 23. Estimated number of DC deaths attributable to chronic hepatitis B across jurisdictions, 1991-2020.

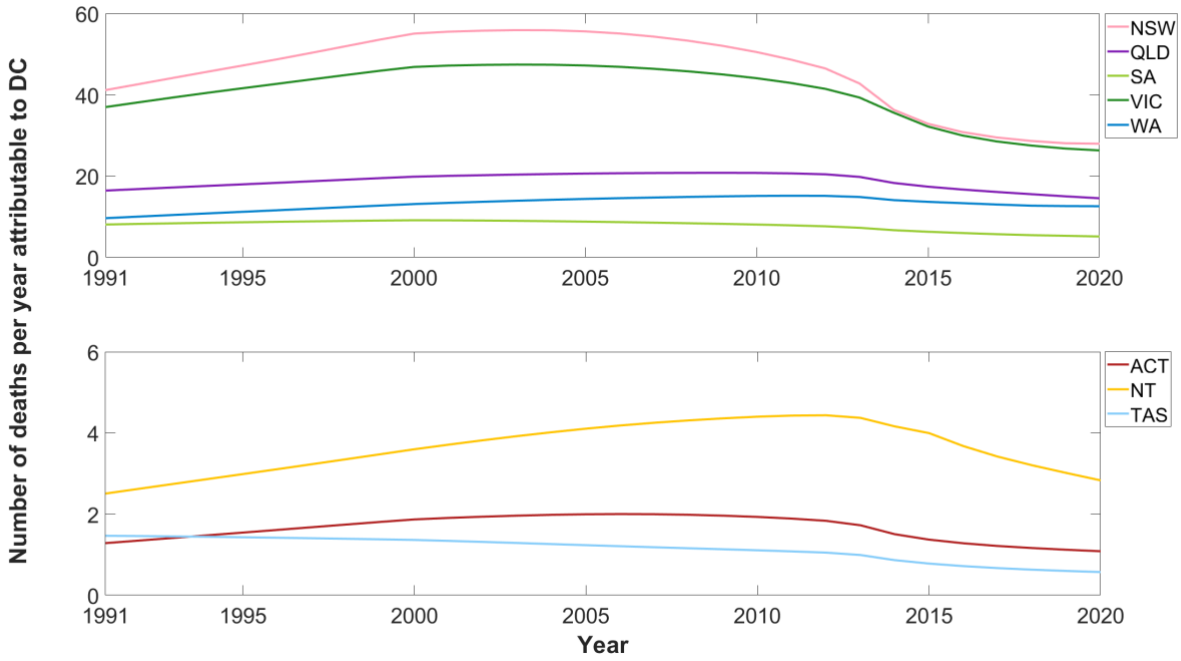


Table 9. Estimated number of HCC deaths and DC deaths attributable to chronic hepatitis B by jurisdictions in 2020

State/Territory	HCC deaths attributable to CHB	HCC Plausible range		DC deaths attributable to CHB	DC Plausible range	
		Minimum	Maximum		Minimum	Maximum
ACT	<10	<10	<10	<10	<10	<10
NSW	91	79	104	28	24	33
NT	<10	<10	<10	<10	<10	<10
QLD	41	38	45	15	13	16
SA	15	12	17	<10	<10	<10
TAS	<10	<10	<10	<10	<10	<10
VIC	79	66	95	26	21	33
WA	34	29	41	13	11	15
Australia	272	235	316	92	77	108

