National Surveillance for Hepatitis B Indicators

Measuring the progress towards the targets of the National Hepatitis B Strategy
Annual Report 2018

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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
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

WHO Collaborating Centre for Viral Hepatitis VIDRL

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Contents

Executive Summary

Number of people living with chronic hepatitis B:

- In 2018 an estimated 226,566 people were living with chronic hepatitis B (CHB) in Australia, representing 0.9% of the population.
- A decrease in prevalence can be seen from 1991 onwards in under 20 year olds, highlighting the achievements of hepatitis B vaccination uptake.

Chronic hepatitis B diagnosis:

- An estimated 154,246 people living with CHB in Australia had been diagnosed in 2018, representing 68.1% of the total.
- The proportion diagnosed in 2018 remains below the National Strategy target of 80%, with 38,707 more people living with CHB requiring diagnosis to reach this by 2022.

Chronic hepatitis B engagement in care:

- During 2018, an estimated 50,970 people were engaged in care for their CHB, receiving either antiviral treatment or monitoring, representing 22.5% of the total.
- The proportion engaged in care in 2018 remains below the National Strategy target of 50%, with 69,626 more people required to be in care to reach this by 2022.

Chronic hepatitis B treatment:

- In 2018, 20,495 people were dispensed drugs for the treatment of hepatitis B through the Pharmaceutical Benefits Scheme, which is an estimated 9.0% of all people living with CHB.
- The proportion on treatment in 2018 remains below the National Strategy target of 20% with 27,743 more people requiring treatment to reach this target by 2022.

Burden attributable to chronic hepatitis B:

- The number of deaths attributable to CHB in 2018 was estimated to be 435. Most deaths were attributable to hepatocellular carcinoma (HCC), which was responsible for 322 deaths, while 113 people were estimated to have died due to decompensated cirrhosis (DC).

Jurisdictional disparities:

- Substantial differences in estimated prevalence, access to care and burden of disease in 2018 are noted between states and territories, and in trends over time;
    - Prevalence of CHB ranges from 0.3% to 1.8%
    - The proportion diagnosed ranges from 47.9% to 77.9%
    - The proportion in care ranges from 10.4% to 27.8%, with the proportion of all those living with CHB receiving antiviral treatment ranging from 5.7% to 11.4%
    - The drop in estimated deaths due to CHB between 2011 and 2018 ranges from 0% to 30% - however accurate estimation is difficult particularly in jurisdictions with relatively low populations of people living with CHB.

Introduction

Chronic hepatitis B (CHB) is a significant public health burden and is now the most prevalent blood-borne viral infection in Australia.[1] CHB is a leading cause of liver cancer, the 6th most common cause of cancer mortality in Australia.[2] 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[3] (National Strategy), released in 2018 sets goals to make significant progress towards eliminating hepatitis B as a public 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**
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

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[4], 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 2nd National Hepatitis B Strategy 2014-2017 and reporting against Hepatitis B Indicators in the National Blood-borne Viruses and Sexually Transmissible Infections Surveillance and Monitoring Plan 2014-2017.

With this strategy ending in 2017, and the release of the new strategy in 2018, this report will focus on reporting against cascade of care and disease burden targets and indicators in the 3rd National Hepatitis B Strategy 2018-2022. This report will not report against vaccination, reduction in local transmission or stigma targets specifically.

This report for the year 2018 is the second publicly available National Surveillance for Hepatitis B Indicators Annual Report. The first publicly available report, presenting estimates for 2017, can be accessed at: https://www.doherty.edu.au/whoccvh/centre-activities/research/blood-born-viruses-and-sexually-transmissible-infections-surveillance-and-research-programme.

Report Updates

Indicator data estimates have been derived using mathematical modelling, extending on previous work.[5-7] These new simulations use additional population information and incorporate increased complexity including disease transition states, treatment uptake and treatment impact. The model accounts for diversity in prevalence and the impact of overseas migration, examining the impact of domestic and overseas vaccination programmes at a population level.

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 new estimates differ in some respects from previous outputs reported in the Kirby Institute's Annual Surveillance Reports,[8] the Doherty Institute's National Viral Hepatitis Mapping Project Reports,[1, 9] and the National Surveillance for Hepatitis B Indicators: 2017 Annual Report.[10] Updates from previously reported 2017 estimates include:

- Newly available net overseas migration (NOM) numbers by country of birth have been incorporated from 2005 onwards. Previously the proportion of migrants from each country of birth were taken from Department of Social Services (DSS) Settlement Data, which assumed the proportion of migrant settlers by country was equal to those leaving Australia.
- Detailed prevalence estimates by year of birth are applied to incoming migrants for the top countries of birth living with CHB. This was previously incorporated for China, Vietnam and Philippines and now also includes Taiwan – together estimated to represent over 45% of migrants living with CHB in Australia in 2016.[11]
- While differential prevalence in Aboriginal and/or Torres Strait Islander peoples is not separately simulated in the national model, this was performed for specific state and territory models, to ensure that the models in these jurisdictions more accurately reflect these differences. Prevalence estimates for Aboriginal and/or Torres Strait Islander peoples in QLD and NT were updated according to newly published research.[12] The proportion of Aboriginal and/or Torres Strait Islander peoples in each disease phase was also updated using real-world data provided by Hepatitis B Sero-coding Project, Northern Territory Government.[13]
- Notification data has been extended to include jurisdictional specific notifications prior to 1991. This has increased the proportion diagnosed in every jurisdiction, with differential effects across states and territories.
- Disease transmission estimates for progression to HCC and mortality rates have been adjusted.
- As each jurisdiction is modelled separately, the sum of estimates across all jurisdictions varies from the modelled national estimate. Jurisdictional estimates have now been standardized to ensure the sum of indicator variables across the jurisdictions matches the modelled national estimate.

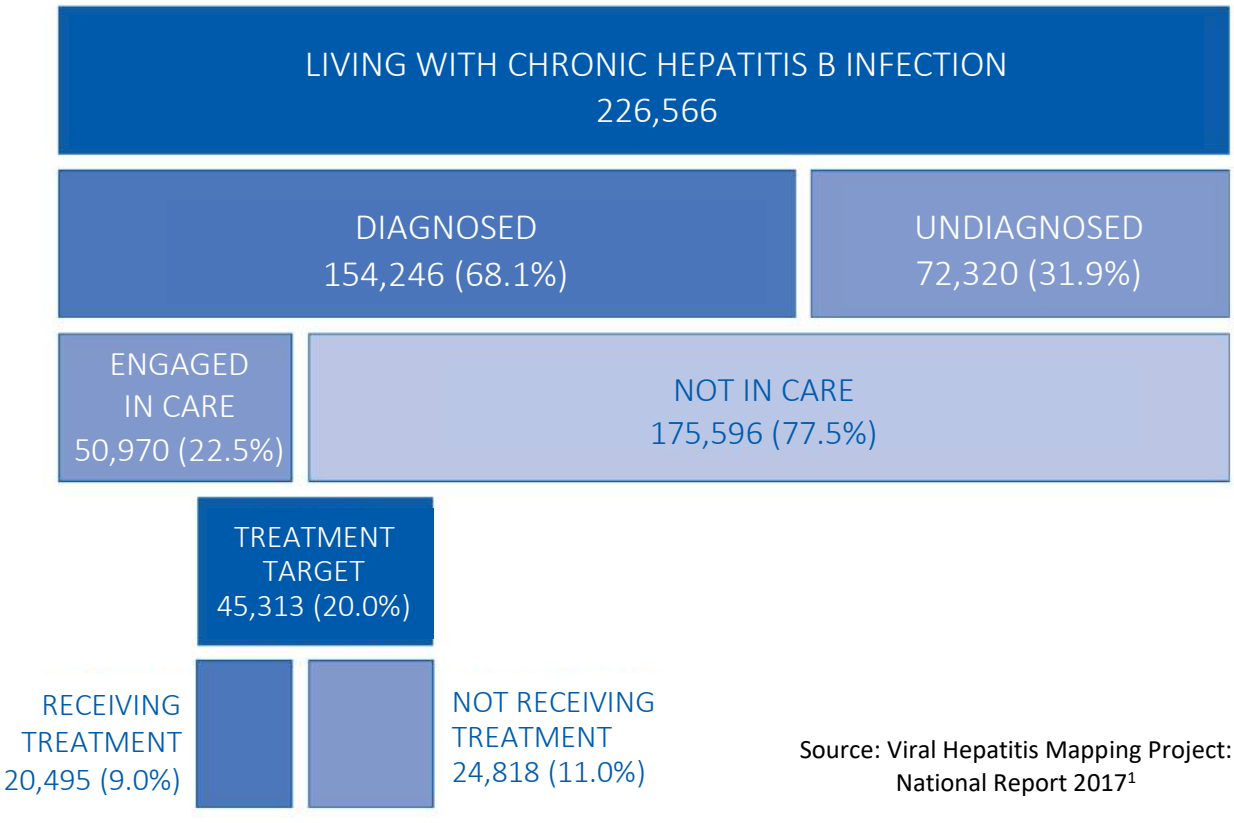
National

Summary National Estimates

Table 1. Australian summary for hepatitis B indicator estimates, 2018

Indicators	Point estimate	Plausible range	
		Minimum	Maximum
1. People living with CHB	226,566	192,534	281,728
2. Proportion of people living with CHB in Australia who have been diagnosed	68.1%	50.1%	83.6%
3. Proportion of people living with CHB in Australia who are receiving care	22.5%	18.1%	26.5%
4. Proportion of people living with CHB who are dispensed drugs for the treatment of hepatitis B	9.0%	7.3%	10.6%
5. Number of attributable deaths due to CHB	435	309	670
6. Number of deaths due to hepatocellular carcinoma attributable to CHB	322	234	491
7. Number of deaths due to attributable to decompensated cirrhosis CHB	113	75	179

