evohealth

May 2023

Time to Act

Protecting our children from RSV

Evohealth acknowledges that we work on the traditional lands of many Aboriginal clans, tribes, and nations.

We commit to working in collaboration with Aboriginal and Torres Strait Islander communities and peoples to improve health, emotional and social well-being outcomes in the spirit of partnership.

About Evohealth

The delivery of healthcare is complex.
Our focus is not.

Better health for all Australians.

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About this report

Background

Time to act: protecting our children from RSV is an evidence-based and product-agnostic report. It analyses the burden of RSV among infants and children in Australia for patients and their families, the healthcare system and the economy. This report makes recommendations for change and was independently authored by Evohealth, a specialist health advisory practice, in partnership with an independent Advisory Committee of Australian clinical and research leaders in paediatrics, epidemiology, public health and respiratory medicine and patient representatives

Approach

This report has a focus on childhood RSV, particularly infants (<12 months) and young children (up to five years old) in Australia. It has been informed by:

- A comprehensive review of published academic and grey literature;
- Interviews with Australian clinicians, researchers and patient representatives;
- An economic analysis of the burden of RSV in infants and young children (see Appendix for methodology); and
- The contributions of our expert project Advisory Committee members.

This project received funding from Sanofi Australia, Sanofi representatives did not participate in the development of the report to ensure the independence of Evohealth and the Advisory Committee.

Acknowledgements

Evohealth wishes to acknowledge the ongoing support from the individuals and organisations who contributed to this project.

We would like to acknowledge the project Advisory Committee who provided critical oversight and input to the development of this report. The Advisory Committee comprised the following members:

Professor Jim Buttery
Murdoch Children's Research Institute

Ms Catherine Hughes
Immunisation Foundation Australia

Professor Helen Marshall
The University of Adelaide

A/Professor Hannah Moore
Telethon Kids Institute and Curtin University

Professor Terry Nolan
Doherty Institute, Murdoch Children's Research Institute and University of Melbourne

Professor Peter Richmond
Perth Children's Hospital and University of Western Australia

A/Professor Sheena Sullivan
Doherty Institute

We extend our sincere thanks to our patient representatives **Cat Irvine, Katherine Kieran, Melinda France and Vanessa Richards,** for sharing their children's stories of RSV with us.

Looking to the future

The Gardasil vaccine was the beginning of a new era for HPV in Australia. I really have that same sense of excitement now with RSV. We are on the threshold of a range of opportunities to do something about preventing RSV infections and disease that we haven't had before

- Professor Terry Nolan, paediatrician and clinical epidemiologist

There is a substantial burden of RSV in the population which is disproportionately born by infants and young children. We now have prevention tools that are close to market, and we need to make sure we have the best data possible to ensure we can target these interventions and reduce the significant burden of RSV

- A/Professor Hannah Moore, Telethon Kids Institute and Curtin University

Let's act now to spare our children the pain and trauma of hospitalisation, invasive treatments, and worried parents. It's time to step up and prevent RSV in our vulnerable young, starting with raising awareness

- Catherine Hughes, patient advocate

'It's important that we leverage existing sentinel surveillance programs to enable surveillance of RSV. This will require additional Government investment to ensure both primary care and hospital surveillance networks are able to generate the intelligence needed for public health planning, response and evaluation of interventions, like vaccination.

- A/ Professor Sheena Sullivan, Doherty Institute

Executive Summary

Respiratory syncytial virus (RSV) is the leading cause of hospitalisation for Australian infants and children under 5 years, [1] yet it does not receive the same attention as other common respiratory viruses such as influenza and COVID-19. It is time to act, put a spotlight on RSV and begin a national conversation.

RSV infection typically presents like a mild cold; however, it can rapidly progress to severe illness in some children.[2-5] The more severe respiratory symptoms can cause pneumonia or bronchiolitis, leading to hospitalisation and even death.[4, 5] Our youngest are disproportionally impacted by RSV, with infants under 12 months being 12 times more likely to be hospitalised when compared to the older population (>12 months).[6-11] Almost all children will have had RSV by their third birthday but there is no way to predict which of those otherwise healthy infants and children will have mild symptoms and which will end up in hospital.[2, 7, 12-17]

Quantifying the full extent of this burden in Australia is impossible as RSV is significantly underreported, and true incidence data cannot be accurately obtained.

There is also a considerable lack of awareness of RSV in the Australian community. Parents and carers report that increasing awareness of RSV, including potential severity would likely change their behaviour and the steps they take to protect their children from contracting the virus.

The burden of childhood RSV extends beyond patient and family– costing our healthcare system and the economy millions of dollars each year.[12, 18-21] This impact is not just limited to hospitalised children, but also those battling RSV at home who often seek support of our primary healthcare system. We can reliably estimate how many infants and children are hospitalised but those seeking care in the community remains a mystery. This is largely a result of the lack of clinical drivers for health care professionals to test for RSV and the data systems to enumerate the burden.

> *"This is the virus of infants and there is no way we can ignore it"*
>
> **- Epidemiologist**

> *It's sad and frightening how many people have the same story. It's important to educate people so that they have at least heard of it [RSV]. Infants/children decline so fast once infected with RSV*
>
> **- Melinda France (mother of Caleb)**

There is hope on the horizon for RSV prevention and management, with several infant and child vaccines, maternal vaccines, and monoclonal antibodies currently in clinical trial.

These have potential to drastically decrease RSV associated hospitalisation and the overall burden of RSV in our community. They also signify a real opportunity to protect our infants and children from this potentially life-threatening disease.

The first step towards this future must include understanding the true incidence of RSV in Australia.

We have a proven track record of successful public health management of influenza and COVID-19. We already have the infrastructure in place to better understand and manage RSV. The time to act is now to increase surveillance and improve data collection so that we can build a true picture of the burden of RSV.

Recommendations

Australia is presented with a real opportunity to improve surveillance of RSV, quantify the true burden and invest in evidence-driven prevention strategies that are going to directly improve the health outcomes of our children and save the system money. We need to leverage the profile and momentum afforded to public health because of the COVID-19 pandemic, and act now to protect the health of Australian children.

These recommendations are informed by a comprehensive review of academic and grey literature; interviews with policymakers, clinicians, patients, and patient advocates; and the contributions of our Advisory Committee.

Increase targeted surveillance of RSV through sentinel surveillance programs in primary and tertiary care.

Create a national evidence-base to quantify the true burden (incidence and hospitalisation) of RSV.

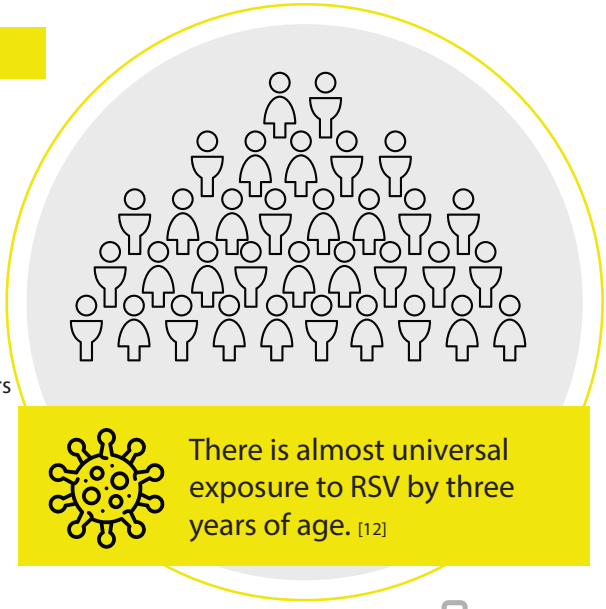
Develop a national strategy for reducing the burden of RSV in our infants and children, including consideration of future preventative measures.

Create a targeted tailored RSV awareness campaign to empower and enable parents, carers, and the clinical community to make informed decisions about RSV testing and management.

There is an annual average of

11,968
hospital admissions
for Australian infants < 12 months old with RSV. [6]

15,864
hospital admissions
for Australian children < 5 years with RSV. [6]



There is almost universal exposure to RSV by three years of age. [12]

For children < 5 years admitted to hospital with RSV the length of stay is usually three days but can range from one to nine days. [7, 10, 12]

10-26%

Of the infants and children that are admitted to hospital, between 10 – 26 per cent spend time in the Intensive Care Unit. [9, 12]

RSV is the most common cause of bronchiolitis and pneumonia in children under one year of age. [3]

80%

Up to 80 per cent of infants and children who are admitted to hospital with RSV are otherwise healthy children, with no predisposing conditions. [7, 13-15]

33 million

Globally 33 million RSV infections occurred in children under five years of age. [22]

In Australia, infants < 12 months are approximately 12 times more likely to be admitted to hospital with RSV than those aged 1-4 years old. [6]

94.9%

In Australia 94.9 per cent of hospitalisations related to RSV occur in children under five years of age. [7]

3-6 X
more likely

Australian Indigenous children are 3-6 times more likely to be hospitalised for RSV compared to non-indigenous children [7]

The average annual costs for Australian children < 5 years admitted to hospital with RSV:

There is no clinically effective curative treatment for RSV infection.

$193m

Societal costs (i.e. costs of hospitalisation, productivity loss and out of pocket costs) is estimated to be $193 million. [6]

$159m

Direct health care costs (i.e. costs of emergency department visits, ambulance, ward care, intensive care) is estimated to be $159 million. [6]

$34m

Indirect costs (i.e. productivity loss and out of pocket costs) is estimated to be $34 million. [6]

A spotlight on RSV

RSV can be as severe for infants as influenza

Through concerted efforts by the Government, Health Care Providers, and the impact of the COVID-19 pandemic, Australians now understand the risks posed by respiratory illnesses such as influenza and COVID-19, particularly to the elderly. RSV, on the other hand, poses a comparatively grave threat to infants and children, but it is neglected, especially when it comes to severity of disease, quantifying burden, prioritisation on the health care agenda and investing in prevention strategies.