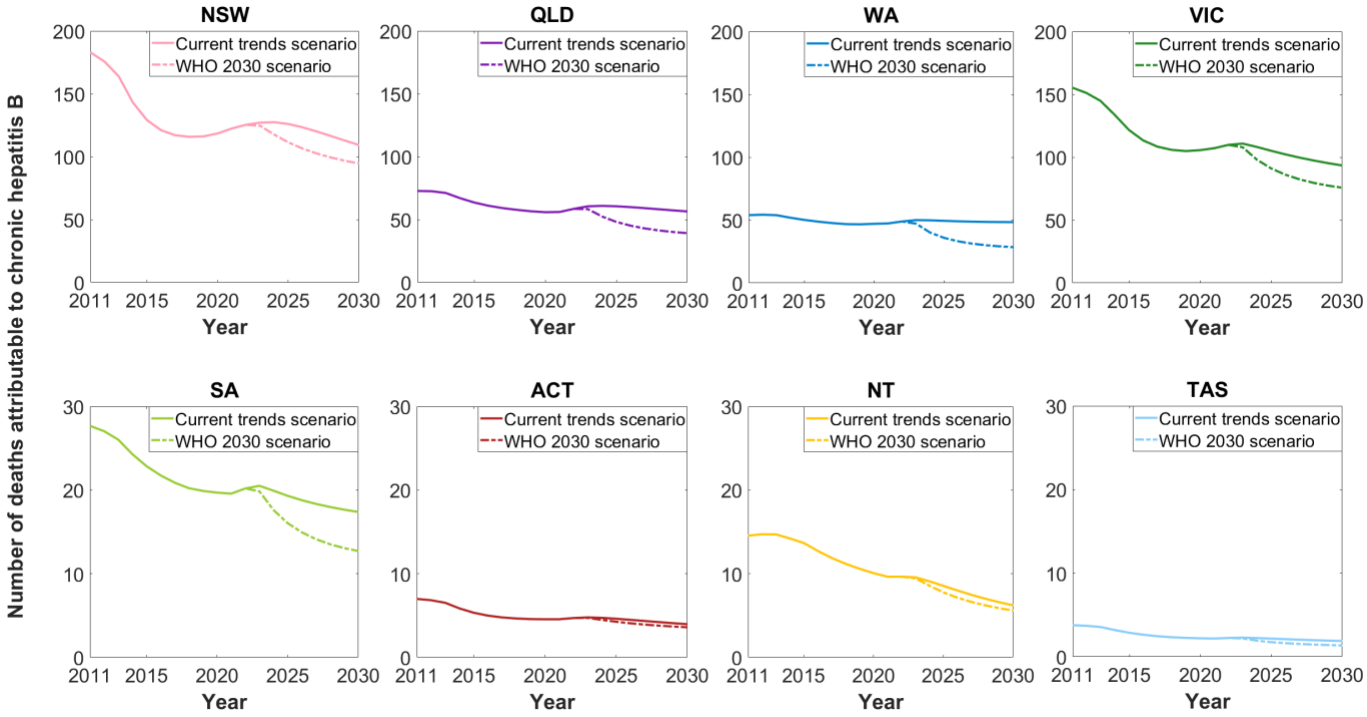
B.2.5.1 Impact of treatment on mortality

Considerable progress will be required in all jurisdictions to reach the National Strategy target of a 30% reduction in hepatitis B attributable mortality by 2022 compared to 2017. The estimated future mortality attributable to chronic hepatitis B depends on the future treatment uptake. Two treatment scenarios were modelled (Figure 20) - the current trends and WHO 2030 scenarios – which result in different reductions in future mortality.

Under the current trends treatment scenario, it is estimated that despite previous decreases, most jurisdictions will start to again see an increase in the number of deaths attributable to CHB (Figure 24) until 2024. This projected increase until 2024 is due to the fact that treatment uptake is increasing at a slower rate when compared to 2011 to 2015, combined with the continual increase in the estimated number of people living with CHB until 2019 and an ageing population (Figure 20). The projected decrease in the number of deaths attributable to CHB seen from 2024 onwards in most jurisdictions under the current trends scenario is due to the assumption that treatment numbers continue to increase similar to trends during 2016 – 2019 combined with the estimated decrease in numbers of people living with CHB due to the impact of COVID-19, followed by stabilising numbers toward 2030 (Figure 16). Under the current trends and WHO 2030 scenarios, future estimates to 2022 show QLD, VIC and NSW will have the highest estimated reduction in mortality when compared to 2017 of 5.2%, 2.3% and 2.1% respectively. This is due to both scenarios assuming the numbers receiving treatment in 2021-2022 remain stable due to the impact of COVID-19.

However, estimates from the WHO 2030 scenario showed mortality declines more rapidly from 2023 to 2030 when compared to the current trends scenario (Figure 24), particularly in jurisdictions with higher numbers of people living with CHB. Under the WHO 2030 scenario, the highest estimated reduction in mortality in 2030 when compared to 2015 is seen in WA (21.8%), QLD (20.8%), VIC (12.8%) and NSW (7.1%) (Figure 24). However, this requires substantial increase in the treatment uptake in jurisdictions from 2020 onwards (Figure 20).

Figure 24: Comparison of estimated total number of deaths attributable to chronic hepatitis B in each jurisdiction under the current trends and WHO 2030 treatment scenarios.



Note the difference in y-axis bounds between top and bottom rows.

C. Methodological Notes

To ensure estimates most accurately reflect the current epidemiology and clinical pattern of CHB in Australia, data inputs and assumptions are updated regularly to incorporate new information. For that reason new estimates may differ in some respects from previous outputs reported in the Kirby Institute's Annual Surveillance Reports[9], the Doherty Institute's National Viral Hepatitis Mapping Project Reports[4, 5, 13], and the National Surveillance for Hepatitis B Indicators: 2019 Annual Report[16].