Figure 1. Chronic hepatitis B cascade of care, Australia, 2018



Source: Viral Hepatitis Mapping Project: National Report 2017[1]

Progress Towards National Cascade of Care Targets

Despite an increase in the number of people having been 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.[10] 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

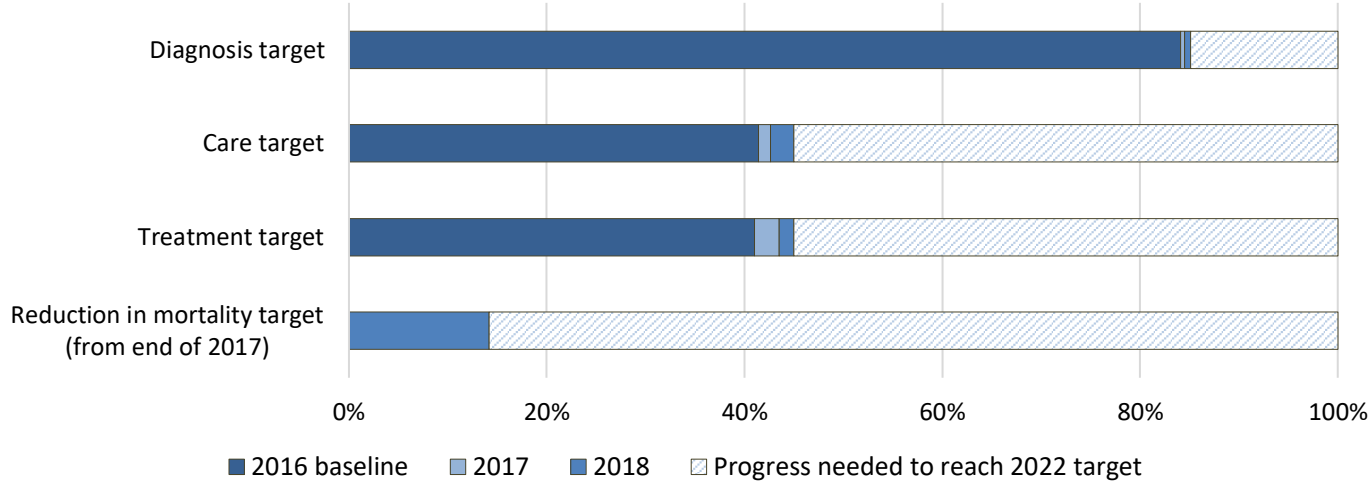


Table 2. Tracking the 3rd National Hepatitis B Strategy 2018-2022 targets

Indicator	2016	2017	2018	2022 Target
Proportion of people living with CHB who have been diagnosed	67.4%	67.6%	68.1%	80.0%
Proportion of people living with CHB who are in care	20.8%	21.3%	22.5%	50.0%
Proportion of people living with CHB who have been treated	8.2%	8.7%	9.0%	20.0%
Reduction of hepatitis B attributable mortality (from end of 2017)	-	-	3.76%	30.0%

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

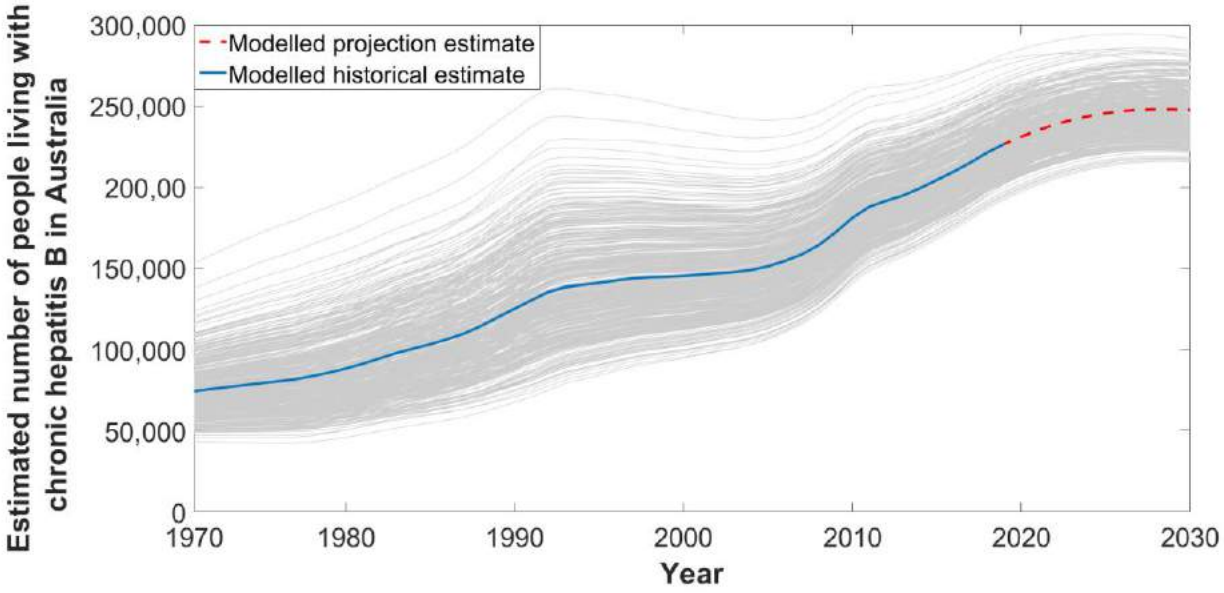
- Increase the number of people diagnosed from 154,246 in 2018 to 222,006 by 2030
- Increase the number of people treated from 20,495 in 2018 to 63,858 by 2030
- Decrease the number of deaths attributable to CHB from 435 in 2018 to 173 by 2030

National Estimates for Hepatitis B Indicators

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

During 2018, an estimated 226,566 (plausible range (PR) 192,534 to 281,728) people were living with CHB in Australia, representing 0.9% of the population. Modelled estimates show that the number of people living with CHB has increased over time in Australia, with an additional 80,702 people living with CHB in 2018 when compared to 2000 (Figure 3, Appendix Table A1). Following current trends, including migration, treatment uptake and historical and current vaccination uptake both in Australia and overseas, an estimated 246,673 (215,160 to 290,429) people will be living with CHB in Australia by 2030 (Figure 3).

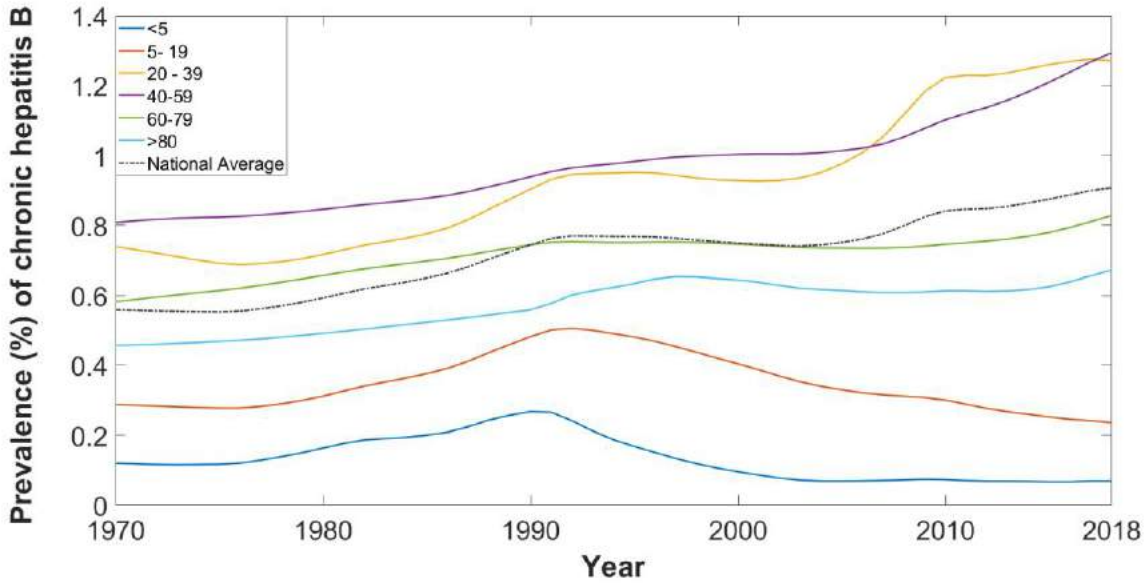
Figure 3. Estimated number of people living with chronic hepatitis B in Australia, 1970-2030.



Grey lines show plausible ranges of estimates.

The prevalence of CHB has increased substantially over time, from 0.6% in 1970 to 0.9% in 2018 (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 and the 5-19 year age group. This 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. 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.[1]

Figure 4. Estimated prevalence of chronic hepatitis B in Australia by age group, 1970-2018.