With vaccines and other preventatives options on the horizon we have a real opportunity to heed the lessons learned from the way we manage influenza and COVID-19, apply these to RSV and affect real change for Australian infants and children.

RSV is a common respiratory virus that can cause a wide range of symptoms, from mild cold-like symptoms to severe lower respiratory tract infections, such as bronchiolitis and pneumonia, and less often otitis media. [4, 5] For most infants and children the symptoms of RSV are usually mild (Figure 1), however the virus can cause serious infection of the lungs and breathing passages that lead to hospitalisation and in some cases even death. [2-4] In fact, RSV is the leading cause of hospitalisation for infants and children under five years in Australia. [1] Even more worryingly, all infants and young children are at risk of contracting RSV, and progressing to severe infection, even those who are otherwise healthy with no predisposing conditions. [7, 13-15]

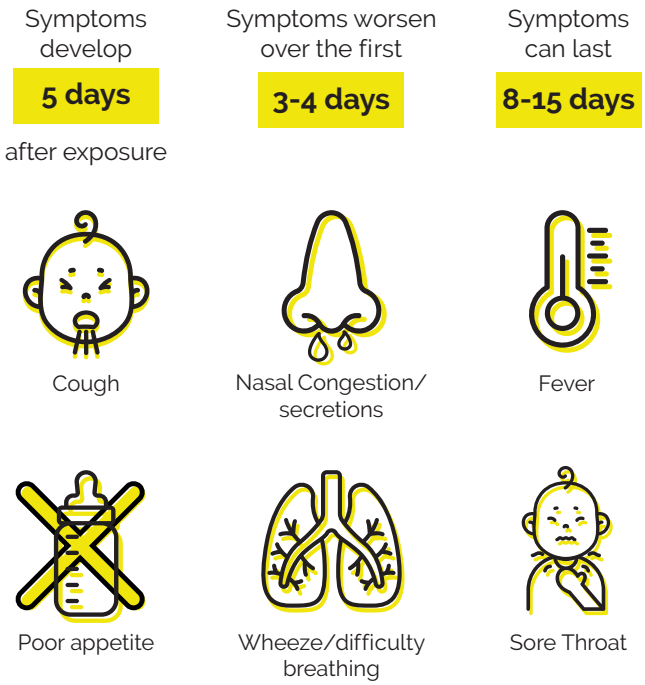
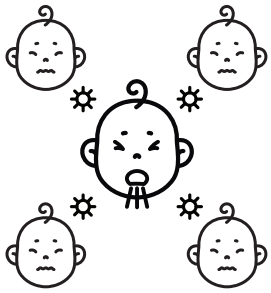


Figure 1. Signs and symptoms of RSV [2-5]



RSV is extremely infectious, potentially more so than influenza and COVID-19. [23-26] It is estimated that one infected individual can spread the virus on average to 4.5 others. [23-25]

Patients are infectious for three to eight days after symptoms begin, or longer for patients with weakened immune systems.[2] This poses some serious problems for halting the spread of disease, particularly in infants and children. Parents have reported that in addition to not knowing what RSV was until their child was hospitalised with it, they had no understanding of how infectious it can be.

Like influenza, we know that in Australia RSV cases will be higher at certain times of the year. In Australia, seasonal outbreaks of RSV occur during the winter months just prior to the typical influenza season in temperate climates such as South Australia. [27-29] in tropical areas such as northern Australia, typical RSV seasonality has two peaks in autumn and winter. [28] These outbreaks significantly contribute to the burden already experienced by our emergency departments and hospitals during the colder months due to influenza cases. Both clinicians and parents of patients readily comment on the number of beds that children with RSV take up in the hospital during these times. Clinicians describe preparing for the RSV season with specific management plans for the surge that they know will be coming.

The predictable nature of the RSV season, like influenza, presents an annual opportunity for public awareness campaigns to empower parents and carers to make decisions that may reduce infections and burden of disease. This includes similar measures to those taken to reduce transmission of COVID-19 including: improved hand hygiene, mask wearing and keeping their child home from day-care or infant away from sick family members or friends.

> *I was shocked when my mothers' groups asked me not to bring my son because he had RSV. I had no idea how infectious it is or dangerous it can be, we need to do more to ensure parents are educated about the dangers of RSV*
>
> **- Cat Irvine (mother of an infant affected by RSV)**

Testing for RSV

RSV can be confirmed with a several testing modalities such as a RSV antibody test or viral culture however, Polymerase Chain Reaction (PCR) test from nasal or oral swabs is the widely used, standard testing method.[2] Some pathology providers are able to test for COVID-19, influenza and RSV in one test, this is known as a Multiplex test.[2]

Since July 2021 laboratory confirmed cases of RSV have been included on the NNDSS. Diseases are added to the NNDSS when an outbreak of a disease could pose a public health risk. [30] This assists Federal and State Governments to monitor the spread and better understand national trends in transmission and risk. [30, 31] This information can inform public health policy to ensure rapid and efficient response to prevent outbreaks from occurring or minimising their impact when they do. [30] Despite this, PCR testing for RSV is not routinely undertaken in clinical settings. In some cases 'test seeking behaviour' is actively discouraged due to the associated cost or because it does not change the way in which the disease is treated.[2, 3] Nevertheless the addition of RSV to the NNDSS is significant step forward in acknowledging the burden of RSV in Australia.

There is still a tension that exists between public health surveillance measures and real-world clinical diagnosis of RSV that makes quantifying the true burden impossible.

Treating RSV

There is no clinically effective curative treatment for RSV infection. As a result, prevention is considered the preferred management strategy and symptom and complication management is the mainstay of RSV treatment. [32-35] The degree of care is dependent on the severity and type of symptoms experienced by the child and their diagnosis (i.e., bronchiolitis, bronchitis, pneumonia, otitis media) (Figure 2).[2-5]

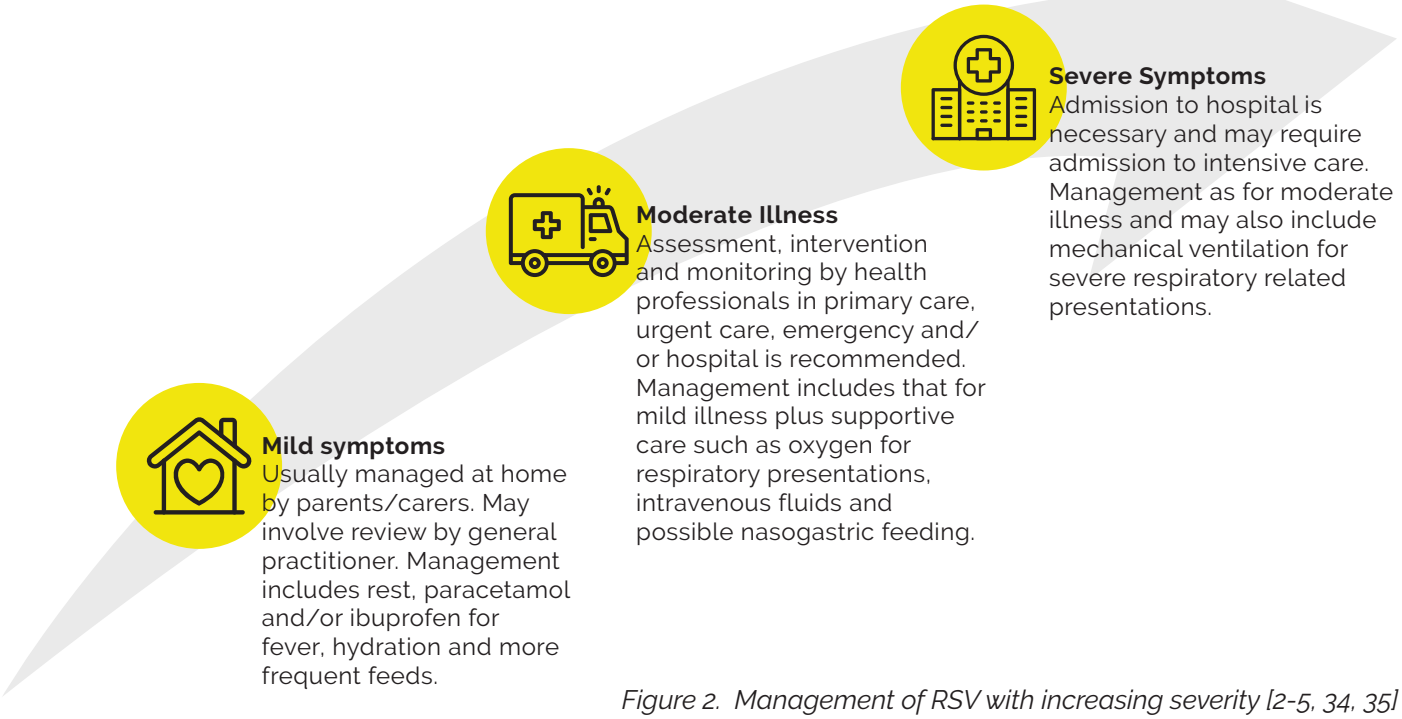


Figure 2. Management of RSV with increasing severity [2-5, 34, 35]

What is bronchiolitis?