C.1 Summary of mathematical model inputs

Mathematical Model Inputs	Source
Disease progression estimates	Published and grey literature, expert opinion
Australian demographic data	Australian Bureau of Statistics
Migration: Net overseas migration 1951 – 2020 2021 - 2050	 Australian Bureau of Statistics Wilson et al. NOM projections[20] and Australian Bureau of Statistics[24]
Migration: country of birth and age distribution 1951 – 1974 1974 – 1990 1991 – 2003 2004 - 2050	 Federation to Century's End Australian Bureau of Statistics Department of Social Services, Australian Bureau of Statistics Australian Bureau of Statistics
CHB prevalence by country of birth	Published literature
CHB phase distribution	Published and grey literature, expert opinion
Treatment uptake	Pharmaceutical Benefits Scheme
Vaccination uptake	Australian Immunisation Register data

C.2 Mathematical Model

The estimates presented in this report were derived from the recently published mathematical model [2]. The model is a dynamic, age-structured deterministic mathematical model that incorporates important demographic features such as births, migration, deaths and aging over time. To optimise accurate representation of the transmission, epidemiology and progression of hepatitis B, the model incorporates 9 exclusive health states, representing the natural history of hepatitis B; susceptible, immune (through vaccination), acute infection, immune tolerant, immune clearance, immune control, immune escape, decompensated cirrhosis, hepatocellular carcinoma and resolved infection. Chronic hepatitis B health states have also been differentiated into no-cirrhosis and cirrhosis classifications and stratified by those receiving treatment and those not

receiving treatment. This results in the model consisting of a total of 21 health states. Each health state is broken down into 18 age categories (those aged between 0 and 84 are grouped into 5-year age categories plus a final 85+ age group). Age groups were chosen to reflect the Australian population and to allow exploration of age-specific and health-state specific estimates, such as disaggregated mortality estimates for DC and HCC.

The model diagram can be found in Appendix Figure A1. Various data inputs and elements of the model are described below.

Disease progression estimates

Disease progression and transitions between each health state, including the impact of treatment on these, were generated based predominantly on a review of published and grey literature. Details of these transition estimates have been published elsewhere[2].

Transmission

A dynamic, age-adjusted measure of the force of infection is incorporated in the model to account for local transmission over time. The impact of vaccine uptake over time was modelled using the Australian Immunisation Register data by age and year. Measures of vaccine efficacy by age group were used to estimate the proportion of individuals receiving effective vaccination for hepatitis B in the Australian population.

Demographic data

The Australian Bureau of Statistics (ABS) provided the majority of the demographic data used in the model. This included total population numbers[33, 34], births[33], deaths[35, 36] and life tables[37] used to derive age-group mortality rates by taking the average rate across the 5 years included in each given age group.

Migration

In addition to Australia-specific demographic data, incoming migration by age and country of birth were also incorporated. Data regarding net overseas migration (NOM) produced by the ABS provided the total number of people entering the population from 1951 to 2020 as well as estimates of the proportion of future NOM entering each jurisdiction from 2021 to 2050[38]. Estimates of future NOM from Wilson and colleagues[20] was used for the total number of people entering the population from 2021 to 2050. Age and country of birth distributions within this were calculated using different sources dependent on time period and data availability:

- *2004 to 2020,* ABS NOM by country of birth and age distribution data were used to estimate the total number of people entering the population each year[17, 18].
- *1991 to 2003,* ABS NOM was used to estimate the total number of people entering the population each year[17]. DSS settlement data[19] were used to estimate the age distribution by country of birth by age by year.
- *1975 to 1990*, ABS NOM data[17] were used to estimate the total number of people entering the population each year. Combined with ABS permanent migration data by country of birth[39] these sources were used to estimate the number of migrants entering by country of

birth. National age distribution data were not available prior to 1991, so data from the state of Victoria (representing 25% of Australia's population) on age distribution during 1975 to 2006 were applied as they were found to be a reasonable approximation.
- *1951 to 1974*, the Department of Immigration resource Federation to Century's End was used to determine the number of permanent settlers to Australia by country of birth[40].