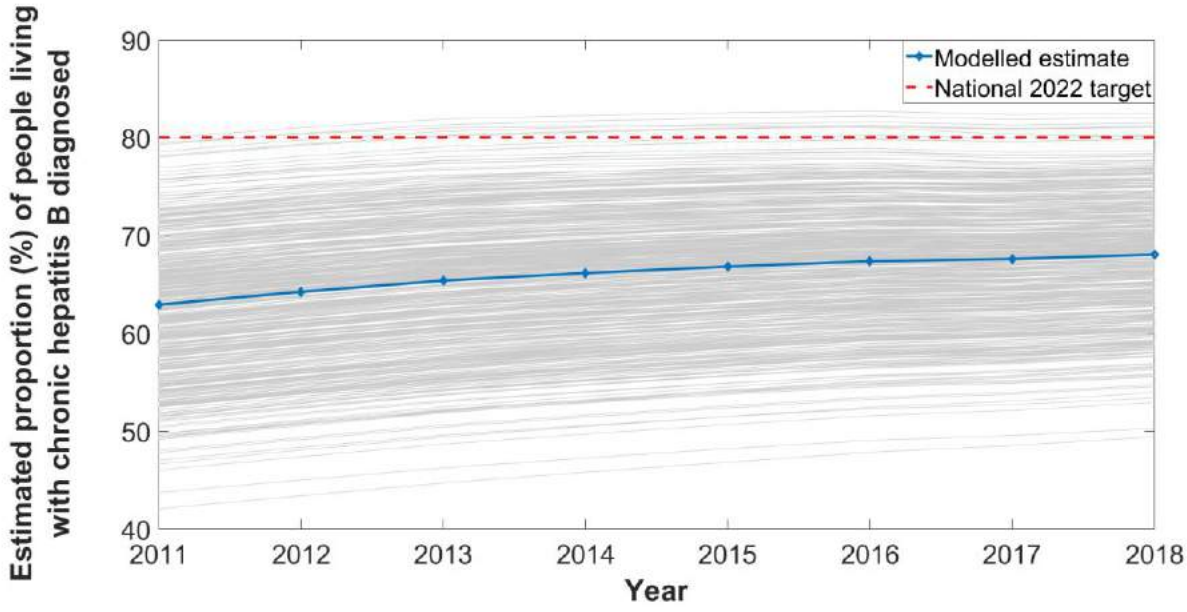
2. Proportion of people living with chronic hepatitis B in Australia who have been diagnosed

In 2018, an estimated 154,246 people living with CHB in Australia had been diagnosed, representing 68.1% (PR 50.1% to 83.6%) of all Australians living with CHB. Modelled trends show modest improvements in this proportion, having increased from 63.0% diagnosed in 2011 (Figure 5, Appendix Table A2). Although thousands of individuals are diagnosed with CHB in Australia each year, the population living with CHB also continues to increase (Figure 3), and a proportion of those previously diagnosed die either due to complications of CHB, or other causes - therefore the rate of diagnosis must increase substantially to have an impact on the total proportion diagnosed.

The proportion diagnosed in 2018 remains below the National Strategy target of 80%, with 38,707 more people living with CHB requiring diagnosis to reach this target by 2022. If the current average annual increase of 0.48% since 2014 were to remain stable, Australia will not reach the target of 80% diagnosed until 2043. To reach WHO's Global Health Sector Strategy of 90% diagnosed by 2030, the proportion diagnosed would need to increase by 1.8% every year to reach 222,006 people diagnosed, representing an additional 67,760 people living with CHB requiring diagnosis.

Considering the plausible range, the proportion diagnosed in 2018 could be as low as 50.1% and as large as 83.6% - 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 is low, as the target was not achieved in 98.2% of model simulations.

Figure 5. Estimated proportion of people living with chronic hepatitis B in Australia who have been diagnosed, 2011-2018.



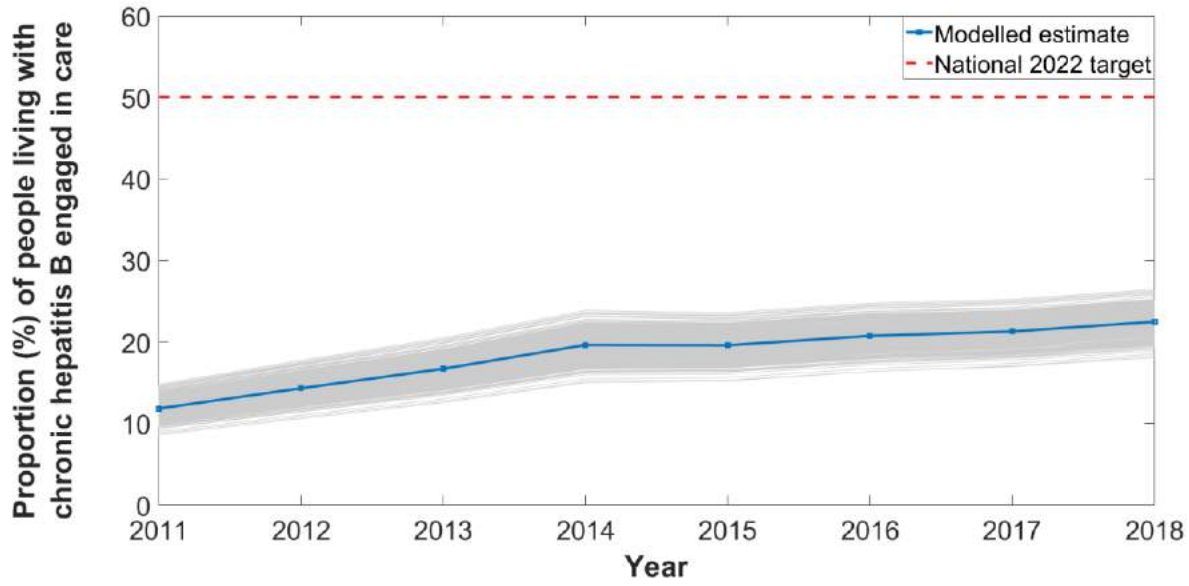
Grey lines show plausible ranges of estimates.

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

During 2018, 50,970 people were engaged in care for their CHB, receiving either antiviral treatment or monitoring without antiviral treatment. As a result, total uptake of care is an estimated 22.5% (PR 18.1% to 26.5%) of all people living with CHB. Modelled trends show substantial improvement in this proportion, increasing from 11.8% since 2011 (Figure 6, Appendix Table A3). Although this increase was relatively rapid between 2011 to 2014, the rate of increase has been substantially slower since 2015. While the total number of people engaged in care has increased each year, the population living with CHB also continues to increase (Figure 3), therefore engagement in care must increase substantially to have an impact on this proportion.

Clinical guidelines recommend that all people living with CHB should be engaged in care, and Australia currently falls well short of accomplishing this. The proportion engaged in care also remains below the National Strategy target of 50%, with 69,626 more people required to be in care to reach this target by 2022. If the current average annual increase of 0.72% since 2014 were to remain stable, Australia will not reach the 50% target until 2057.

Figure 6. Estimated proportion of people living with chronic hepatitis B in Australia who were engaged in care (receiving either treatment or monitoring), 2011-2018.

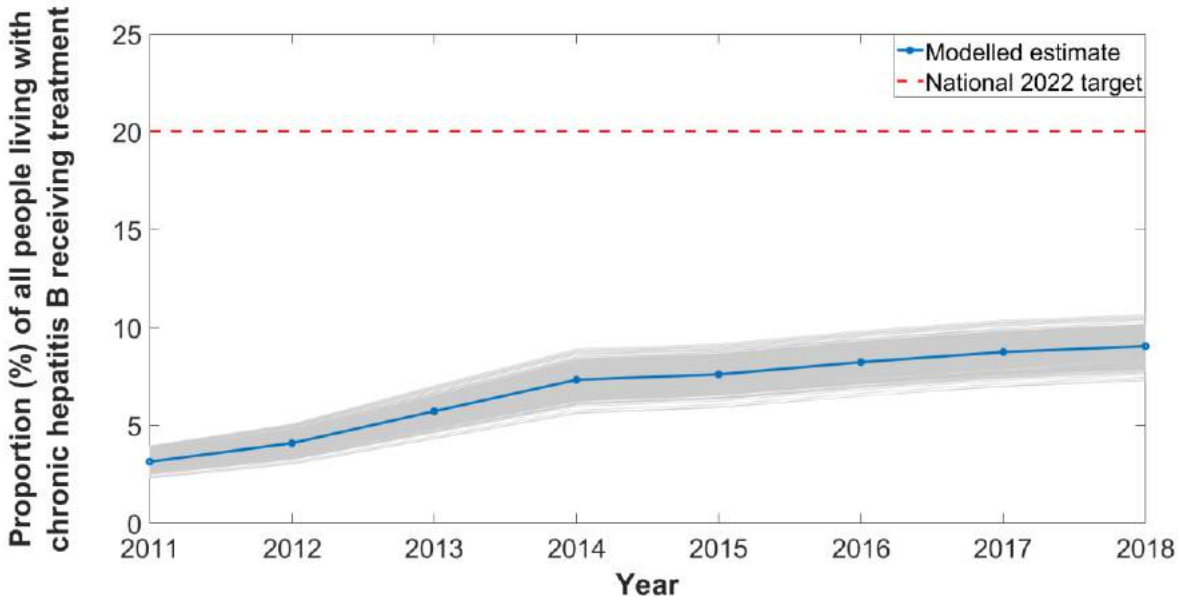


Grey lines show plausible ranges of estimates.

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 2018, 20,495 people were dispensed drugs for the treatment of hepatitis B through the Pharmaceutical Benefits Scheme (PBS), which is an estimated 9.0% (PR 7.3% to 10.6%) of people living with CHB. Modelled trends since 2014 show an ongoing modest increase in this proportion (average increase 0.43% per year) (Figure 7, Appendix Table A4). For Australia to achieve the National Strategy target of 20%, an additional 27,743 people living with CHB will need to receive antiviral treatment by 2022. With current trends in uptake it will be 2044 before 20% of Australians living with CHB will be receiving treatment.

Figure 7. 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, 2011-2018.



Grey lines show plausible ranges of estimates.

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 hepatitis B, 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.[14]

Based on limited overseas data, it has previously been estimated that 10-30% of people living with CHB are eligible for treatment.[15-17] The true proportion of people living with chronic hepatitis B who require treatment will vary by hepatitis B genotype, age group, sex, and other factors, and 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, enables estimation of the number of people living with CHB eligible for antiviral treatment in Australia for the first time.