Bronchiolitis is caused by viral infection of the lungs and most commonly RSV infection. [36] Bronchiolitis causes inflammation and mucus build-up in the airways making it difficult for the infant/child to breathe. [34, 37] Infants/children with bronchiolitis often display alarming symptoms such as wheezing, increased/decreased respiratory rate and general difficulty breathing. [2, 34] Anything beyond mild symptoms usually results in hospitalisation for infants and children and thus, bronchiolitis is the most common diagnosis for an infant/child admitted to hospital with RSV. [8, 34]

Clinical outcomes

Hospitalisation for infants and children is distressing, and for those with severe RSV infection, particularly severe bronchiolitis or pneumonia, there is also a risk of poorer health outcomes later in life. Severe RSV infection has been associated with recurrent wheezing, recurrent respiratory symptoms, clinical allergies and sensitisation to perennial allergens.[38-40] These long-term impacts are often overlooked as they are difficult to quantify, but the burden on families can be ongoing.

Sadly, babies born prematurely, with a low birth weight, or those that have underlying or chronic illness (i.e. lung disease, neurological condition or congenital heart disease) or a weakened immune systems experience a much higher rate of hospitalisation, and poor outcomes from RSV.[7, 9, 10, 41]

Those who identify as Aboriginal and Torres Strait Islander are also at increased risk of poorer outcomes with RSV infection. [7, 42] In fact, Australian indigenous children are three to six times more likely to be hospitalised for RSV compared to non-indigenous children. [7, 42] These disparities have been explained by the increased proportion of Aboriginal and Torres Strait Islander babies who are likely to be premature or low birth weight and who are more likely to live rural and remote with limited access to healthcare and testing. Public health strategies to reduce the burden of RSV must improve outcomes for all children, regardless of where they live, with careful consideration for protecting those who are most vulnerable.

In Australia, infant and child deaths associated with RSV are rare and have been found to account for 15 per cent of all RSV related deaths.[7]

> *First nations children are at an increased risk of severe RSV. Thus, at an increased risk of hospitalisation due to RSV*
>
> **- Paediatric Respiratory Physician**

The hidden burden of RSV in Australia

To test, or not to test?

Grasping the true burden of infant and childhood RSV infection resulting in hospitalisations in Australia today is near impossible.

Despite the acknowledgement of RSV's risk to public health and inclusion on the NNDSS, there is currently no imperative to test for RSV in the real-world clinical setting, primarily as a positive RSV test result does not change clinical management. Consequently, our RSV testing rates are low and determining true incidence is difficult.

A recent Western Australian (WA) study estimated that only 10 per cent of children are ever tested for RSV, with 21 per cent of tests occurring in community settings and the majority of the remainder (68 per cent) in hospital.[11] Another WA study seeking to determine the degree of underreporting observed that the true burden of RSV resulting in hospitalisations may be 30-57 per cent higher than best estimates.[43] As a result of this chronic under reporting across all of Australia and the clinical testing shortcomings, determining the true incidence of RSV in Australia is currently impossible.

RSV resulting in hospitalisations may be 30-57 per cent higher than best estimates. [43]

Our youngest are most at risk of hospitalisation

Despite not knowing the overall incidence

of RSV in Australia, we do have reported rates of hospitalisation likely resulting from RSV. This data is provided by the State and Territories to the Australian Institute of Health and Welfare (AIHW). [44] Alarmingly, this data reveals that almost all hospitalisations (94.9 per cent) for RSV in Australia occur in children less than five years old.[7] Subsequently, RSV infection is one of the most common causes of hospitalisation in young children.[7] To put that into perspective, RSV is associated with up to eight times more hospitalisations than seasonal influenza for Australian children less than 5 years old.[29] This could be even more for those less than six months old.[7, 12, 36] The younger a child the more likely they are to be hospitalised with RSV, with infants less than six months old at particular risk. [7-11]

> *Clinically in training we are always told to watch out for RSV especially in infants and toddlers*
>
> **- Paediatrician**

RSV is not just a disease that affects the vulnerable, **up to 80 per cent of infants hospitalised with RSV are otherwise healthy.**[7, 13-15] That is, they have no pre-existing illness or condition that would make them more at risk of severe disease.[7, 13-15] Predicting those who will become most unwell with RSV is not possible.

The average length of hospital stay for children under five with RSV is three days but it can range from one to nine days.[7, 10, 12] Concerningly, of the infants and children that are admitted to hospital, it is estimated that between 10– 26 per cent spend time in the Intensive Care Unit (ICU) (neonatal or paediatric) [9, 12] and up to 14 per cent of children are readmitted to hospital within 30 days and up to 42 per cent within 6 months.[12]

> *I want people to know it can affect any child and just because yours seems okay, doesn't mean that mine will be, mine will end up in hospital, yours could end up in hospital too, you just don't know*
>
> **- Cat Irvine (mother of an infant affected by RSV)**

Patient story – Hazel Cresswell

In November 2019, Hazel was just two months old when she caught RSV from her older brother who was in day care at that time. Hazel was also born four weeks premature and became very unwell.

Hazel was infected with RSV during the height of COVID-19 and so her parents had a telehealth consult with their GP. The GP told Katherine and her husband that Hazel looked fine and to monitor her at home. However, when Hazel declined two days later, Katherine called HealthDirect and was advised to take her to the Emergency Department (ED).

When Katherine and her husband got to the hospital with Hazel, the medical staff took her temperature and blood pressure and immediately called a code blue. The hospital staff stabilised Hazel but then her heart rate dropped to below 20 and the staff had to administer CPR and adrenaline to stabilise her.

Once she was stable, Hazel was transferred to the Perth Children's Hospital (PCH) ICU ward and was ventilated for eight days. Hazel's mother recalls that's the hospital staff were unsure of the cause of Hazel's illness initially. At two months old she was checked for meningitis, had an Electrocardiography (ECG), chest x-ray and a Magnetic Resonance Imaging (MRI).

While in the hospital ICU ward, Hazel's left lung collapsed. After eight days Hazel was extubated and put on the Continuous Positive Airway Pressure (CPAP) machine for a few days. She was then admitted to the hospital ward for 11 days.

Upon discharge on the 23rd day the hospital staff told Katherine that Hazel had RSV and bronchiolitis. Prior to this Katherine had not heard of RSV before.

– Katherine Kieran (mother of Hazel).

The impact of this disease on the youngest in our society can be immense and it is time we start to build out a better picture of just how much it is affecting Australian families.

Our analysis of reported RSV related hospitalisations over a five-year period from 2016-2021 shows that:

15,864 hospital admissions

In Australia annually there are an **average of 15,864 hospital admissions** for Australian children <5 with RSV.[6]

11,968 hospital admissions

In Australia annually there are an **average of 11,968 hospital admissions** for Australian infants <1 year old with RSV.[6]

12x more likely

In Australia, infants **< 12 months are approximately 12 times** more likely to be **admitted to hospital** with RSV than those aged 1-4 years old.[6]

While these numbers are alarming, we can see from State and Territory data analysis below (Figure 3) that these hospitalisation rates are very likely an underestimate of RSV cases. These rates were calculated using nationally aggregated hospitalisation data from the AIHW, overlayed with proportions of infection for each State and Territory as reported in existing published literature (Appendix).[7, 44] The published literature utilised likely demonstrates a historical underreporting of RSV, however this is the only national study of its kind available. This underreporting is most likely due to de-prioritisation of testing in some states and territories during the reporting period (2006-2015). [7] For example, Victorian cases are substantially under reported as we would expect to see numbers similar in scale to that of New South Wales. Conversely, South Australia appears to have the highest hospitalisation rates despite having the fifth largest population of less than five-year-olds. So, while these figures provide an indicative snapshot of RSV in Australia over a five-year period, it is important to take them in the context of the clinical, and policy environment in each state at the time of reporting.