Prevalence

At the start of the modelled period (1951), the baseline prevalence of the Australian population was assumed to be 0.5%[41], representing a low prevalence country. The number of people living with CHB migrating to Australia each year was derived using the estimated prevalence of CHB according to country of birth. To account for changing age-specific source population prevalence over time (due predominantly to infant vaccination programs), we derived varying prevalence estimates across different time periods and applied these to migration data according to age group and year of arrival for country of birth for the majority of migrants to Australia. Prevalence for the top 4 countries of birth for CHB was estimated using a separate method (see 'Direct estimation of immunisation impact' section, below). Different data sources were used for different time periods:

- *1991 to 2050,* For those migrating into Australia born in 1991 or later, prevalence estimates derived for the Viral Hepatitis Mapping Project National Report 2018-2019[4] were applied. These prevalence estimates were taken predominately from local seroprevalence surveys,[42-44] supplemented with global systematic reviews[45, 46]. Antenatal estimates were adjusted upwards to correct for the discrepancy in CHB prevalence by sex[47].
- *1951 to 1990,* For those migrating into Australia born prior to 1991, prevalence estimates derived by the CDC as of 2008 were applied[41]. Countries were divided into three categories, based on the prevalence during this period; low prevalence (0.5%), intermediate prevalence (5%) and high prevalence (10%). These estimates are higher compared to those during 1991-2020 which takes into account prevalence estimates in the pre-vaccination era.

Direct estimation of immunisation impact

A literature review was conducted to obtain age- and year-prevalence estimates for the 4 countries which had the highest numbers of people living with CHB in Australia - China, Vietnam, Philippines and Taiwan[4, 13, 45, 48-52]. Specific prevalence estimates by country and year of birth were applied to incoming migrants.

Phase distribution

Individuals living with CHB migrate into Australia in different disease phases. The proportion of individuals living with CHB in each disease phase (immune tolerant, immune clearance, immune control and immune escape) by age group were derived for different world regions using published data and expert opinion[53-55]. All source countries were categorised into three world regions (Asia/Pacific, Africa, and Other) to account for differences in natural history.

Treatment

This model incorporates the impact of treatment by estimating differential uptake rates by disease phase, with proportions according to disease phase determined using expert opinion and literature reviews, which were then fitted to treatment uptake derived from PBS data.
Data obtained from PBS records were used to derive the number of people on treatment in Australia each year since 2000. It excludes individuals prescribed lamivudine or tenofovir for HIV infection.

Plausible range

The plausible ranges reported were derived by allowing the force of infection, migrant population prevalence, proportion of migrants with CHB living with cirrhosis, CHB mortality, and other disease transition estimates to vary according to prior knowledge of possible distributions[2]. In addition, for modelled future projection estimates the total number of migrants entering the population varied for 2021 – 2030 according to the short, moderate and long impact scenarios[20]. This was achieved using Latin-hypercube sampling (LHS), as described by Marino et al.[56] The national mathematical model was run using 1000 different combinations of these varied parameters (while the jurisdiction models were run using 100 different combinations of these varied parameters), which produced a range of overall estimates. The minimum and maximum estimates defined by the 10th and 90th percentiles respectively were then used to define the plausible range around the point estimate value.

Jurisdictional estimates

The national model was applied to each state and territory using state specific demographic information obtained from the ABS. Some of the data sources differed from the national model due to availability and appropriateness of data. For years when ABS NOM by jurisdiction was not available (1951 to 1971), we imputed total numbers entering the population for each jurisdiction by applying a proportion (derived from available jurisdiction NOM breakdown) to the national NOM by year. The age distribution of incoming migrants by country of birth was imputed for missing years based on the overall age distribution of permanent settlers arriving in 1991 (obtained from DSS settlement data) which were applied back to 1951.

Although the national model does not currently explicitly model the differential prevalence among Aboriginal and/or Torres Strait Islander peoples, this was incorporated into the model for state and territories where this proportionally has the greatest effect on the number of people living with CHB (QLD and NT). This also ensures that estimates in QLD and NT more accurately reflect the true population. This was incorporated by adjusting the prevalence among the proportion of Aboriginal and/or Torres Strait Islander peoples living in both jurisdictions[57-59].

Prior to 1990, Census data poorly reflect the actual number of Aboriginal and/or Torres Strait Islander peoples living in Australia[60], which underestimates the population and has a substantial impact on output estimates. To better reflect total population numbers in the years prior to 1990, reported populations and number of births were adjusted upwards each year in accordance with the proportion of Aboriginal and/or Torres Strait Islander population and births during the 1991 to 2016[61]. Differential phase information for Aboriginal and/or Torres Strait Islander peoples living

with CHB was estimated[62] to reflect the differences in natural history. Data were provided from the Hepatitis B Sero-Coding Project, Northern Territory Government. Further model development will incorporate adjustments for the remaining states and territories, dependent on the availability of appropriate data.

Each jurisdiction was modelled separately to adequately capture trends in the epidemiology of CHB over time. Jurisdictional estimates were then standardized to ensure the sum of indicator variables across the jurisdictions matches the modelled national estimate.