In 2018, an estimated 68,619 (PR 54,177 to 90,529) people living with CHB were eligible for antiviral treatment, representing 30.3% (PR 28.1% to 32.1%) of the total. This suggests the National Strategy target of 20% of people living with CHB receiving antiviral treatment by 2022 remains conservative (Figure 6). Based on this modelling, Australia treated a third of those

estimated to require treatment in 2018 and would have needed to treat an additional 48,124 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 20,495 in 2018 to 63,858 in 2030. Since 2014, an average annual increase of 1.4% 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 2053.

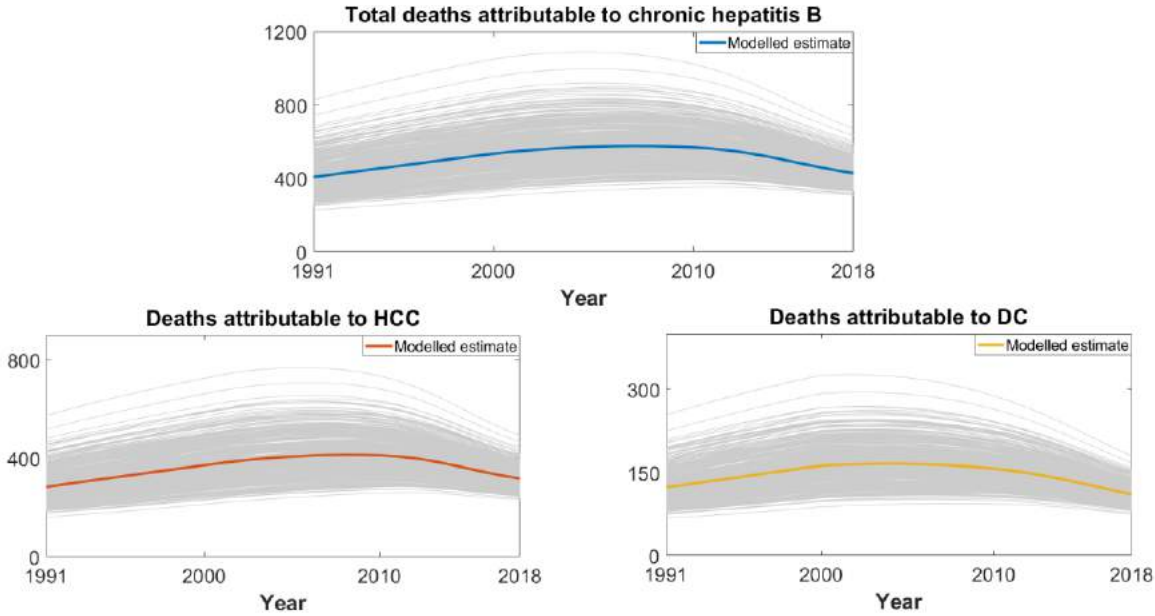
5. Burden of disease attributable to chronic hepatitis B in Australia

In 2018 an estimated 435 (PR 309 to 670) people died due to complications of CHB in Australia. The total number of estimated attributable deaths has changed over time, increasing from 407 in 1991 to a peak of 575 deaths in 2007 followed by a gradual decline (Figure 8, 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.

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, the majority of estimated deaths due to CHB were attributable to HCC, which was responsible for 322 (PR 234 to 491) deaths in 2018, while 113 (PR 75 to 179) 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 (31.5% reduction, from peak of 165 in 2004, Figure 8) than for HCC (22.0% reduction, from the peak of 413 in 2008, Figure 8).

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.

Figure 8. Estimated number of deaths attributable to chronic hepatitis B in Australia over time, 1991-2018

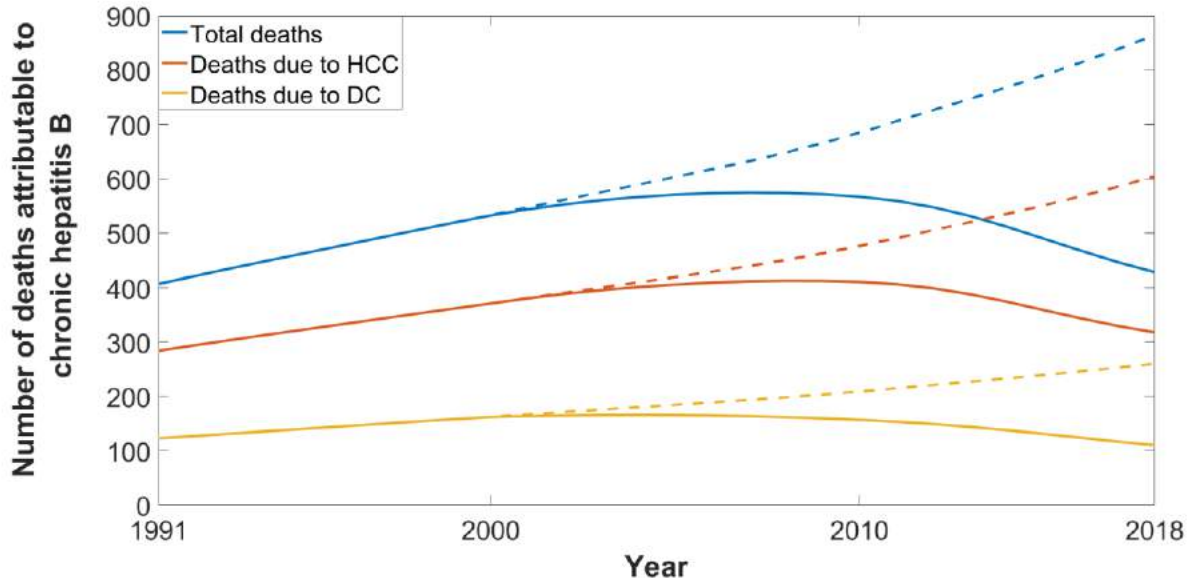


Grey lines show plausible ranges of estimates.

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 864 CHB attributable deaths estimated in 2018 (Figure 9). Our assessment estimates that in 2018, 429 lives were saved due to treatment, with a total of 2,708 lives saved since the introduction of antiviral treatment for CHB in Australia from 2000.

The reduction in deaths attributable to CHB at the end of 2018 relative to the end of 2017 was 3.76%, with considerable 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 316 deaths. Although the reduction in deaths has been pronounced since the introduction of antiviral treatment, following current mortality trends since 2014, Australia will not reach the 2022 target until 2024. 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 173 deaths by 2030.

Figure 9. Estimated number of deaths attributable to chronic hepatitis B in Australia, current treatment vs no treatment, 1991 – 2018



Dotted lines show estimated deaths per year without treatment for CHB

State and Territories

Summary State and Territory Estimates

Table 3. Australian summary for hepatitis B indicator point estimates by jurisdiction, 2018

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	3,386	65.2%	21.3%	9.2%	5	4	1
NSW	80,363	77.9%	27.8%	11.4%	134	101	33
NT	4,348	73.8%	26.2%	7.4%	11	8	3
QLD	34,726	70.1%	17.1%	6.3%	75	55	20
SA	12,019	64.1%	19.6%	7.5%	25	18	7
TAS	1,624	47.9%	13.4%	6.3%	4	3	1
VIC	67,391	59.9%	23.5%	9.0%	127	94	33
WA	22,709	57.9%	10.4%	5.7%	53	39	14
Australia	226,566	68.1%	22.5%	9.0%	435	322	113

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

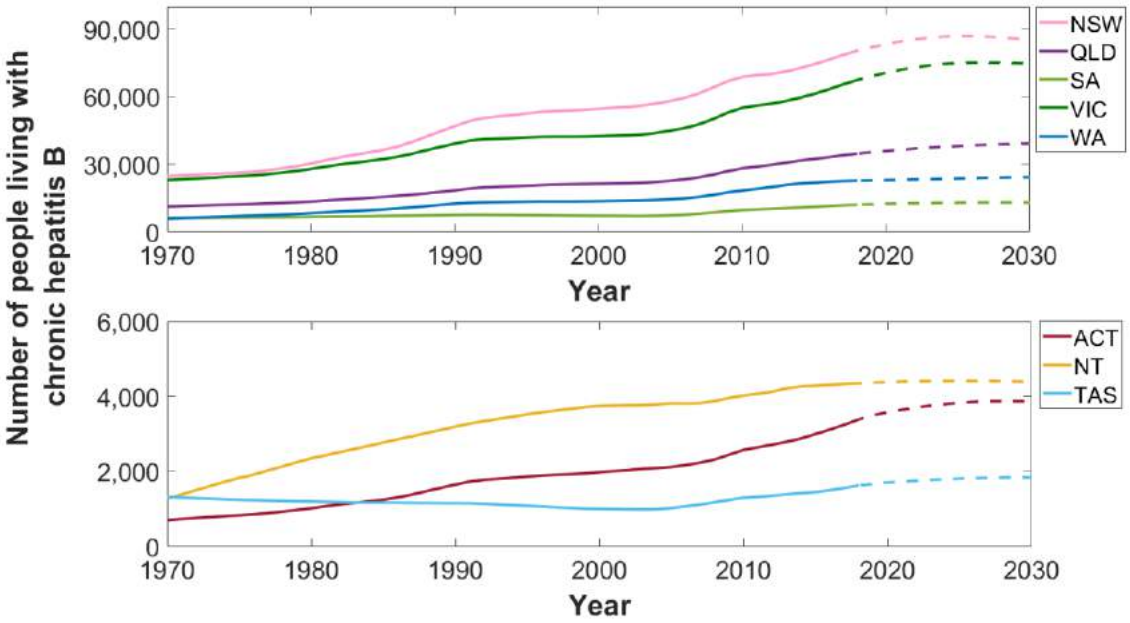
State and Territory Estimates for Hepatitis B Indicators

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

Modelled estimates show that the number of people living with CHB has increased over time in all jurisdictions, aside from TAS (Figure 10, 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 10). Despite steady increases in this number after 2004, TAS still had the lowest estimate in 2018 with 1,624 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 2018 (80,363 and 67,391 respectively), and historically saw relatively high increases after increased migration in 1990 (Table 4).