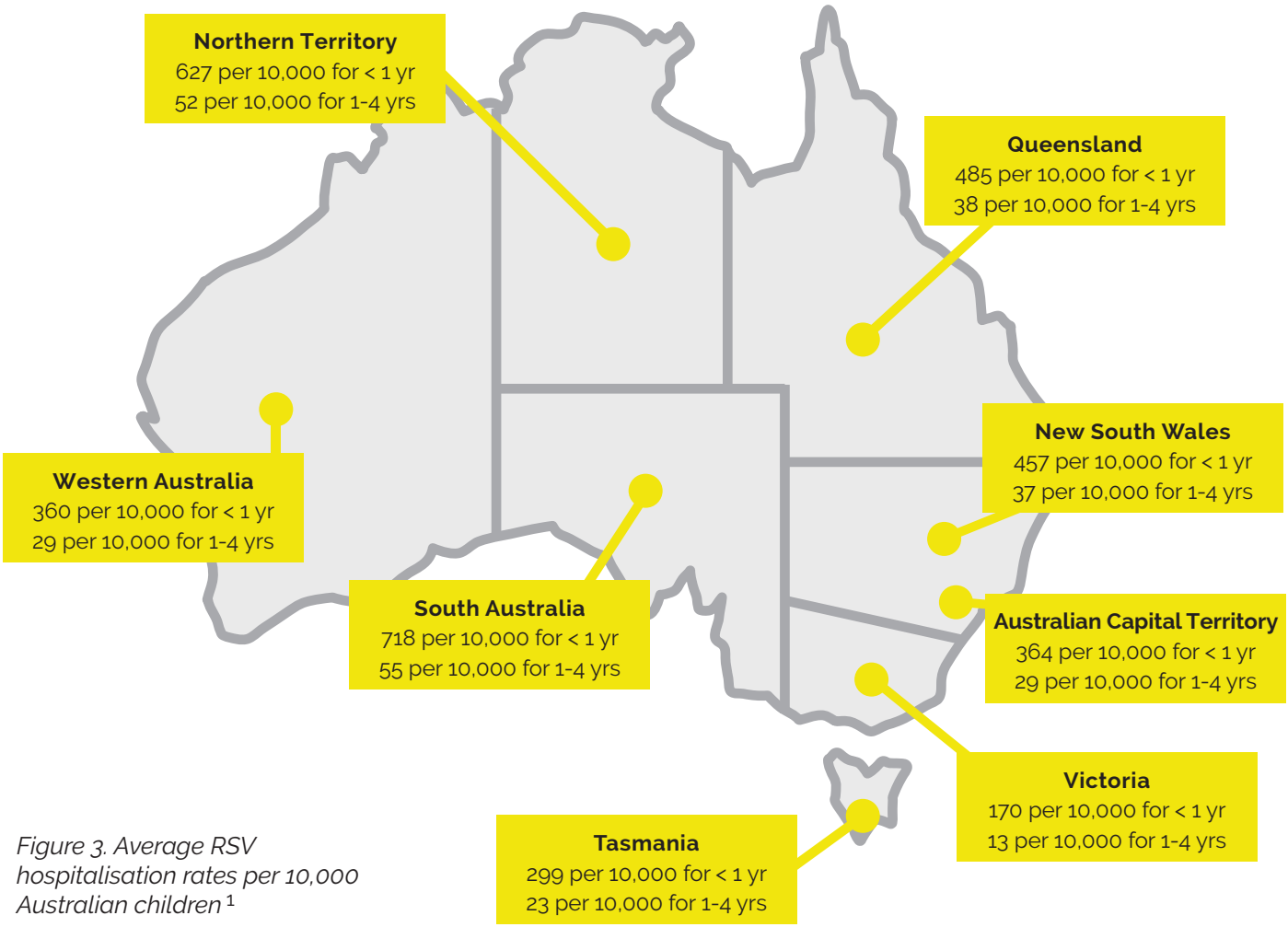


Figure 3. Average RSV hospitalisation rates per 10,000 Australian children [1]

1 *RSV hospitalisations in Australia are underestimated in the data. These data discrepancies further highlight the practical challenges with getting a true grasp on the burden of this disease in Australia.*

Once the borders opened in April/May 2022 we saw a significant increase and there was a stage where I was doing ward duties, I saw 50 patients in a row with RSV and that is almost unheard of in the context of regular season.

- Consultant Paediatrician

COVID-19 non-pharmaceutical public health measures could decrease RSV burden

In Australia, there was a significant reduction of winter cases and hospitalisation relating to RSV in 2020 across several states, followed by a spring and summer surge [2, 45-48] In particular, there was a larger proportion of cases in older children two to four years old reported, due to increased number of children who had not yet been exposed to RSV during this time.[47]

This initial reduction in cases has almost exclusively been attributed to the success of the non-pharmaceutical public health measures that were in place during the COVID-19 pandemic such as mask wearing, increased hand hygiene vigilance and social distancing/lockdowns. Not only did these measures significantly decrease the amount of COVID-19 circulating in the community but also prevented exchange of other respiratory viruses such as RSV and influenza.

The introduction of quadraplex testing (a single test that screens for multiple diseases including COVID-19, RSV and influenza) and increase in 'test seeking behaviours' during this time also allowed for more accurate surveillance of RSV and other respiratory illnesses. Lessons learned during the pandemic could be leveraged in public health initiatives in the future to prevent and reduce the impact of RSV outbreaks.

Some clinicians reflect that the 2022 RSV season was unusually bad, they suspected this could be a surge after the complete removal of the COVID-19 prevention measures.

The 2022 Winter season was the worst I had observed in the past decade since surveillance has been in place.

- Consultant paediatric respiratory physician and research fellow

RSV is costing Australia in more ways than one

The burden of RSV significantly impacts Australia's health systems, the economy, and quality of life for the unwell child and their family. When a child is unwell with RSV, they may receive care from several people in many different settings (Figure 4). The severity and duration of a child's illness, as well as the location of care and assistance sought by their parents, can all contribute to the incurred costs. Each level of care provided has financial, societal, and emotional costs associated, albeit some are more easily quantified than others.

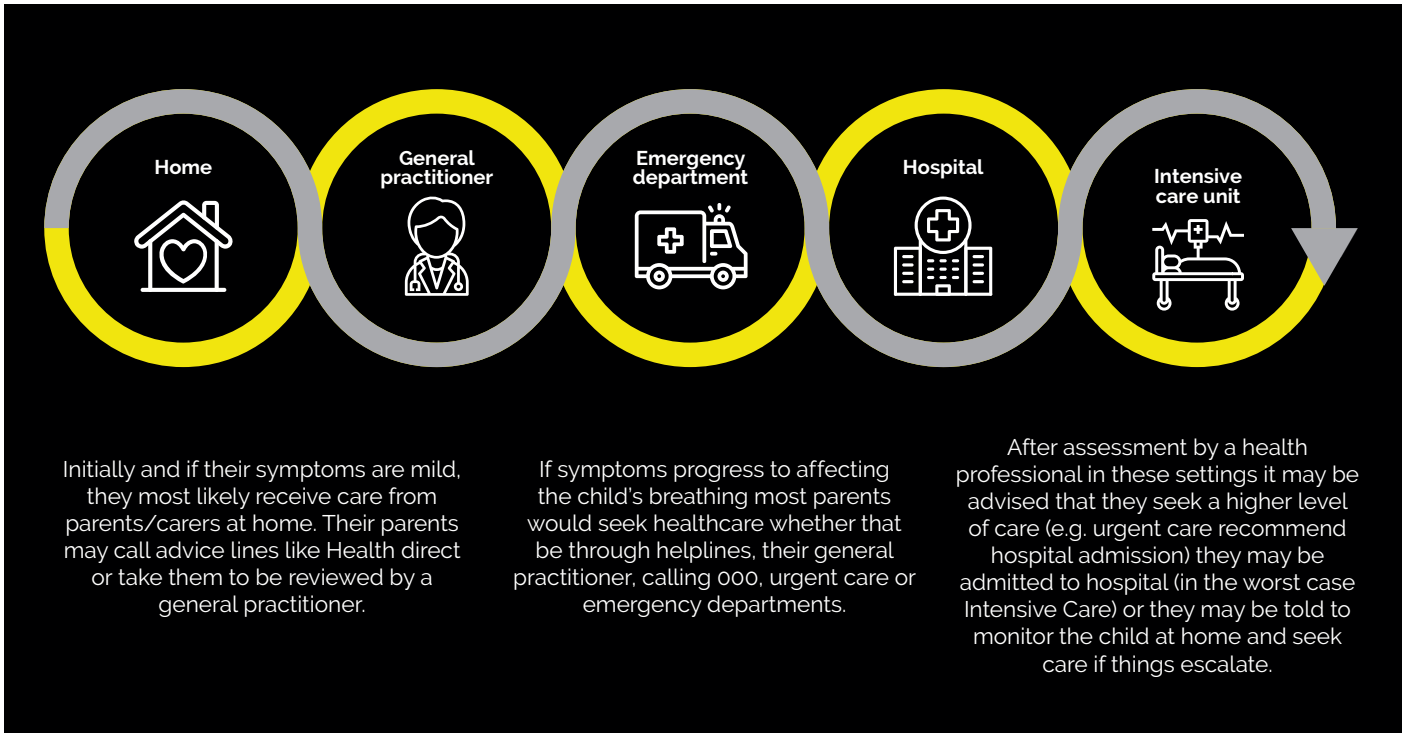


Figure 4. Settings an infant or child may interact with to receive care when they are unwell.

So, we know that RSV is costing families, the health system, and the economy, but do we know how much? Evohealth has undertaken a review of literature, interviewed clinicians, academics, patient representatives and developed an economic model to delve into the societal burden of childhood RSV infection, with a specific focus on hospitalisations, primary care and community level impacts. Full detail on the methodology of the economic model is in the Appendix.

As highlighted previously, the absence of systematic collection of RSV data to estimate the burden on the economy and healthcare system impedes the quantification of the absolute impact of RSV in Australia. [49]

The tip of the iceberg: RSV Hospitalisations in Australia

In Australia, hospitalisation data from the AIHW can facilitate calculation of the direct hospital cost burden. Unfortunately, the costs of hospitalisation of a baby or child with RSV is not just limited to the healthcare systems but also extends to the broader economy and families. While some of these costs are financial and quantifiable, some such as impact on quality of life and emotional trauma are not.

What is RSV costing our healthcare system?

The costs of hospitalisation in Australia are substantial and can vary greatly depending on the type of condition and treatment received. Our modelling has quantified the costs of ambulance, emergency department visits, ward care and intensive care (i.e., direct health care costs) for RSV related admissions in children under 5 years.