C.3 Methodology for Indicators

1: Estimating the number of people living with chronic hepatitis B in Australia
The total number of people living with chronic hepatitis B in Australia and the number according to age group and state and territory are direct outputs of the model. Prevalence of CHB was calculated using the number of people living with chronic hepatitis B as the numerator and the total population according to ABS numbers as the denominator.

2: Estimating the proportion of people living with chronic hepatitis B in Australia who have not been diagnosed
The number of people living with hepatitis B who have been diagnosed is derived using the model output of the number of people who have ever lived with CHB in Australia since 1951 as the denominator and the cumulative number of notifications of hepatitis B from 1971 to 2020 as the numerator. Notification data has been sourced from the National Notifiable Diseases Surveillance (NNDSS) system. The proportion of people living with chronic hepatitis B in Australia who have not been diagnosed is one minus the proportion who have been diagnosed.

NNDSS data may contain duplicates if individuals have been diagnosed in multiple jurisdictions, inflating the number ever diagnosed. A national linkage study has commenced under the auspices of this project which aims to quantify the extent of duplicate reporting across jurisdictions to the NNDSS for both hepatitis B and hepatitis C, allowing identification of the true number of individuals diagnosed and refining of modelled estimates. When the results of this national notifications linkage project are available the results will be incorporated into this model.

3: Estimating the proportion of people living with chronic hepatitis B who are engaged in care, receiving either treatment or monitoring
The proportion of people living with CHB who are receiving care was calculated using the number of people receiving either treatment or monitoring as the numerator and the modelled number of people living with CHB as the denominator.

The number of people receiving monitoring was obtained from Medicare Benefits Schedule (MBS) records and calculated by assessing the number of individuals who received a viral load test in a given year while not receiving treatment items in the past 12 months, in order to identify those undergoing off-treatment monitoring separately from those monitored during treatment. This number was then combined with the number of individuals who were receiving treatment, to

generate the number in care. The number of people receiving treatment was obtained from PBS records and excludes individuals prescribed lamivudine or tenofovir for HIV infection.

These data do not include services that were not provided by Medicare, such as those paid for by individual patients, or subsidised by state government services. However, previous analyses and comparison with other source data demonstrate that the vast majority of testing and treatment services for patients with hepatitis B are provided through Medicare and included in these estimates[1].

4: Estimating the proportion of people living with chronic hepatitis B who are dispensed drugs for the treatment of hepatitis B through the Pharmaceutical Benefits Scheme

The proportion of people living with CHB who are receiving treatment was calculated using the number of people receiving treatment (obtained from PBS data) as the numerator and the modelled number of people living with CHB as the denominator.

The proportion eligible for treatment is derived by dividing the modelled number of people eligible for treatment by the modelled number of all people living with chronic hepatitis B.

5: Estimating the burden of disease attributable to chronic hepatitis B in Australia

The number of deaths attributable to CHB, and specifically due to DC and HCC, in Australia is a direct output of the model.

D. Appendix

Table A1. *Model output for the number of people living with chronic hepatitis B in Australia per year, 1970-2030*

Year	National	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
1970	74264	704	24679	1276	11274	6170	1315	22925	5921
1971	75556	731	25018	1387	11459	6212	1301	23309	6139
1972	76630	759	25293	1500	11619	6238	1283	23624	6314
1973	77062	791	25397	1601	11698	6221	1257	23745	6352
1974	77650	821	25569	1704	11790	6213	1230	23895	6428
1975	77981	846	25680	1793	11752	6149	1202	24032	6527
1976	77226	865	25446	1839	11594	5974	1165	23896	6447
1977	77730	897	25727	1937	11513	5876	1135	24150	6495
1978	79454	935	26574	2075	11522	5839	1111	24766	6632
1979	80920	973	27475	2191	11556	5711	1077	25269	6668
1980	83309	1018	28788	2273	11700	5676	1055	26002	6797
1981	86493	1070	30300	2352	11966	5762	1039	26921	7083
1982	90200	1120	31903	2463	12338	5902	1027	27921	7526
1983	93106	1157	33072	2550	12591	6063	1012	28762	7899
1984	94870	1193	33762	2655	12643	6200	1001	29366	8050
1985	97175	1236	34827	2764	12747	6289	993	30102	8217
1986	100690	1293	36377	2891	12999	6402	989	31117	8622
1987	105196	1368	38399	3001	13346	6524	987	32381	9190
1988	111066	1457	41073	3107	13854	6650	984	34017	9924
1989	117613	1546	43948	3213	14512	6818	981	35796	10799
1990	122643	1631	46186	3312	14966	6941	971	37216	11420
1991	126132	1706	47848	3393	15302	7008	953	38159	11763
1992	127681	1752	48724	3438	15554	6982	928	38465	11838
1993	127553	1777	48833	3474	15614	6890	897	38261	11807
1994	127171	1800	48822	3514	15634	6785	868	37949	11799
1995	128142	1832	49489	3571	15771	6710	844	38030	11895
1996	130068	1859	50665	3635	16002	6664	824	38367	12052
1997	131110	1873	51381	3685	16186	6594	801	38445	12145
1998	131662	1888	51731	3737	16330	6514	779	38460	12223
1999	132676	1910	52307	3801	16490	6444	759	38620	12345
2000	134035	1942	53082	3842	16652	6377	735	38896	12509
2001	136080	1970	54188	3862	16939	6317	721	39329	12754
2002	138314	1995	55278	3877	17457	6264	716	39716	13011
2003	140118	2035	55931	3884	17980	6233	717	40089	13249
2004	143419	2092	56904	3907	18664	6393	763	41067	13629
2005	147866	2144	58290	3927	19511	6716	821	42342	14115
2006	152820	2193	59927	3917	20430	7092	864	43722	14675