Prevalence across jurisdictions vary according to differing population demographics, with the highest prevalence in 2018 estimated in NT (1.8%) and the lowest was in TAS (0.3%). Among other jurisdictions, VIC (1.0%) and NSW (1.0%) had estimated prevalence above the national average (0.9%) in 2018, WA (0.9%) was equivalent, and ACT (0.8%), SA (0.7%) and QLD (0.7%) were below (Table 4).

Figure 10. 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, 2018

State/Territory	People living with CHB	Plausible range		Prevalence (%)
		Minimum	Maximum	
ACT	3,386	2,858	4,250	0.8%
NSW	80,363	68,541	100,804	1.0%
NT	4,348	3,945	4,985	1.8%
QLD	34,726	30,424	41,065	0.7%
SA	12,019	10,196	14,794	0.7%
TAS	1,624	1,377	2,021	0.3%
VIC	67,391	56,296	85,019	1.0%
WA	22,709	18,897	28,790	0.9%
Australia	226,566	192,534	281,728	0.9%

Note: As each state and territory is modelled separately, the sum of estimates across jurisdictions varies from the modelled national estimate.

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 11, Appendix Table A2). The estimated proportion diagnosed varied greatly between jurisdictions, with NSW (77.9%), NT (73.8%) and QLD (70.1%) having the highest proportion diagnosed in 2018 (Table 5). Estimates for all other states and territories were below the national average of 68.1%, with ACT (65.2%), SA (64.1%), VIC (59.9%) and WA (57.9%) exceeding 50%. The estimate for TAS (47.9%) suggests that the majority of the people living with CHB in this jurisdiction remain undiagnosed.

No jurisdiction has yet reached the 2022 National Strategy target of 80% of people living with CHB being diagnosed. Following current diagnosis trends since 2014, NT, NSW, QLD and WA will reach the 80% diagnosed target in 2024, 2024, 2036 and 2039 respectively, compared with the projected national estimate of 2043. All other jurisdictions will reach the target after 2043. A significantly increased rate of diagnosis is required in all 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 and in underlying population differences in each jurisdiction, such as the level of interstate migration after diagnosis (which may be more common in some jurisdictions).

Figure 11. Estimated proportion of people living with chronic hepatitis B who have been diagnosed by jurisdiction, 2011-2018

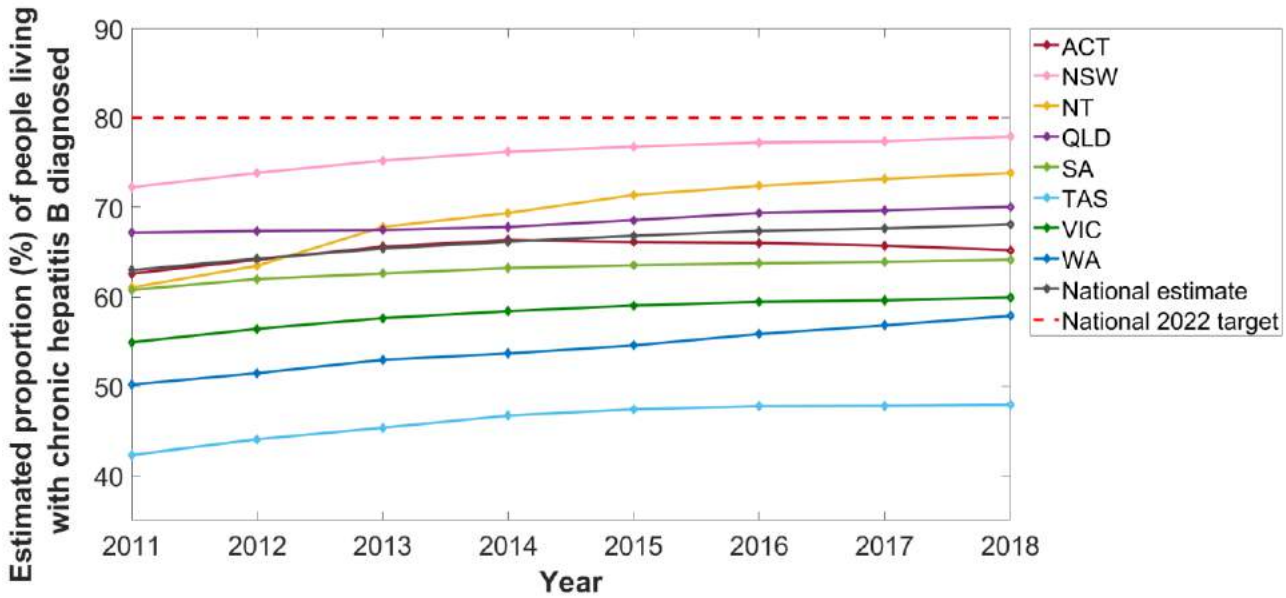


Table 5. Estimated proportion of people living with chronic hepatitis B who have been diagnosed by jurisdiction, 2018

State/Territory	Proportion diagnosed	Plausible range	
		Minimum	Maximum
ACT	65.2%	47.1%	82.4%
NSW	77.9%	57.8%	94.7%
NT	73.8%	60.3%	83.6%
QLD	70.1%	55.5%	81.7%
SA	64.1%	44.7%	81.1%
TAS	47.9%	36.4%	57.3%
VIC	59.9%	42.4%	75.8%
WA	57.9%	42.0%	72.7%
Australia	68.1%	50.1%	83.6%

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 were engaged in care varied greatly between state and territories (Figure 12, Appendix Table A3). Despite some fluctuations, generally the proportion of people living with CHB who are engaged into care has been increasing in all states and territories since 2011.

It can be observed that jurisdictions with a higher proportion diagnosed also had a higher proportion engaged in care. In 2018 NSW (27.8%), NT (26.2%) and VIC (23.5%) had the highest proportions of people living with CHB engaged in care, with ACT (21.3%) and SA (19.6%) estimated to fall just under the national average of 22.5% (Table 6). All other jurisdictions, who also had lower diagnosis proportions, fell well under the national average of engagement in care; QLD (17.1%), TAS (13.4%), WA (10.4%).

No jurisdiction has yet reached the 2022 National Strategy target of 50% of people living with CHB engaged in care. Following current trends since 2014, NT, NSW , QLD and VIC will not reach this target until 2029, 2042, 2047 and 2048 respectively. All other jurisdictions will reach the 2022 target after the national estimate, in 2057. 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 12. Estimated proportion of people living with chronic hepatitis B who were engaged into care, receiving wither treatment or monitoring by jurisdiction, 2011-2018

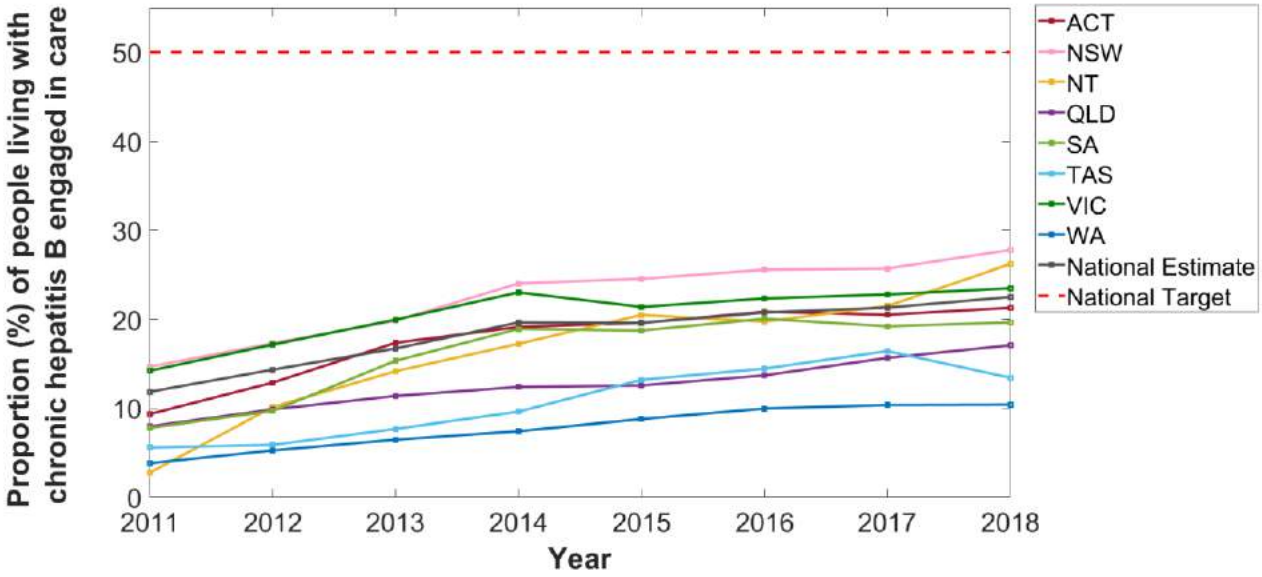


Table 6. Estimated proportion of people living with chronic hepatitis B who were engaged in care by jurisdiction, 2018

State/Territory	Proportion in care	Plausible range	
		Minimum	Maximum
ACT	21.3%	16.9%	25.2%
NSW	27.8%	22.1%	32.5%
NT	26.2%	22.8%	28.9%
QLD	17.1%	14.4%	19.5%
SA	19.6%	16.0%	23.1%
TAS	13.4%	10.8%	15.8%
VIC	23.5%	18.6%	28.1%
WA	10.4%	8.2%	12.5%
Australia	22.5%	18.1%	26.5%

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,[1] the proportion of people living with CHB receiving antiviral treatment has increased over time in all states and territories (Figure 13, Appendix Table A4). Treatment uptake varied greatly between jurisdictions,

with NSW (11.4%), ACT (9.2%) and VIC (9.0%) estimated to have the highest proportion of people with CHB receiving treatment in 2018 (Table 7). All other states and territories were below the national average (9.0%) for treatment uptake, including SA (7.5%), NT (7.4%), TAS (6.3%), QLD (6.3%) and WA (5.7%). 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.