$159,064,934 Annual Costs

The average annual direct health care costs associated with Australian children < 5 years admitted to hospital with RSV is estimated to be $159,064,934.[6]

$10,040 Direct Costs

The average direct health care costs associated with Australian children < 5 years per RSV related hospital admission is $10,040. [6]

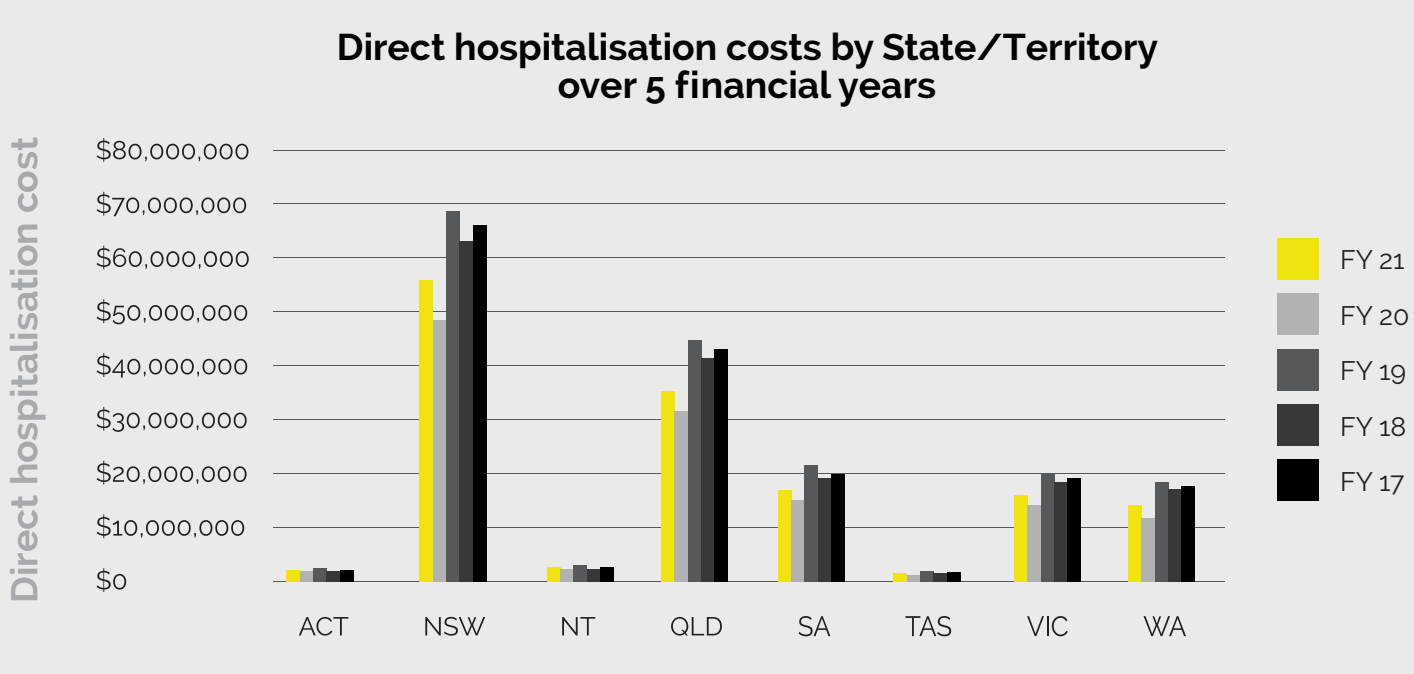


Figure 5. Direct hospitalisation costs of children less than five years old with RSV per State and Territory over five financial years (FY17-21) [1,2]

> *Hospitalisations are tip of the iceberg" – the broader economic impact due to the burden on families is the bigger issue but hasn't received a lot of attention.*
>
> **- Consultant paediatric respiratory physician and research fellow**

1 The published literature utilised likely demonstrates a historical underreporting of RSV for the reasons detailed on page 18 of this report.

2 At the time of reporting, the FY22 hospitalisation data had not been published and is such is not included in this analysis.

What is RSV costing our society?

RSV related parent and/or carer productivity loss has not previously been quantified in Australia although is expected to be substantial given the amount of time a child may be symptomatic and unwell, especially if they are hospitalised. Children are usually hospitalised for three days, but this could be up to five days for a first admission and ranges from one to nine days.[7, 10, 12] One carer is often absent from work on these days. Studies have shown that even if the second carer returns to work their productivity could be less than half (54.1 per cent).[50] Furthermore, we know this number is an underestimate because children are often unwell with symptoms for 8 to 15 days in total and parents may also be required to take time off work to care for them at home once they are discharged.[3]

We estimate the annual **economic losses** (e.g. productivity loss due to parents/carers absence from work) experienced due to children < 5 years admitted to hospital with RSV to be at least **$25,400,760.** [6]

While her son Emmett was sick with RSV, Vanessa had stopped working for five weeks – one week for when she was in hospital with her son and the remaining four weeks when she stayed home with him until he had recovered. The loss of income over the four weeks accumulated to approximately $5,000.

– Vanessa Solomon (mother of Emmett)

Cost of productivity loss due to hospitalisation by State/Territory over 5 financial years

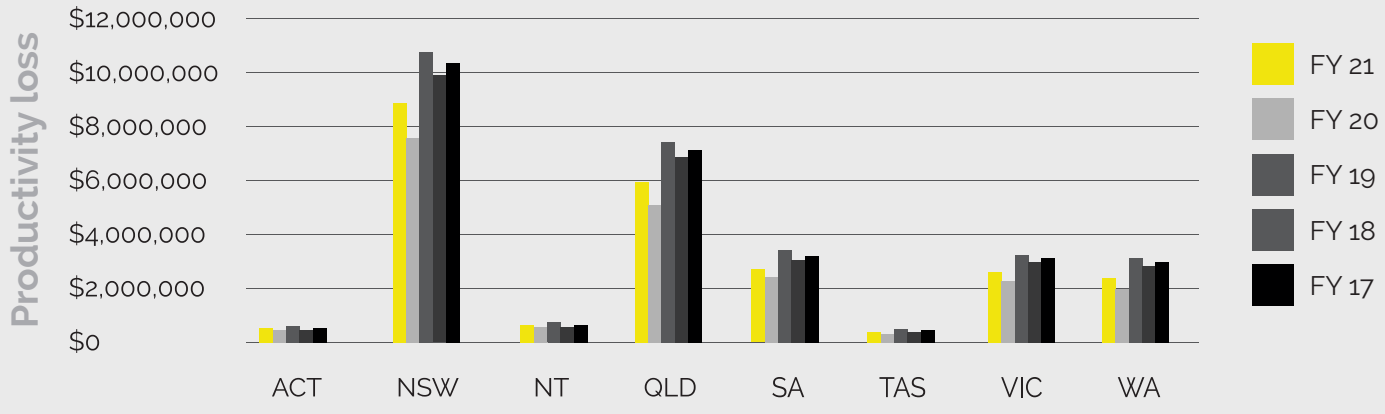


Figure 6. Costs of productivity loss due to hospitalisation of children less than five years old with RSV per State and Territory over five financial years (FY17-21) [3, 4]

[3] The published literature utilised likely demonstrates a historical underreporting of RSV for the reasons detailed on page21 of this report.

[4] At the time of reporting, the FY22 hospitalisation data had not been published and is such is not included in this analysis.

What is RSV costing our families and communities?

Despite having world class healthcare in Australia, families are often contributing financially. This can include paying an excess for admission to a private hospital and non-medical costs such as loss of income if no parental/carer leave is available, loss of childcare fees, costs of travel and parking, accommodation, food, and amenities to name a few. There can also be additional costs involved when organising care for other dependents or children.

One Australian study, reviewing non-medical costs associated with paediatric hospital admissions found that on average parents spent a total of $125 per day ($89 per day on travel + $36 per day on meals, accommodation and sundries).[19] These costs were found to significantly increase if they lived in a remote area and had a greater distance to travel to the hospital.[19]

As with many elements of health care in Australia, there is much greater burden on people living in rural and remote Australia, given the well-documented access challenges. However, quantifying the full extent of this burden is difficult due to limited visibility on the demographics of those admitted to hospital with RSV.

> *"The LifeFlight pilot informed us that the trip from a regional hospital in Warwick to St Vincent's Private Hospital in Toowoomba costs about $12,000.*
>
> **- Vanessa Solomon (mother of Emmett)**

Cat and her husband have had to take time off work whenever Parker has been admitted to hospital or taken to ED. They still had to pay for day care. Other out of pocket costs included medications (steroids, Ventolin), a gap fee for the GP visit, urgent care visits and the cost of food, water and parking during Cat's hospital stay with Parker. **"Nothing was covered for me."**

– Cat Irvine (mother of an infant affected by RSV)

Our analysis estimates that the average annual **out of pocket costs** associated with children < 5 years admitted to hospital with RSV is at least **$8,413,746**.

Vanessa shares that both herself and her husband had to find accommodation quickly after Emmett was flown from Warwick to Toowoomba as only one of them were allowed to stay with him at St Vincent's Private Hospital. The cost to the family of accommodation for four nights combined with purchasing clothes and food for a couple of days amongst other expenses totalled approximately $600-$800.