2007	159622	2263	62158	3935	21590	7545	915	45732	15484
2008	168665	2369	64966	4012	23191	8098	978	48406	16645
2009	177090	2493	67289	4093	24845	8671	1038	50971	17690
2010	181736	2565	68288	4158	25916	9041	1072	52277	18419
2011	184581	2610	68699	4218	26707	9232	1094	52884	19137
2012	188341	2674	69392	4299	27669	9417	1118	53739	20033
2013	193092	2742	70575	4378	28698	9693	1150	55007	20849
2014	197876	2823	72073	4405	29590	9997	1179	56427	21382
2015	202777	2916	73674	4426	30341	10293	1207	57978	21942
2016	208535	3013	75546	4460	31209	10587	1252	59895	22573
2017	214173	3117	77548	4492	32070	10863	1317	61844	22922
2018	218964	3200	79130	4513	32922	11121	1406	63529	23143
2019	223860	3247	80388	4549	33843	11477	1501	65261	23594
2020	222559	3211	79522	4538	33987	11507	1513	64632	23649
2021	217626	3135	77603	4484	33575	11275	1480	62844	23230
2022	213932	3077	76071	4436	33351	11068	1453	61581	22895
2023	212347	3048	75154	4411	33489	10971	1438	60930	22906
2024	212609	3045	74781	4406	33941	10978	1436	60761	23261
2025	213760	3057	74663	4411	34547	11033	1441	60820	23788
2026	215085	3072	74595	4418	35182	11098	1447	60921	24352
2027	216248	3084	74479	4425	35789	11152	1452	60978	24889
2028	217187	3093	74299	4429	36356	11192	1456	60975	25387
2029	217912	3100	74059	4431	36883	11219	1458	60914	25848
2030	218414	3103	73757	4433	37369	11233	1459	60791	26269

Table A2. *Model output for the proportion of people living with chronic hepatitis B in Australia who have been diagnosed, 2011-2020*

Year	National (%)	ACT (%)	NSW (%)	NT (%)	QLD (%)	SA (%)	TAS (%)	VIC (%)	WA (%)
2011	65.44%	60.85%	70.56%	56.97%	70.25%	62.63%	46.09%	55.78%	48.87%
2012	66.67%	62.50%	72.05%	59.01%	70.03%	64.01%	48.03%	57.24%	49.96%
2013	67.77%	64.08%	73.33%	63.22%	69.94%	64.56%	49.47%	58.35%	51.64%
2014	68.63%	64.97%	74.34%	64.95%	70.28%	65.23%	50.94%	59.17%	52.58%
2015	69.39%	65.19%	75.03%	66.81%	71.07%	65.68%	51.75%	59.88%	53.18%
2016	69.92%	65.46%	75.49%	67.64%	71.63%	65.97%	52.05%	60.27%	53.92%
2017	70.31%	65.55%	75.82%	68.32%	71.89%	66.22%	51.94%	60.61%	54.83%
2018	70.88%	65.99%	76.53%	68.89%	72.08%	66.37%	51.42%	61.10%	55.82%
2019	71.31%	67.07%	77.25%	69.20%	72.24%	66.33%	51.62%	61.46%	56.11%
2020	73.01%	69.26%	79.22%	69.99%	73.39%	67.17%	53.10%	63.00%	57.30%

Table A3. *Model output for the proportion of people living with chronic hepatitis B in Australia who are engaged in care, 2011-2020*