No jurisdiction has reached the National Strategy target of 20% treatment uptake by 2022. Following current trends since 2014 and considering recent successes, NT will be the first jurisdiction to reach the 2022 target in 2028. If current trends continue, no other jurisdiction will reach this target for another 11 years, with TAS, VIC and NSW reaching the target in 2039, 2044 and 2046 respectively.

Figure 13. Estimated proportion of people living with chronic hepatitis B who were dispensed drugs for the treatment of hepatitis B through the PBS by jurisdiction, 2011-2018

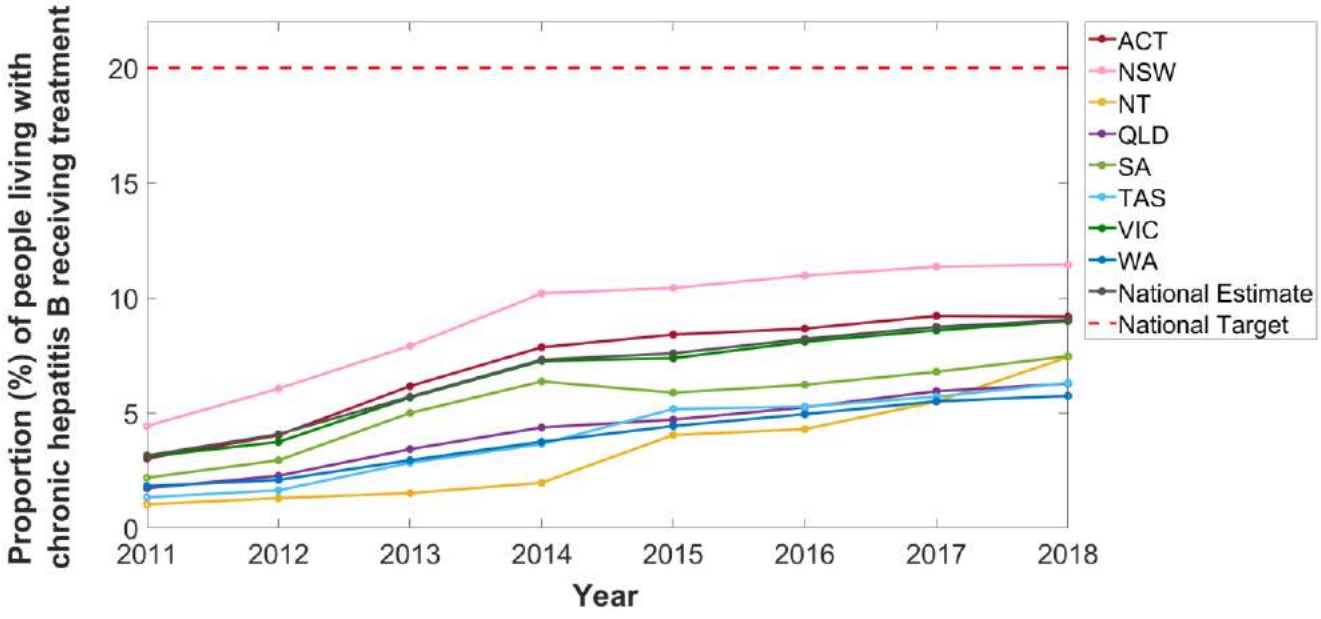


Table 7. Estimated proportion of people living with chronic hepatitis B who were dispensed drugs for the treatment of hepatitis B through the PBS by jurisdiction, 2018

State/Territory	Proportion receiving treatment	Plausible range	
		Minimum	Maximum
ACT	9.2%	7.3%	10.9%
NSW	11.4%	9.1%	13.4%
NT	7.4%	6.5%	8.2%
QLD	6.3%	5.3%	7.2%
SA	7.5%	6.1%	8.8%
TAS	6.3%	5.1%	7.4%
VIC	9.0%	7.1%	10.8%
WA	5.7%	4.5%	6.9%
Australia	9.0%	7.3%	10.6%

Treatment eligibility

As described in the National Estimates section of this report (Page 15), not all people living with CHB are eligible for treatment due to the dynamic natural history of hepatitis B. Based on limited overseas data, it is estimated that 10-30% of people living with CHB are eligible for treatment.[15-17] 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 2018, NT (32.3%), NSW (30.5%) and WA (30.4%) were estimated to have the highest proportion of people living with CHB who are eligible for treatment, followed by VIC (30.3%), SA (30.0%), QLD (29.9%), ACT (28.7%) and TAS (28.4%).

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 onwards, 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 14, Appendix Table A5).

NSW and VIC were estimated to have the highest burden of CHB attributable deaths in 2018 (134 and 127 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 (204 in 2006) compared to VIC (174 in 2007). 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 15, Appendix Table A5) and DC (Figure 16, Appendix Table A6) attributable deaths.

The reduction in deaths attributable to CHB at the end of 2018 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 similar reduction in deaths when compared to the national estimate of 3.76%, with VIC and NSW estimated to have reductions of 4.5% and 4.3%, respectively. However, QLD and WA estimated to have reductions below the national estimate with 2.6% and 1.8% respectively. 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.

Figure 14. Estimated number of deaths attributable to chronic hepatitis B by jurisdiction, 1991-2018

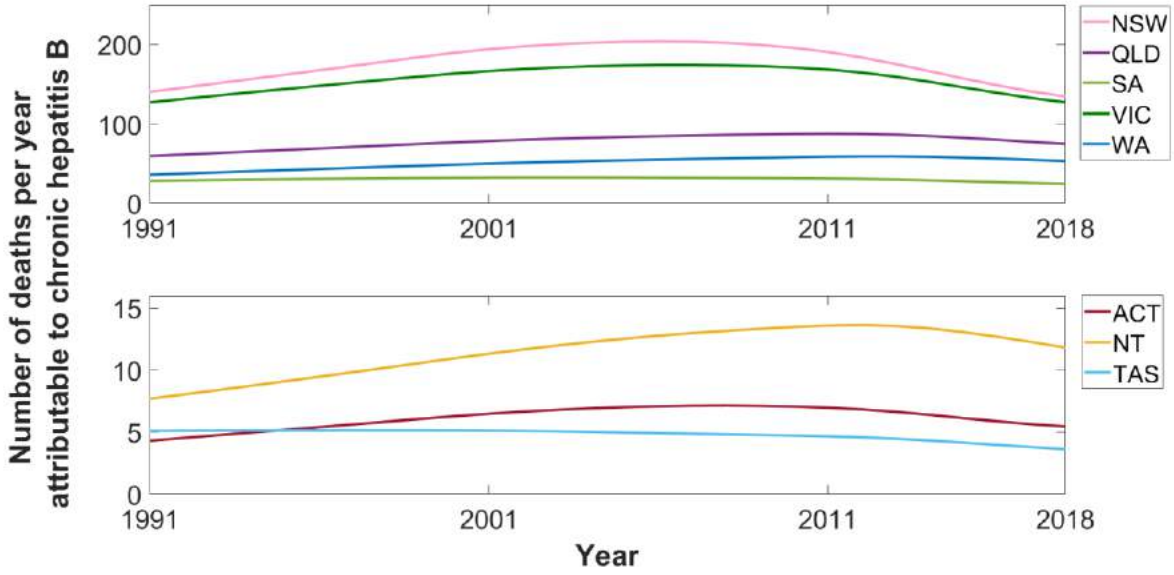


Table 8. Estimated number of total deaths attributable to chronic hepatitis B and population numbers by jurisdiction, 2018

State/Territory	Total deaths attributable to CHB	Plausible range		People living with CHB
		Minimum	Maximum	
ACT	5	4	9	3,386
NSW	134	96	203	80,363
NT	11	9	16	4,348
QLD	75	58	105	34,726
SA	25	17	39	12,019
TAS	4	2	6	1,624
VIC	127	86	209	67,391
WA	54	37	83	22,709

Figure 15. Estimated number of HCC deaths attributable to chronic hepatitis B across jurisdictions, 1991-2018

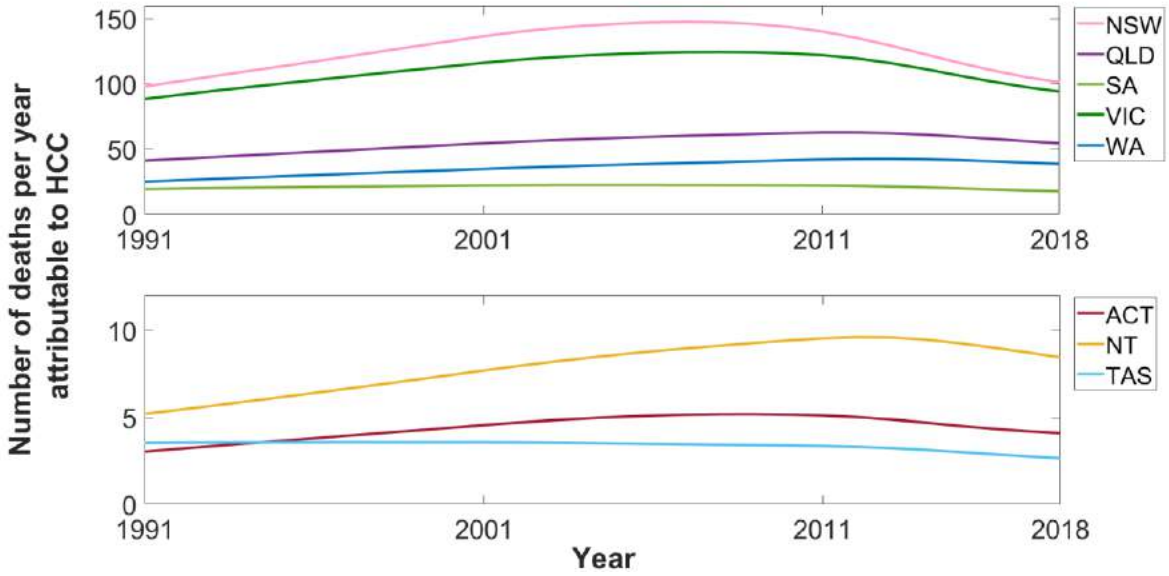


Figure 16. Estimated number of DC deaths attributable to chronic hepatitis B across jurisdictions, 1991-2018

