



# Review of respiratory diseases among Aboriginal and Torres Strait Islander children

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## Suggested citation

O'Grady KF, Hall, K, Bell, A, Chang AB, Potter, C (2018) Review of respiratory disease among Aboriginal and Torres Strait Islander children. *Australian Indigenous HealthBulletin* 18(2).

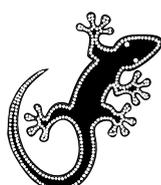
## Introduction

The term respiratory disease refers to a number of conditions that affect the lungs or their components [1]; each of these conditions is characterised by some level of impairment of the lungs in performing the essential function of gas exchange [2]. Respiratory diseases, which can be caused by a variety of different factors and other medical problems (which may or may not start in the lungs), are generally divided into two basic categories: acute respiratory infections and chronic respiratory diseases [3].

While respiratory diseases are major causes of poor health across the lifespan and death in Aboriginal and Torres Strait Islander people [4], this review focuses on the respiratory health of Aboriginal and Torres Strait Islander children. In 2012–2013, one-fifth of Aboriginal and Torres Strait Islander children aged 0–14 years were reported to have had a long-term respiratory condition [5]. In 2014–15, they were up to two times more likely to be hospitalised for selected respiratory conditions (asthma, influenza and pneumonia, whooping cough and acute respiratory infections) compared with non-Indigenous children [6]. Selected respiratory diseases (asthma, upper and lower respiratory conditions) were in the top ten specific conditions responsible for the total burden of diseases among Aboriginal and Torres Strait Islander children in 2011 [3]. The high levels of respiratory disease among Aboriginal and Torres Strait Islander children reflect a broad range of contributing factors, which are discussed in this review.

Throughout this review, it is important for readers to take into account that Aboriginal and Torres Strait Islander groups vary with regard to geography, socioeconomic status and local customs, and 'Indigenous' as a descriptor belies the heterogeneity among cultures and belief systems that impacts on perceptions of disease and treatments. Further, as the review highlights, there is a paucity of high quality data and research that addresses respiratory diseases in children, with most limited to children in remote regions of Western Australia (WA), the Northern Territory (NT) and Queensland (Qld). Hence caution is required in generalising information from limited data to all Aboriginal and Torres Strait Islander children, particularly from data collected in remote communities and applying to urban communities and vice-versa.

Core funding  
is provided by the  
Australian Government  
Department of Health



Australian Indigenous  
HealthInfoNet

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## About this review

The purpose of this review is to provide a comprehensive synthesis of key information on respiratory disease among Aboriginal and Torres Strait Islander children in Australia to:

- inform those involved or interested in Aboriginal and Torres Strait Islander health
- provide the evidence for future policy, strategy and program development and delivery.

The review provides general information on the historical, social and cultural context of respiratory health, and the environmental and behavioural factors that contribute to respiratory disease. It provides information on the extent of respiratory disease, including: incidence and prevalence data; hospitalisations and health service utilisation; mortality and burden of disease. It discusses the issues of prevention and management of respiratory health, and provides information on relevant programs, services, policies and strategies that address the health issue of respiratory diseases among Aboriginal and Torres Strait Islander children. It concludes by discussing possible future directions for respiratory health in Australia.

This review draws primarily on journal publications and government reports and some national data collections and surveys, the majority of which can be accessed through the HealthInfoNet's publications database (<https://healthinonet.ecu.edu.au/key-resources/publications>).

Edith Cowan University prefers the term 'Aboriginal and Torres Strait Islander' rather than 'Indigenous Australian' for its publications. However, when referencing information from other sources, authors may use the terms from the original source. As a result, readers may see these terms used interchangeably with the term 'Indigenous' in some instances. If they have any concerns they are advised to contact the HealthInfoNet for further information.

## Acknowledgements

Special thanks are extended to:

- the anonymous reviewer whose comments greatly assisted finalisation of this review
- Jane Burns and other staff at the Australian Indigenous HealthInfoNet for their assistance and support
- the Australian Government Department of Health for their ongoing support of the work of the Australian Indigenous HealthInfoNet.

## Key facts

### **The context of Aboriginal and Torres Strait Islander health and respiratory disease**

- The factors contributing to respiratory disease among Aboriginal and Torres Strait Islander children reflect a combination of broad historical, social and cultural factors as well as proximal health risk factors.
- Risk factors for respiratory diseases common among Aboriginal and Torres Strait Islander mothers and children include: exposure to tobacco smoke during pregnancy; maternal immunisation during pregnancy; air pollution, maternal nutrition and stress; pre and post natal care of mothers; a child's home, social and physical environment, family history; nutrition and physical activity.