– Vanessa Solomon (mother of Emmett)

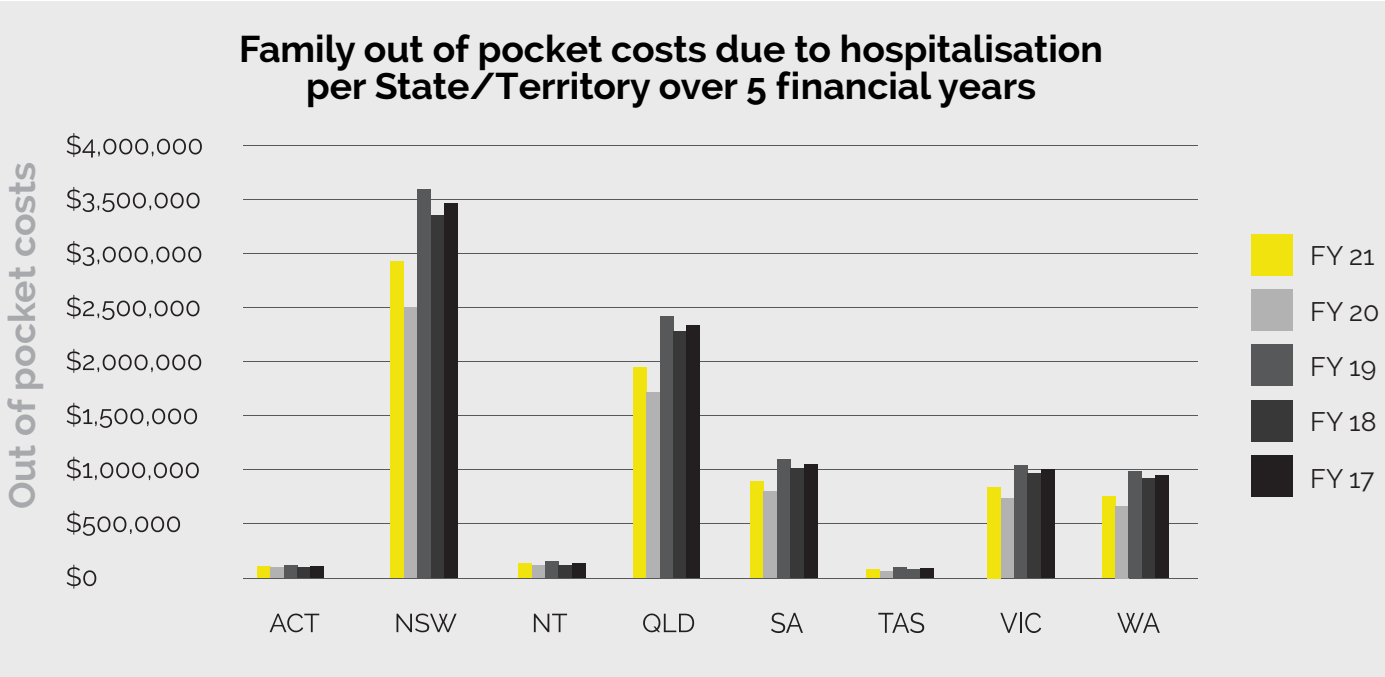


Figure 7. Family out of pocket costs of RSV hospitalisation in children under five years old by state and territory over five financial years (FY17-21), [5, 6]

The costs of RSV extend beyond direct financial loss incurred by families to impact on the broader family unit. Short and long-term impacts on the child's quality of life and their family members who care for them are scarcely acknowledged in Australia but are undoubtedly some of the lingering impacts for parents and carers. An unwell child can be distressing at the best of times, let alone when they are usually healthy and now requiring repeat emergency presentations to hospital for a virus they had never heard of.

[5] The published literature utilised likely demonstrates a historical underreporting of RSV for the reasons detailed on page 18 of this report.

[6] These average costs were based on those incurred by parents of children in a paediatric hospital in Sydney but were applied to the rest of the country. They do not consider remoteness which is likely to result in additional out of pocket costs for families.

The price we pay...

We have established that RSV burdens patients, families, and the Australian healthcare system.

The average annual societal costs (associated with Australian children < 5 years admitted to hospital with RSV) is at least $192,879,441.[6]

This equates to **$12,158 per hospital admission** in this patient population.

However, this is likely an underestimate given all the data limitations and challenges already highlighted.

The impact of RSV on our primary care system

The true burden of RSV on primary care is currently impossible to determine in Australia due to a lack of reliable data on the incidence of RSV in the community and on the number of General Practitioner (GP) consults that result from these cases. While all laboratory confirmed positive RSV tests are now required to be directly reported to the NNDSS, the origin of the test is not reported (i.e., community case versus hospitalised case) which limits estimations of incidence in the community.

There is also no clinical incentive for practitioners to test for RSV during diagnosis. As discussed earlier, a positive result does not change disease management. This further exacerbates the incidence data gap. While we can't ascertain the true burden of RSV in the community, we can be certain that its currently significantly underreported.

> *Testing clinically doesn't make a difference, but it most definitely does help surveillance, and does help education and setting expectations for parents.*
>
> **- Consultant Paediatrician**

Regardless, the costs of managing RSV in the community are likely to be substantial considering this is where most infants and children are managed.

Of the few studies conducted in Australia, one found that 97 per cent of the infants and children diagnosed with RSV were managed at home or as outpatients.[17] Of the children in this study that were symptomatic with RSV 88.3 per cent of them were managed in the community with over half (55.0 per cent) requiring a visit to their GP.[17] Another study found that out of every 10 RSV infections in pre-school aged children, 7.4 required a GP visit. [51]

Given the difficulties in determining primary care costs associated with RSV, we can look to the real-world experiences of Australian families impacted by this disease. Stories shared by parents/care givers highlight some of the key frustrations associated with caring for a child with RSV. For those whose child received a diagnosis and were hospitalised, carers expressed frustration at the lack of information they were provided on the virus and how severe it can be. Some reported that they didn't find out the name of the virus until much later in their care journey or in some cases not at all. Reports of their concerns being dismissed or downplayed to "it's not that bad" and advice to "just seek care again if it gets worse" without specific advice as to what symptoms would indicate escalation was disconcerting. Although, given the nature of the virus, and as mentioned previously, the lack of testing it is unsurprising that the specific virus was often not named in the primary care setting.

Parents/carers also report that knowledge of RSV may potentially have changed their subsequent actions in terms of caring for the child, by encouraging isolation, staying home from childcare and enhanced monitoring of their symptoms.

These experiences highlight a real opportunity to increase awareness of RSV both in the community and among health care providers. It furthers the case to encourage testing to improve incidence and surveillance data to one day support informed and data driven investment in RSV prevention measures, such as vaccines.

The broader impact on the family of a child unwell with RSV remains un-quantified. However, this cost is expected to be substantial considering most children are cared for at home or in the community.

What is RSV costing our community?

There are several associated costs for families/carers of children with RSV. This includes the costs of GP visits, over the counter and prescription medications, ED presentations and costs associated with diagnostic testing. [20] Families/carers also bear the burden of a loss of income due to time away from work while caring for their sick child. [20] According to Lambert et al. (2008) the reported mean cost for children with RSV managed in the community is approximately $304 per child. [20]

The 2008 Australian study also assessed the portion of the total costs that were met by different sectors for all the viruses in Australia. It was concluded that 79 per cent of the total cost was contributed by the patient and their family, with the remaining 15 per cent from employers and 6 per cent from the healthcare sector. [20] This would not be expected to be substantially different for RSV cases specifically and highlights the disproportionate burden that carers/families bear financially when caring for a sick child.

For the family/carer of a child who becomes unwell with RSV there are significant fiscal and social costs involved in managing their condition and nursing them back to full health. These costs can include:

To estimate this cost, we have assumed that a 1-year-old child with RSV is symptomatic and unwell enough to miss childcare for three days, that a parent must take leave to care for them and does not have carer leave provisions or has run out, and that the child requires symptomatic relief from fever for at least those three days (Table 1).

Table 1. The costs to parents managing their child's RSV in the community.

Item	Estimate	Cost of item	Sub total
OTC medicines	Paracetamol for children 1-5 years old 200mL bottle, dose = 7mL four times a day, therefore 1 bottle needed.	Cost is dependent on brand and ranges from $6.00 - $17.49 [52]	**$11.75**
	Ibuprofen for children 3 months-5 years old 200mL, dose = 5mL three times a day, therefore 1 bottle needed.	Cost is dependent on brand and ranges from $13.99 - $21.99 [53]	**$17.99**
Visit to General Practitioner	1 visit	Out of pocket cost is dependent on the practice the national average is $42 [54]	**$42.00**
Carer missed days of work	3 days' work missed [21]	Average weekly wage = $1095.10 (i.e. $219.02 per day)* [55]	**$657.06**
Missed days of childcare	3 days home from childcare [21]	Cost is dependent on the provider national average daily cost reported as $105 per day [56]	**$315.00**
Cost of a COVID-19 Rapid Antigen Test	1 test per child or person displaying symptoms	2 pack of tests $9.99 [57]	**$5.00**
Total **adjusted for after tax*			**$1,048.80**

These costs would vary depending on where the family lives in Australia, how far away they are from a pharmacy or GP and the services they access (e.g., bulk bill versus out of pocket cost). Additional costs and burden may also be placed on a family if another family member or child contracts RSV and becomes unwell, leading to further losses of productivity and caring costs. [18]

In addition to the financial and productivity costs associated with RSV, there is also a significant emotional burden placed on the entire family. The emotional turmoil and lasting effects on the mental health of family members involved in caring for a sick child have scarcely been reported. However, there are compelling stories detailing the emotional impact of caring for a child with RSV. This emotional impact can also persists beyond the child's recovery. [18]

The impact on other family members such as siblings of infants or children infected by RSV should also be acknowledged. Siblings can be affected by the sight of seeing their brother or sister extremely unwell. Additionally, they may experience reduced attention from their parents or carers who are focused on their sick infant or children.

Realising the true toll of RSV

Patient story – Emmett Richards

In early March 2021, Emmett was just two years old when he was diagnosed with RSV. On initial presentation to ED, Emmett was thought to have asthma and pneumonia. Vanessa recalls being sent home twice from ED. Emmett was struggling to breathe and was extremely lethargic.

The third time Emmett's parents took him to ED in three days, he was tested for COVID-19, RSV and other respiratory infections. It was confirmed he had RSV.