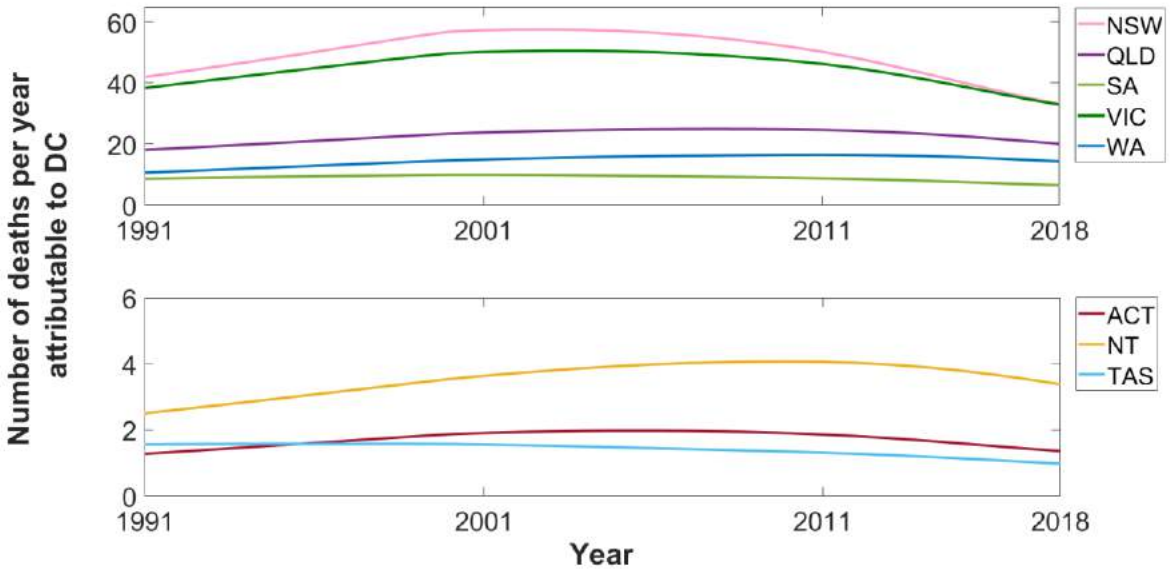


Table 9. Estimated number of HCC deaths and DC deaths attributable to chronic hepatitis B by jurisdictions in 2018

State/Territory	HCC deaths attributable to CHB	HCC Plausible range		DC deaths attributable to CHB	DC Plausible range	
		Minimum	Maximum		Minimum	Maximum
ACT	4	3	7	1	1	2
NSW	101	74	152	33	22	51
NT	8	7	11	3	2	5
QLD	55	43	76	20	15	29
SA	18	13	28	7	4	11
TAS	3	2	4	1	0	2
VIC	94	64	153	33	22	56
WA	39	28	60	15	9	23

Methodological Notes

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	Australian Bureau of Statistics
Migration: country of birth and age distribution 1951 – 1974 1974 – 1990 1991 – 2018 2019– 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

Mathematical Model

The estimates presented in this report were generated from mathematical models based on previous work[5] with substantial revision in structure, processes and data sources used; further details with comments on the strengths and limitations of the model are in the process of being published.[18] 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 are in press.[18]

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,[19, 20] births,[21] deaths[22] and life tables[23] 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 2018 as well as estimates of future NOM from 2019 to 2050.[24] Age and country of birth distributions within this were calculated using different sources dependent on time period and data availability:

- *2005 to 2018,* ABS NOM by country of birth data were used to estimate the total number of people entering the population each year. Department of Social Services (DSS) settlement data[25] were used to estimate the age distribution by country of birth and applied to the ABS NOM country of birth to estimate the number of people by age group and country of birth migrating into the population.
- *1991 to 2004,* DSS settlement data[25] were used to estimate total migrant arrival numbers by country of birth by age by year.
- *1975 to 1990*, ABS migration data[26] were used to determine 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.[27]

Prevalence
At the start of the modelled period (1951), the baseline prevalence of the Australian population was assumed to be 0.5%,[28] 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 2018,* For those migrating into Australia born in 1991 or later, prevalence estimates derived for the Viral Hepatitis Mapping Project National Report 2017 [1] were applied. These prevalence estimates were taken predominately from local seroprevalence surveys,[29, 30] supplemented with global systematic reviews.[31, 32] Antenatal estimates were adjusted upwards to correct for the discrepancy in CHB prevalence by sex.[33]
- *1951 to 1990,* For those migrating into Australia born prior to 1991, prevalence estimates derived by the CDC as of 2008 were applied.[28] 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 1991-2017 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.[9, 31, 34-37] 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.[38-40] 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.[18] This was achieved using Latin-hypercube sampling (LHS), as described by Marino et al.[41] The mathematical model was run using 1000 different combinations of these varied parameters, which produced a range of overall estimates. The minimum and maximum estimates produced 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, 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.[12, 42, 43]

Prior to 1990, Census data poorly reflect the actual number of Aboriginal and/or Torres Strait Islander peoples living in Australia,[44] 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.[45] Differential phase information for Aboriginal and/or Torres Strait Islander peoples living with CHB was estimated [13] 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.

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 2018 as the numerator. Notification data has been sourced from the National Notifiable Diseases Surveillance (NNDSS) system.

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 [46].

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.

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	75555	732	25018	1386	11459	6211	1301	23309	6139
1972	76801	757	25339	1502	11642	6250	1286	23674	6351
1973	78012	783	25654	1613	11817	6286	1271	24029	6559
1974	79212	809	25966	1724	11988	6324	1257	24381	6763
1975	80352	831	26260	1826	12146	6368	1244	24717	6960
1976	81593	853	26619	1915	12309	6426	1235	25076	7160
1977	83523	888	27333	2026	12579	6445	1224	25621	7407
1978	85729	928	28191	2133	12843	6480	1213	26276	7665
1979	88225	970	29153	2244	13124	6547	1203	27027	7957
1980	91160	1018	30335	2349	13448	6628	1195	27910	8277
1981	94503	1072	31728	2429	13840	6706	1187	28920	8621
1982	97783	1123	33080	2517	14271	6770	1180	29879	8963
1983	100541	1161	34181	2598	14665	6825	1172	30674	9265
1984	103216	1200	35199	2681	15062	6900	1166	31425	9583
1985	106237	1247	36345	2769	15482	7003	1166	32279	9946
1986	109808	1306	37796	2854	15937	7099	1166	33298	10352
1987	114432	1382	39836	2935	16474	7177	1160	34625	10843
1988	119854	1474	42247	3023	17075	7281	1157	36189	11408
1989	125141	1563	44604	3106	17694	7382	1154	37693	11945
1990	130390	1650	46913	3192	18404	7476	1153	39131	12471
1991	135373	1729	49144	3274	19157	7556	1149	40448	12916
1992	138270	1776	50536	3340	19691	7555	1137	41135	13100
1993	139617	1804	51222	3399	19999	7509	1119	41377	13188
1994	140816	1830	51826	3457	20252	7460	1101	41604	13286
1995	142290	1864	52576	3521	20504	7420	1082	41915	13408
1996	143566	1892	53252	3576	20748	7370	1063	42167	13498
1997	144210	1908	53627	3622	20955	7299	1043	42236	13520
1998	144571	1924	53885	3667	21101	7218	1025	42235	13516
1999	145040	1947	54191	3714	21222	7146	1010	42283	13527
2000	145864	1980	54631	3742	21348	7100	1003	42463	13597
2001	146678	2008	55056	3751	21459	7062	997	42651	13694
2002	147422	2031	55445	3757	21588	7020	989	42808	13784
2003	148713	2070	56050	3763	21800	7000	983	43149	13898
2004	151023	2091	56935	3787	22142	7076	991	43898	14103
2005	154361	2116	58087	3812	22657	7299	1025	44925	14440

2006	158393	2168	59479	3811	23314	7620	1069	46055	14877
2007	164131	2232	61469	3818	24213	8057	1118	47739	15485
2008	172065	2317	64150	3874	25421	8582	1177	50143	16401
2009	181059	2444	66908	3956	26926	9155	1241	52942	17487
2010	187890	2572	68748	4022	28164	9679	1297	55055	18353
2011	191574	2642	69528	4066	28921	9978	1322	56072	19045
2012	194883	2712	70087	4124	29697	10198	1352	56851	19862
2013	199419	2788	71129	4213	30661	10463	1388	57999	20778
2014	204494	2877	72633	4263	31584	10788	1418	59500	21431
2015	209687	2996	74389	4283	32369	11136	1450	61217	21847
2016	215264	3115	76323	4308	33135	11468	1497	63199	22219
2017	221420	3243	78557	4334	33994	11773	1560	65424	22535
2018	226566	3386	80363	4348	34726	12019	1624	67391	22709
2019	230945	3493	81946	4362	35332	12210	1670	69123	22809
2020	234894	3574	83384	4379	35896	12379	1702	70658	22922
2021	238302	3641	84569	4391	36425	12537	1727	71953	23059
2022	241192	3702	85506	4397	36918	12677	1753	73027	23212
2023	243537	3752	86196	4402	37358	12798	1775	73875	23381
2024	245345	3794	86649	4406	37751	12894	1791	74504	23556
2025	246622	3827	86863	4409	38093	12971	1807	74924	23728
2026	247403	3851	86870	4409	38390	13027	1818	75144	23894
2027	247698	3867	86671	4406	38644	13060	1827	75178	24045
2028	247649	3870	86352	4399	38856	13074	1832	75101	24165
2029	247298	3869	85932	4392	39024	13071	1835	74926	24249
2030	246673	3864	85427	4384	39151	13050	1837	74661	24299