Year	National (%)	ACT (%)	NSW (%)	NT (%)	QLD (%)	SA (%)	TAS (%)	VIC (%)	WA (%)
2011	12.3%	9.4%	14.8%	2.6%	8.6%	8.4%	6.7%	15.0%	3.8%
2012	14.8%	13.0%	17.5%	9.7%	10.6%	10.5%	7.1%	18.1%	5.2%
2013	17.2%	17.6%	20.0%	13.6%	12.1%	16.5%	9.3%	21.0%	6.4%
2014	20.3%	19.5%	24.2%	16.7%	13.2%	20.4%	11.5%	24.3%	7.4%
2015	20.3%	20.1%	24.8%	19.8%	13.4%	20.3%	15.8%	22.6%	8.7%
2016	21.4%	21.5%	25.8%	19.1%	14.5%	21.7%	17.3%	23.6%	9.8%
2017	22.0%	21.3%	26.0%	20.7%	16.6%	20.8%	19.4%	24.1%	10.2%
2018	22.8%	23.4%	27.3%	26.7%	17.9%	20.1%	18.2%	24.6%	9.6%
2019	23.2%	24.4%	27.7%	25.0%	18.4%	19.4%	17.3%	25.5%	9.8%
2020	22.6%	25.7%	27.0%	24.8%	18.8%	16.7%	17.3%	24.4%	10.2%

Table A4. *Model output for the proportion of people living with chronic hepatitis B in Australia who are dispensed drugs for the treatment of hepatitis B through the PBS, 2011-2020*

Year	National (%)	ACT (%)	NSW (%)	NT (%)	QLD (%)	SA (%)	TAS (%)	VIC (%)	WA (%)
2011	3.3%	3.1%	4.5%	1.0%	1.9%	2.4%	1.6%	3.3%	1.8%
2012	4.2%	4.1%	6.1%	1.2%	2.4%	3.2%	2.0%	4.0%	2.1%
2013	5.9%	6.3%	8.0%	1.5%	3.7%	5.4%	3.4%	6.0%	2.9%
2014	7.6%	8.0%	10.3%	1.9%	4.7%	6.9%	4.4%	7.7%	3.8%
2015	7.9%	8.6%	10.5%	3.9%	5.0%	6.4%	6.2%	7.8%	4.4%
2016	8.5%	9.0%	11.1%	4.1%	5.6%	6.7%	6.3%	8.5%	4.9%
2017	9.0%	9.6%	11.5%	5.3%	6.3%	7.4%	6.8%	9.1%	5.4%
2018	9.7%	10.7%	12.1%	6.9%	7.0%	7.8%	7.8%	9.7%	6.0%
2019	10.2%	11.4%	12.7%	8.5%	7.7%	8.5%	7.1%	10.2%	6.5%
2020	10.7%	12.5%	12.9%	9.1%	8.3%	8.8%	8.5%	11.0%	6.9%

Table A5. *Model output for the total number of deaths attributable to chronic hepatitis B in Australia, 2011-2020*

Year	National	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
2011	518	7	183	14	73	28	4	155	54
2012	504	7	175	14	72	27	4	151	54
2013	484	7	164	14	71	26	4	144	54
2014	444	6	143	14	67	25	3	134	52
2015	408	5	129	14	63	23	3	121	50
2016	386	5	121	13	61	22	3	113	48
2017	373	5	117	11	59	21	3	109	48
2018	365	4	116	11	58	20	3	106	47
2019	363	4	116	11	57	20	3	105	47
2020	364	4	119	10	56	20	3	105	47

Table A6. *Model output for the total number of HCC deaths attributable to chronic hepatitis B in Australia, 2011-2020*

Year	National	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
2011	375	5	134	10	52	20	3	112	39
2012	367	5	129	10	52	19	3	110	39
2013	353	5	121	10	51	19	3	105	39
2014	326	4	107	10	49	18	2	98	38
2015	300	4	96	10	46	17	2	89	36
2016	283	4	90	9	44	16	2	83	35
2017	275	4	88	8	43	15	2	80	35
2018	269	3	87	8	42	15	2	78	34
2019	270	3	88	8	42	15	2	78	34
2020	272	3	91	7	41	15	2	79	34

Table A7. *Model output for the total number of DC deaths attributable to chronic hepatitis B in Australia, 2011-2020*