Emmett had become too unwell for the regional hospital in Warwick to continue his care. He was airlifted from Warwick to a St Vincent's Private Hospital in Toowoomba. But Vanessa recalls that ***"by the time he was transferred in the chopper he was on a ventilator. We were met on the ground by paramedics and then a specialist doctor in the ambulance to St Vincent's Toowoomba. The LifeFlight team were critical to him surviving".***

At St Vincent's Private Hospital in Toowoomba, Emmett was treated with high-flow oxygen. He showed improvement after three days.

Vanessa and her husband were told by the Paediatrician that the strain of RSV that Emmett had was "particularly bad" and that a high proportion of children had the same strain as well.

– Vanessa Richards (mother of Emmett)

Patient story – Caleb France

Seven month old Caleb had been unwell for several days. On a Monday evening his breathing became laboured. Caleb was taken to ED, diagnosed with bronchiolitis and kept overnight for observation. After being sent home, the following night Caleb's breathing declined again. Back at ED, he was admitted overnight, swabbed for influenza and RSV and sent for a chest X-ray. The next morning Caleb's mother was told that Caleb had tested positive for RSV which had developed into bronchiolitis. Once again due to a slight improvement in his condition he was sent home.

"I was naïve, I had never heard of RSV before, I thought she said virus B and I told my husband to tell our GP that when he took Caleb's sick brother for a check-up."

On Wednesday night Melinda recalls that Caleb's fluid intake was quite low. Again, presenting to ED, Caleb had a fluid test and was sent home.

On Thursday evening Caleb's breathing became extremely laboured once more prompting another trip to ED. He was assessed as critical and put on oxygen. Eventually Caleb was admitted at midnight.

Caleb spent six days on oxygen and three days being fed expressed breastmilk via a nasogastric tube. He had no predisposing conditions. It took Caleb two to three weeks post discharge before he fully recovered.

In hindsight Caleb's mother Melinda wishes that the medical staff at the hospital had given herself and her husband more information on RSV, the cause of the virus and its signs and symptoms when he was diagnosed. ***"As parents, you get decision fatigue about whether to go back to the hospital, especially when you've barely slept"***. She wishes that it was noticed that Caleb consistently declined in the evenings and was kept for longer the first time that he was admitted to the ward. She now understands that there is not a lot that can be done for infants/children with RSV other than supporting their breathing and feeding however she does wonder ***"if he would have gotten better sooner if they had provided that support earlier."***

- Melinda France (mother of Caleb)

Preparing for the new paradigm of RSV

There is currently no treatment or preventative vaccine available for RSV. There is, however, hope on the horizon, with a range of RSV vaccines and preventative interventions currently undergoing clinical trials.

Australia must ensure that it can seize the opportunity to lead the way in assessing the potential value and impact of these new innovations.

Prevention of RSV is a global priority

The burden that RSV puts on our children, the healthcare system, economy, and families is significant. In recognition of this, the development of a vaccine against RSV has been announced as a global health priority by the World Health Organisation (WHO).[58]

Globally vaccination and immunisation working groups are increasing their efforts to address the rising burden of RSV. The National Immunisation Technical Advisory Groups (NITAGs) in partnership with WHO are multidisciplinary bodies who provide policy makers with evidence-based recommendations to inform decision making for funding of new vaccines such as those for RSV. [59] The United States, United Kingdom and Canada NITAGs have all commenced work to review the potential of RSV prevention measures:

In the United States the Advisory Committee on Immunization Practices (ACIP) are actively considering the use of RSV vaccine(s) and immunoglobulin products in development for infants, young children, and pregnant women. There is also a separate working group considering RSV prevention policy for adults. [60]

In the United Kingdom the Joint Committee on Vaccination and Immunisation (JCVI) is considering the cost-effectiveness of RSV prevention. [61]

In Canada the National Advisory Committee on Immunization (NACI) has made targeted recommendations for the use of approved RSV vaccines and monoclonal antibodies. The Advisory Committee is actively reviewing evidence to guide strategies to prevent the severe implications of RSV on children at high risk of severe RSV. [62]

Preparing for when, not if

In Australia, to ensure priority access to these innovations is not delayed and that cost effectiveness can be readily ascertained, more robust surveillance data is needed to determine the incidence and burden of childhood RSV accurately. Furthermore, ongoing surveillance after introduction or trials of any preventative therapies would also allow for real time assessment of their effectiveness and impact on disease burden. This is not just a challenge that Australia needs to address but a global one with similar issues being discussed in Europe and by the WHO. [63, 64] The introduction of RSV being a notifiable disease may go some way to address this data deficit, but the system will need to be further optimised so that we have visibility on disease burden in priority communities (i.e. Aboriginal Torres Strait Islander People) and the general community, not just hospitalisations. Following the lead of the WHO it may be prudent to extend influenza and other respiratory disease surveillance programs and public health initiatives to include RSV.[64]

The scene is set, the time to act is now

One of the few positives from the COVID-19 pandemic is society is more informed about the deadly nature of respiratory viruses and the role both pharmaceutical and non-pharmaceutical strategies (e.g., mask wearing, increased hand hygiene vigilance and social distancing) play in protecting individuals and decreasing the burden of disease. Australia must stay on our front foot and leverage this opportunity to raise awareness of RSV and ensure we can invest in targeted and proven preventative strategies such as the forthcoming vaccines and other technologies.

It's time for action!

We know that infants and children are disproportionally affected by RSV in Australia, bearing the burden of severe disease and RSV related hospitalisation. Yet, despite the significant impact, RSV is drastically underreported in Australia and true incidence is impossible to determine in the current setting.

Australia is presented with a real opportunity to improve surveillance of RSV, quantify the true burden, and invest in evidence-driven prevention strategies that are going to directly improve the health outcomes of our children and save the system money. We need to leverage the profile and momentum afforded to public health because of the COVID-19 pandemic, and act now to protect the health of Australian children.

We present 4 simple and tangible recommendations that will drastically improve Australia's ability to develop national, evidence-based policies and strategies to combat the severe and sometimes long-lasting impact of RSV on our children. Our recommendations have been informed by a comprehensive review of academic and grey literature; interviews with policymakers, clinicians, patients, and patient advocates; and the contributions of our project Advisory Committee.

Recommendations

Summary of Recommendations

Australia is presented with a real opportunity to improve surveillance of RSV, quantify the true burden and invest in evidence-driven prevention strategies that are going to directly improve the health outcomes of our children and save the system money. We need to leverage the profile and momentum afforded to public health because of the COVID-19 pandemic, and act now to protect the health of Australian children.

These recommendations are informed by a comprehensive review of academic and grey literature; interviews with policymakers, clinicians, patients, and patient advocates; and the contributions of our Advisory Committee.

Increase targeted surveillance of RSV through sentinel surveillance programs in primary and tertiary care.

Australia has made great strides in RSV surveillance by incorporating it on the NNDSS under the NNDSS. Yet the lack of drivers for health care professionals to test for RSV in the clinical setting undermines the policy intent of the program. We have well-established respiratory disease surveillance systems, predominantly instigated to monitor the burden of Influenza. To quantify the true burden of RSV the Australian Government should invest in and leverage these existing programs to include targeted surveillance of RSV. Examples of Government funded surveillance systems that could be expanded to support this initiative include Australian Sentinel Practices Research Network (ASPREN), FluTracking and Influenza Complications Alert Network (FluCan). The use of multiplex tests across clinical settings will also further support this initiative as it will allow for coordinated testing and reporting for three of the most common respiratory illnesses listed on the NNDSS.

Create national evidence base to quantify the true burden (incidence and hospitalisation) of RSV.

To fully understand the burden of any disease, the incidence must be determined. Following the implementation of improved and targeted sentinel surveillance of RSV, a national evidence-base should be established through the NNDSS that articulates the true burden of RSV in terms of incidence, prevalence, and RSV related hospitalisations. The evidence-base should identify origin of testing (the primary or tertiary setting) so that the true burden on our primary and community care sector can be articulated. This will be enabled through the collection of targeted data through surveillance programs like those listed above. Linkage of data through established record linkage systems will further enhance our ability to accurately determine population level incidence. This will ensure that Australia is best placed to develop, implement and invest in targeted, evidence-based preventative strategies that will improve the outcomes for infants and children and inform funding and implementation of future treatments or preventative measures (such as vaccines and other technologies).

Develop a national strategy for reducing the burden of RSV in our infants and children, including consideration of future preventative measures.

Broadly speaking, we know that preventative health measures lead to cost savings for health systems. [65] Even without knowing the true burden of RSV, we know that it is sending infants and children to hospital and costing the health system and economy millions of dollars each year. This is an avoidable cost and so we must develop a nationally consistent approach to reducing the burden of this disease and preventing future outbreaks. The development of a national strategy for RSV is instrumental in reducing the burden of this disease as well as forward planning for health expenditure, innovative treatments, and the potential of prophylaxis in the future.

Create a targeted tailored RSV awareness campaign to empower and enable parents, carers and the clinical community to make informed decisions about RSV testing and management.

RSV is not as well-known as other respiratory viruses such as influenza and COVID-19. There is a need for the Australian Government to support prevention and surveillance activities by developing a targeted awareness campaign. The campaign will serve to educate, empower, and enable parents and patients to seek testing for RSV, manage symptoms appropriately and seek clinical care as appropriate. This program should be versatile and adapted to sub-population as needed e.g., where an outbreak is occurring or those at greatest risk such as the Aboriginal and Torres Strait Islander community. The awareness campaign will also support the implementation of recommendation 1 by raising the profile of RSV in the clinical community and bringing the public health benefits of testing to the forefront of clinician's minds.