### **The extent of respiratory disease among Aboriginal and Torres Strait Islander children**

- Aboriginal and Torres Strait Islander children are hospitalised for respiratory diseases at a higher rate than non-Indigenous children.
- Lower respiratory tract infections and upper respiratory conditions were in the top ten conditions contributing to the total burden of disease for Aboriginal and Torres Strait Islander female children.
- Asthma was a leading contributor to the total burden of disease for both Aboriginal and Torres Strait Islander male and female children.

### **Prevention and management of respiratory diseases**

- Prevention of respiratory diseases depends on ongoing changes in socioeconomic disparities between Aboriginal and Torres Strait Islander children and non-Indigenous children, and a reduction in modifiable risk factors.
- Effective respiratory disease management through early detection; use of evidence-based, multi-disciplinary, culturally appropriate management pathways; established models of care and patient health education, which are easy to access could assist in sustained improvements in respiratory disease care and health outcomes for Aboriginal and Torres Strait Islander children

### **Programs and services**

- Specific Government funded Aboriginal and Torres Strait Islander paediatric outreach respiratory clinics are run in Qld and WA.
- National initiatives that focus on housing, Aboriginal and Torres Strait Islander specific immunisation programs, reducing tobacco smoking, health checks, funding of key research organisations and the monitoring of trends in diseases over time are vital to reducing the burden of disease among Aboriginal and Torres Strait Islander children.

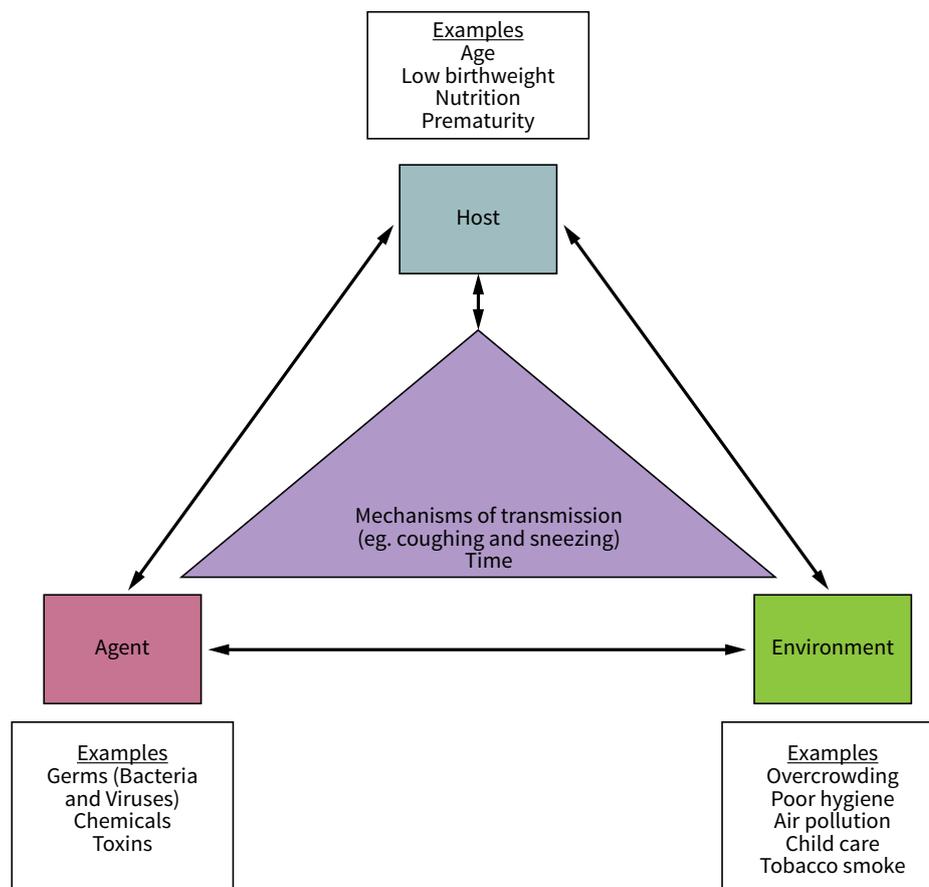
### **Policies and strategies**

- The National Aboriginal and Torres Strait Islander Health Plan 2013–2023 includes an expansion of the focus on child health.
- The National Early Childhood Development Strategy aims to strengthen universal maternal, child and health services.