Year	National	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
2011	143	2	49	4	21	8	1	43	15
2012	137	2	46	4	20	8	1	41	15
2013	131	2	43	4	20	7	1	39	15
2014	118	2	36	4	18	7	1	36	14
2015	108	1	33	4	17	6	1	32	14
2016	103	1	31	4	17	6	1	30	13
2017	98	1	29	3	16	6	1	29	13
2018	96	1	29	3	16	5	1	28	13
2019	93	1	28	3	15	5	1	27	13
2020	92	1	28	3	15	5	1	26	13

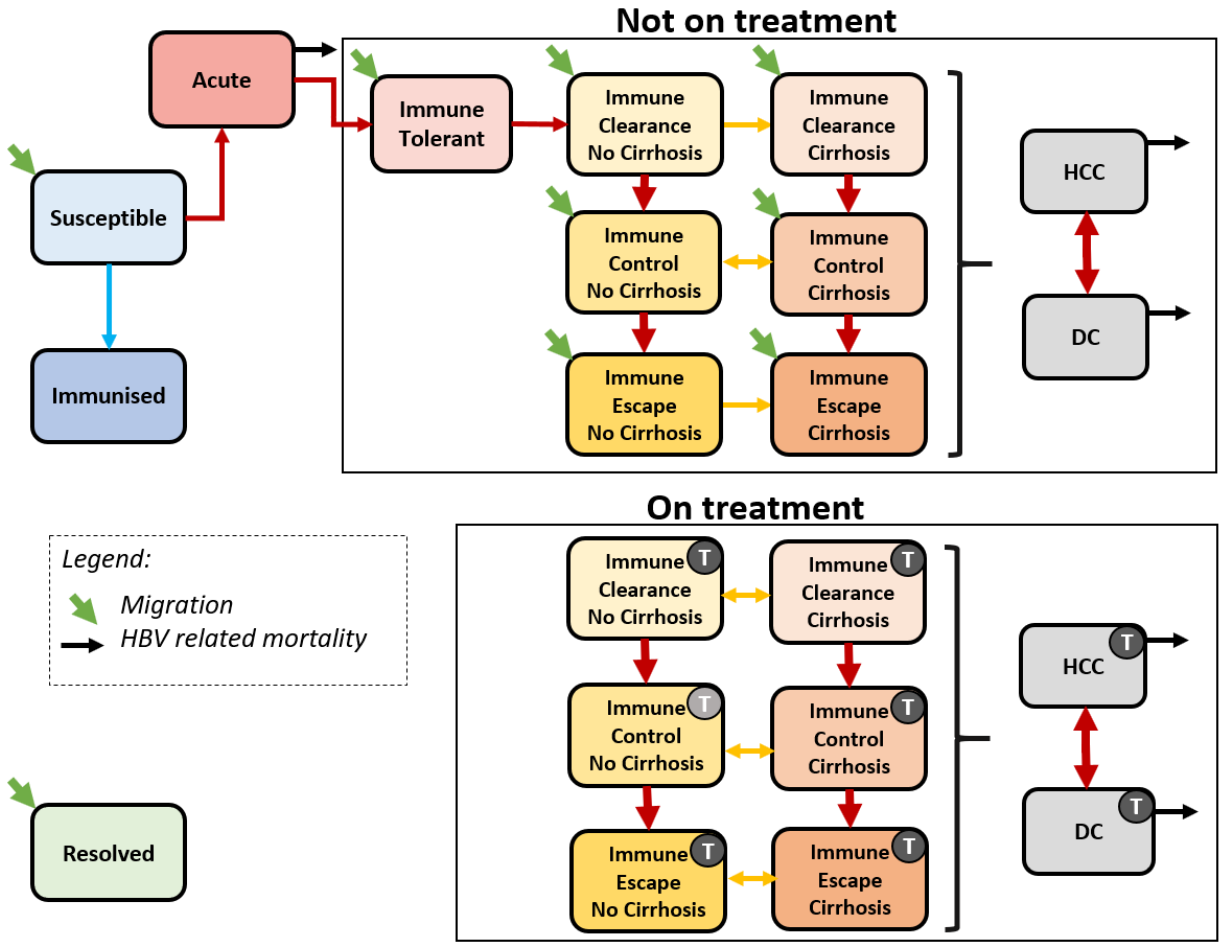


Figure A1: Schematic diagram of the mathematical model describing the progression of hepatitis B infection and indicating key transitions. Chronic hepatitis B phases are within the boxes. Phases with a 'T' indicate individuals in that phase receiving treatment. Light grey treatment icon indicates those who have transitioned into this phase while on treatment. HCC = hepatocellular carcinoma; DC = decompensated cirrhosis. Coloured arrows represent transitions between states. Each health state is stratefied by age. Resolution of infection is possible from acute infection and from CHB phases and results in the transition into the resolved state.

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