Table A2. *Model output for the proportion of people living with chronic hepatitis B in Australia who have been diagnosed, 2011-2018*

Year	National (%)	ACT (%)	NSW (%)	NT (%)	QLD (%)	SA (%)	TAS (%)	VIC (%)	WA (%)
2011	62.95	62.56%	72.25%	61.01%	67.15%	60.74%	42.32%	54.91%	50.17%
2012	64.25	64.13%	73.85%	63.44%	67.36%	61.96%	44.05%	56.42%	51.45%
2013	65.38	65.58%	75.23%	67.79%	67.46%	62.58%	45.34%	57.62%	52.95%
2014	66.15	66.33%	76.22%	69.36%	67.79%	63.19%	46.71%	58.39%	53.66%
2015	66.81	66.11%	76.80%	71.38%	68.56%	63.51%	47.41%	59.04%	54.56%
2016	67.37	66.02%	77.24%	72.40%	69.37%	63.73%	47.75%	59.45%	55.84%
2017	67.63	65.71%	77.36%	73.18%	69.66%	63.89%	47.80%	59.63%	56.81%
2018	68.1	65.2%	77.9%	73.8%	70.1%	64.1%	47.9%	59.9%	57.9%

Table A3. *Model output for the proportion of people living with chronic hepatitis B in Australia who are engaged in care, 2011-2018*

Year	National (%)	ACT (%)	NSW (%)	NT (%)	QLD (%)	SA (%)	TAS (%)	VIC (%)	WA (%)
2011	11.82	9.31%	14.65%	2.75%	7.94%	7.79%	5.58%	14.19%	3.81%
2012	14.31	12.85%	17.29%	10.10%	9.84%	9.66%	5.88%	17.13%	5.25%
2013	16.70	17.34%	19.83%	14.14%	11.35%	15.32%	7.67%	19.95%	6.46%
2014	19.63	19.12%	24.03%	17.23%	12.37%	18.90%	9.58%	23.02%	7.41%
2015	19.59	19.59%	24.55%	20.48%	12.54%	18.72%	13.17%	21.38%	8.76%
2016	20.75	20.83%	25.55%	19.73%	13.67%	20.05%	14.43%	22.33%	9.93%
2017	21.30	20.51%	25.67%	21.48%	15.64%	19.20%	16.41%	22.79%	10.34%
2018	22.50	21.28%	27.76%	26.19%	17.06%	19.63%	13.40%	23.48%	10.37%

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, 2011-2018*

Year	National (%)	ACT (%)	NSW (%)	NT (%)	QLD (%)	SA (%)	TAS (%)	VIC (%)	WA (%)
2011	3.14	3.02%	4.43%	1.02%	1.72%	2.18%	1.33%	3.10%	1.81%
2012	4.07	4.03%	6.06%	1.29%	2.26%	2.94%	1.63%	3.74%	2.08%
2013	5.71	6.17%	7.92%	1.51%	3.42%	5.00%	2.83%	5.67%	2.94%
2014	7.31	7.85%	10.19%	1.96%	4.37%	6.37%	3.64%	7.26%	3.75%
2015	7.59	8.41%	10.42%	4.04%	4.71%	5.88%	5.17%	7.38%	4.43%
2016	8.22	8.67%	10.97%	4.29%	5.25%	6.23%	5.28%	8.10%	4.95%
2017	8.74	9.22%	11.35%	5.49%	5.95%	6.79%	5.71%	8.60%	5.51%
2018	9.05	9.20%	11.44%	7.43%	6.27%	7.47%	6.31%	9.00%	5.74%

Table A5. *Model output for the total number of deaths attributable to chronic hepatitis B in Australia, 2011-2018*

Year	National	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
2011	562	7	192	14	88	31	4	168	58
2012	550	7	183	14	88	31	4	164	59
2013	534	7	176	14	86	29	4	159	59
2014	515	7	166	13	84	29	4	154	58
2015	493	7	157	13	82	28	4	145	57
2016	473	6	149	13	80	26	4	139	56
2017	452	5	140	13	77	25	4	133	55
2018	435	5	134	11	75	25	4	127	54

Table A6. *Model output for the total number of HCC deaths attributable to chronic hepatitis B in Australia, 2011-2018*

Year	National	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
2011	408	5	141	10	63	22	3	122	42
2012	400	5	135	10	63	22	3	119	43
2013	390	5	130	10	62	21	3	116	43
2014	376	5	123	9	61	21	3	112	42
2015	361	5	116	9	60	20	3	106	42
2016	347	4	111	9	58	19	3	102	41
2017	333	4	105	9	56	18	3	98	40
2018	322	4	101	8	55	18	3	94	39

Table A7. *Model output for the total number of DC deaths attributable to chronic hepatitis B in Australia, 2011-2018*

Year	National	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
2011	154	2	51	4	25	9	1	46	16
2012	150	2	48	4	25	9	1	45	16
2013	144	2	46	4	24	8	1	43	16
2014	139	2	43	4	23	8	1	42	16
2015	132	2	41	4	22	8	1	39	15
2016	126	2	38	4	22	7	1	37	15
2017	119	1	35	4	21	7	1	35	15
2018	113	1	33	3	20	7	1	33	15

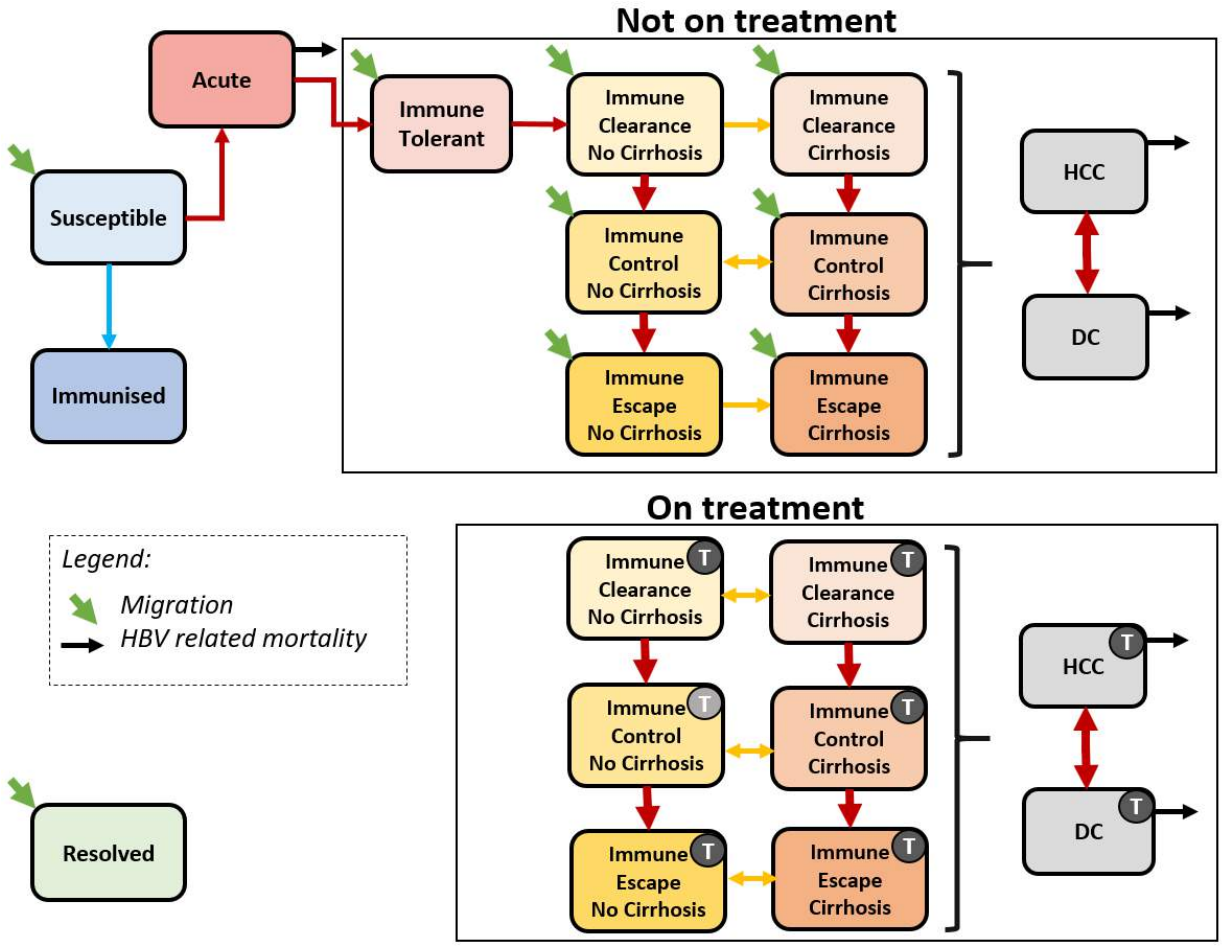


Figure A1: Schematic diagram of the mathematical model describing the progression of hepatitis B infection and indicating key transitions. Chronic hepatitis B phases are within the boxes. Phases with a 'T' indicate individuals in that phase receiving treatment. Light grey treatment icon indicates those 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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