## The context for respiratory health among Aboriginal and Torres Strait Islander children

Respiratory diseases, both acute and chronic, are major causes of poor health and death in children worldwide. The burden is highest in children who live in environments of socioeconomic disadvantage, including in wealthy countries such as Australia. Respiratory diseases in children result from complex interactions between multiple factors including genetic, environmental, socioeconomic and demographic characteristics and the relationship between the host, environment, agents responsible for disease (e.g. viruses, bacteria, toxins, chemicals, pollution etc.), the mechanisms by which an agent causes disease, how those agents are transmitted (e.g. inhaled, ingested, direct contact) and time since first exposed to an agent (Figure 1). While it is essential for a person to be exposed to a virus or bacteria to get an infection, whether that person actually gets sick from that infection is dependent on many other factors.

**Figure 1. Interactions between the host, the environment and agents in the casual pathways of disease**



Source: O'Grady, KF (2018)

A child has unique and different exposure pathways that begin in the pre-conception period and continue into the post-natal period. Children have a dynamic physiology that is turned up on high due to growth and developmental demands that occur during embryonic and foetal life [7]. Further rapid growth and development in the post-natal period – in particular the respiratory, neurological and immune systems – make children vulnerable to environmental exposures. A child's exposure to environmental stimulants whether they be external, physical, social, cultural, economic or prenatal/antenatal is a major concern in all aspects of children's health worldwide [8].

Focusing on respiratory health among Aboriginal and Torres Strait Islander children is important as respiratory diseases are common and can be serious. Many chronic lung diseases are potentially modifiable through clinically based interventions, or are preventable. Reasons for this include; (a) the lung continues to grow at least until 7–8 years of age, if not longer; and (b) the pulmonary immunity and respiratory phenotype is influenced by genetic-environmental interactions that commence very early in life (possibly in-utero). It is highly biologically plausible that many common conditions in adulthood emerge from early childhood factors [9] and there is indeed increasing evidence that

a substantial proportion of lung disease in adults (such as chronic obstructive lung disease and bronchiectasis) has its roots in childhood (where it is potentially reversible) [9-11].

## **The historical, social and cultural context**

Aboriginal populations were fragmented by colonisation [12, 13]. Traditional life was suppressed and people who had lived with well-established traditional laws, languages, dress, religions, sacred ceremonies, rituals, healers, and remedies were adversely affected [12]. This disruption to physical, social, emotional, mental health and wellbeing in traditional societies was worsened by legalised socioeconomic and political marginalisation and racial prejudice, which was often entrenched and institutionalised [12-15]. The process hastened the dispossession of traditional lands, subsequent poverty, under-education and unemployment. This disempowerment, marginalisation and the cultural destruction of Aboriginal and Torres Strait Islander people are described as transgenerational trauma [12, 16, 17]. The Stolen Generations is a particular example; children were separated from their families, institutionalised, subjected to physical and emotional abuse, racism, maltreatment and little or no exposure to culture, spiritual knowledge and identity [15, 16, 18-21]. These factors, in conjunction with poor living conditions, inadequate nutrition and high exposure rates to infectious organisms are associated with health inequalities and a heavy burden of disease in infants and children. The inequalities of transgenerational trauma in Aboriginal and Torres Strait Islander people led to unsatisfactory disease and health outcomes, impaired emotional and social wellbeing, and poor prospects for future generations [12, 15, 16]. Social factors not only have an impact on health across the course of life, but the ensuing health issues may create conditions that subsequently influence health and they represent a well-recognised determinant of health [22-25].

The impacts of colonisation on Aboriginal and Torres Strait Islander people continue to be witnessed today. The current health status of Aboriginal and Torres Strait Islander people is directly linked to the disruption that occurred to cultural, social, holistic and economic way of life [26-28]. For Aboriginal and Torres Strait Islander people, the determinants of good health and health behaviours are broader than socioeconomic issues; these include history, the quality and quantity of relationships with the wider mainstream community, the ability to connect with other Aboriginal and Torres Strait Islander community members, connection to land, the ability to express themselves culturally, and the ability to have personal and community control of issues surrounding their health [27]. Negative health outcomes among Aboriginal and Torres Strait Islander people can be linked to factors such as inadequate housing, poor education and employment outcomes, low income, and poor access to services, loss of identity, poor nutrition, low physical activity, smoking and consumption of alcohol [29]. Underlying causes of these factors include racism and discrimination, forced removal of children, loss of identity, language, culture and land [6]. These factors influence the broader social, cultural and economic environment in which Aboriginal and Torres Strait Islander people live.