Abbreviations

Abbreviation	Description
ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
CPAP	Continuous Positive Airway Pressure
CPI	Consumer Price Index
ECG	Electrocardiography
ED	Emergency Department
FY	Financial Year
GP	General Practitioner
ICU	Intensive Care Unit
MC	Monte Carlo
MRI	Magnetic Resonance Imaging
NHDS	National Hospitals Data Collection
NNDSS	National Notifiable Diseases Surveillance System
PCR	Polymerase Chain Reaction
PDVAC	Polymerase Chain Reaction
RSV	Respiratory Syncytial Virus
SD	Standard Deviation
UK	United Kingdom
WHO	World Health Organization

Appendix

Methodology for the economic analysis

The economic model was developed to facilitate quantitative analysis of the economic burden of RSV related hospitalisations for children less than 5 years old in Australia for FY 2016-2021. Modelling was undertaken in February 2023.

Approach

This economic model is based on that produced by RAND Europe to model the burden of RSV in the United Kingdom (UK). [18] The current model has been amended to include the differences in data availability between Australia and the UK. This included modelling hospitalisations only, as no adequate primary care data was available. Like the RAND model, we include direct costs for the hospitalisations, and indirect costs including productivity loss and out-of-pocket costs for hospitalisations. [18] Unlike the RAND Europe model, we did not include costs associated with deaths, or any estimates on the impact of quality of life. [18] For productivity loss, we modelled both absenteeism and presentism costs, whilst the RAND Europe model included only absenteeism costs, although it identified studies that investigate presenteeism costs associated with RSV.[18] A Monte Carlo (MC) simulation was run with 1000 trials to determine an "average year" based on means and standard deviations (SD) outlined in Table 2.

Determining Hospitalisations

Hospital separation statistics, by principal diagnosis, were sourced from data that are publicly available from the Australian Institute of Health and Welfare (AIHW) website.[44] Data summarised for analysis included five financial years (FY17 to FY21) for two age groups (< 1 year and 1-4 years) and four relevant International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) separation codes (J12.1 Respiratory syncytial virus pneumonia, J20.5 Acute bronchitis due to respiratory syncytial virus, J21.0 Acute bronchiolitis due to respiratory syncytial virus and J21.9 Acute bronchiolitis, unspecified). Results were reported as the number of cases per 10,000 population. Population data was obtained from data summaries publicly available on the Australian Bureau of Statistics (ABS) website for relevant years and ages. [66, 67] For the separation code 'J21.9 Acute bronchiolitis, unspecified', the level attributable to RSV was assumed to be 80 per cent of cases, based on prior research. [43, 68, 69] For the MC simulation, the SD was based on a range of cases calculated by varying the level of 'J21.9 Acute bronchiolitis, unspecified' cases attributable to RSV, from a minimum value based on 0 per cent attributable to a maximum based on 100 per cent attributable. A Gamma distribution was assumed, given the mean at 80 per cent produced a skewed distribution.

Direct Hospitalisation Costs

Hospital separation statistics, by principal diagnosis, were sourced from data that are publicly available from the Australian Institute of Health and Welfare (AIHW) website.[44] Data summarised for analysis included five financial years (FY17 to FY21) for two age groups (< 1 year and 1-4 years) and four relevant International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) separation codes (J12.1 Respiratory syncytial virus pneumonia, J20.5 Acute bronchitis due to respiratory syncytial virus, J21.0 Acute bronchiolitis due to respiratory syncytial virus and J21.9 Acute bronchiolitis, unspecified). Results were reported as the number of cases per 10,000 population. Population data was obtained from data summaries publicly available on the Australian Bureau of Statistics (ABS) website for relevant years and ages. [66, 67] For the separation code 'J21.9 Acute bronchiolitis, unspecified', the level attributable to RSV was assumed to be 80 per cent of cases, based on prior research. [43, 68, 69] For the MC simulation, the SD was based on a range of cases calculated by varying the level of 'J21.9 Acute bronchiolitis, unspecified' cases attributable to RSV, from a minimum value based on 0 per cent attributable to a maximum based on 100 per cent attributable. A Gamma distribution was assumed, given the mean at 80 per cent produced a skewed distribution.

Indirect Costs – productivity

Utilising the average Australian wage obtained from publicly available ABS data and length of stay and productivity loss estimates from prior research, productivity loss for carers of hospitalised children were estimated.[12, 50, 55] Productivity costs were estimated using the Human Capital Approach, whereby the loss was calculated as time off work (absenteeism) for parents caring for their sick children whilst in hospital multiplied by the average gross income in Australia. Productivity costs also include time the secondary carer would be at work but not focusing as they normally would (presenteeism). These values were inflated to reflect the 2022 yearly average CPI for the general category. [70] The MC simulation utilised the mean and SD reported by Brusco et al. [12] for length of stay (5.2 days, SD = 10.3 days) and the mean and range of the per cent of presenteeism reported by Mitchell, Defoy and Grubb 2017 (21.4 per cent to 62.7 per cent).[50] A gamma distribution was assumed for costs (most commonly used) and length of stay (to ensure positive length of stay only). A beta distribution was assumed for the per cent presenteeism (to ensure a value between 0 and 1). It was assumed that the days off work taken by the first carer were equivalent to the average length of stay in hospital of the child, and that all children had a second carer who would suffer from presenteeism only. For children under 6 months old, it was assumed that one carer was on parental leave, therefore no productivity loss was included for these cases. The proportion of children under 6 months old was based on the 2014-2019 averages reported by Saravanos et al. [47, 71] An average work day was considered 8 hours, and it was assumed that the average Australian wage accounts for the proportion of unemployed/those on welfare, thus all carers were treated as employed, All input parameters and costs are reported in Table 2.

Indirect costs – out-of-pocket

Utilising the costs reported by a recent Australian study from Mumford et al. [19] the family out-of-pocket costs for hospitalisation of a child were estimated. These values were inflated to reflect the 2022 yearly average consumer price index (CPI) for general category. [70] The MC simulation utilised the mean and SD reported in their study (Table 2). A Gamma distribution was again assumed for costs (most commonly used).

These out-of-pocket costs included such things as transport to hospital and parking, childcare for siblings of the sick child, meals, sundries, and accommodation for parents who need to travel large distances for their hospitalised children. These average costs were based on those incurred by parents of children in a paediatric hospital in Sydney but were assumed to be generalisable to the rest of the country.

Stratifying according to State/Territory

Hospitalisations and costs were estimated and presented for each Australian state and territory. These were calculated from the aggregate national number of RSV-coded hospitalisations, multiplied by the average proportions of RSV-coded hospitalisations (J12.1 Respiratory syncytial virus pneumonia, J20.5 Acute bronchitis due to respiratory syncytial virus, J21.0 Acute bronchiolitis due to respiratory syncytial virus B97.4 Respiratory syncytial virus as the cause of diseases classified elsewhere) for each state and territory between 2006-2015, as published in a previous Australian study by Saravanos et al.[7] It is worth noting that their study did not include 'J21.9 Acute bronchiolitis, unspecified' in their calculations, which is a limitation of our stratification strategy.

	Mean	SD	Distribution	Source
Hospitalisation cases by State - children with RSV less than 1 year old				
ACT	198	62.94	Gamma	[7, 44]
NSW	4483	1423.27	Gamma	[7, 44]
NT	236	74.79	Gamma	[7, 44]
QLD	2990	949.30	Gamma	[7]
SA	1317	435.28	Gamma	[7, 44]
TAS	168	53.35	Gamma	[7, 44]
VIC	1304	413.90	Gamma	[7, 44]
WA	1219	387.07	Gamma	[7, 44]
Hospitalisation cases by State - children with RSV from 1 - 4 years old				
ACT	65	17.76	Gamma	[7, 44]
NSW	1459	401.59	Gamma	[7, 44]
NT	77	21.10	Gamma	[7, 44]
QLD	973	267.86	Gamma	[7]
SA	446	122.82	Gamma	[7, 44]
TAS	55	15.05	Gamma	[7, 44]
VIC	424	116.79	Gamma	[7, 44]
WA	397	109.22	Gamma	[7, 44]

Table 2: List of parameters for Monte Carlo simulation

	Mean	SD	Distribution	Source
Hospitalisation proportions by State				
ACT	1.66%	-	-	[7]
NSW	37.46%	-	-	[7]
NT	1.97%	-	-	[7]
QLD	24.98%	-	-	[7]
SA	11.46%	-	-	[7]
TAS	1.40%	-	-	[7]
VIC	10.89%	-	-	[7]
WA	10.19%	-	-	[7]
Hospitalisation costs - Index admission				
Children <1 year	$13,695	$23,753	Gamma	[12]
Children 1-4 year	$14,024	$24,008	Gamma	[12]
Hospitalisation costs - Re-admission (0-30 days)				
Children <1 year	$1,233	$7,854	Gamma	[12]
Children 1-4 year	$1,382	$8,410	Gamma	[12]
Hospitalisation costs - Re-admission (1 month - 6 months)				
Children <1 year	$2,721	$11,355	Gamma	[12]
Children 1-4 year	$8,410	$19,942	Gamma	[12]
OOP Hospitalisation costs				
Children <1 year	$532.11	$851.48	Gamma	[19]
Children 1-4 year	$532.11	$851.48	Gamma	[19]
Productivity loss - Primary caregiver				
Total hospital admission LOS - all children	5.2	10.3	Gamma	[12]
Absenteeism - 1st parent's time off work per day	5.2	10.3	Gamma	[50]
Presenteeism - 2nd parent productivity loss (if normal workday productivity = 1)	0.514	0.103	Beta	[50]
Average hourly wage	$37.49	-	-	[55]
Proportion of 1 year old population less than 6 months old	0.65	-	-	[7]

Note: All costs reported in 2022 Australian dollars.

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