Urban Aboriginal and Torres Strait Islanders face many of the same problems of their remote counterparts. Urban dwelling Aboriginal and Torres Strait Islander people can suffer from having their Aboriginality denied and it is assumed that they have assimilated into mainstream society [30]. The stereotype of 'real' Aboriginals being those living 'out bush' or in 'traditional' settings may lead to a denial of the possibility of a dynamic, contemporary Aboriginal and Torres Strait Islander culture [31]. In urban areas, there may be no 'community' as such, but a loose network of geographically dispersed family and organisational affiliations not at all obvious to non-Indigenous observers [30, 31]. The needs of those without social networks often go unnoticed and unmet. The disadvantages of cultural isolation can be just as acute as those of geographic isolation. All of the above factors have led to a loss of autonomy which has undermined social vitality, which, in turn, affected the capacity to meet challenges, including health challenges, leading to a cycle of transgenerational dispossession, demoralisation and poor health [32].

Despite the disadvantage and barriers faced by Aboriginal and Torres Strait Islander people since the time of colonisation, communities have survived and many have thrived. This largely reflects the resilience of individuals, their families and communities that has been evident since colonisation and persists today [33]. It is an important strength that needs more recognition in the efforts directed at improving Aboriginal and Torres Strait Islander health [34].

## **Socioeconomic factors**

Socioeconomic factors such as income, education, family structure (e.g. single parent, both parents at home and household size), access to transport, mobile phones, and the internet, geographic location and quality of housing are all important determinants of health. Not only are they important to the prevention of illness but also to the early diagnosis and management of an illness to prevent adverse outcomes. All of these factors are important in the prevention and management of respiratory illnesses in children. The substantial disparity in socioeconomic status between Aboriginal and Torres Strait Islander people and non-Indigenous people [35] is a well-recognised cause of the higher respiratory disease burden in Aboriginal and Torres Strait Islander children [36]. Major changes in this burden are only likely to occur once the socioeconomic disadvantage experienced by Aboriginal and Torres Strait Islander people has been addressed.

According to the 2016 Census, more than one-third (38%) of Aboriginal and Torres Strait Islander people lived in major cities, with 44% in regional areas and 18% in remote areas [37]. There is a gradient in the burden of disease and injury by region of residence in Australia, with those in remote areas experiencing the highest burden, followed by very remote areas [3]. However a lack of data on urban and regional Indigenous children is an important impediment to closing the gap in health disparities [38], given the majority of Aboriginal and Torres Strait Islander people live in those areas. Most research conducted on respiratory diseases in Aboriginal and Torres Strait Islander children has been undertaken in remote areas, or settings with a large proportion of Aboriginal and Torres Strait Islander people (e.g. NT, WA and north Qld). An urban study of the characteristics of young Aboriginal and Torres Strait Islander children registered with a primary health care centre identified levels of socioeconomic disadvantage that were similar to their remote peers [39]. That finding highlights the limitations in applying national or state composite data (e.g. hospitalisations) to describe Aboriginal and Torres Strait Islander disadvantage and health status.

## Factors contributing to respiratory disease

The traditional Aboriginal and Torres Strait Islander perspective of health is holistic [40]; it encompasses everything important in a person's life, including land, environment, physical body, community relationships and law. Health is the social, emotional, and cultural wellbeing of the whole community and the concept is linked to the sense of being Aboriginal and Torres Strait Islander.

There is a paucity of data on the perceptions, knowledge and attitudes of Aboriginal and Torres Strait Islander families with respect to protective and risk factors for respiratory illness in their children. As stated by Thompson et al. [18], 'risk factors relating to health outcomes can only be understood in terms of their social meanings and consequences, recognising the important role that social identity, connections, and sense of coherence and control play in the physical configuration of risk'. A qualitative study undertaken by an Aboriginal social worker of the perceptions of respiratory risk in urban Aboriginal and Torres Strait Islander families and their children [41] families reported key protective factors as heightened parental vigilance, access to support networks, traditional Indigenous culture and values, knowledge about respiratory illnesses, traditional Indigenous medicines, social and emotional wellbeing and exercise. Families reported key risk factors as parental neglect, lack of support networks, poor communication with and lack of trust in medical professionals, stress, loss of traditional culture and values, the external environment, tobacco smoking, hereditary factors and poverty. Parent/carer perceptions of risk and impact of respiratory diseases in their children were influenced by traditional values, connections to family, friends and community, beliefs about both illness and wellness handed down from Elders and family members, experiences within mainstream and Indigenous-specific health services, access to knowledge and information about respiratory diseases, access to reliable support networks and social, emotional and spiritual wellbeing.

Studies undertaken in many countries have identified many risk factors for respiratory illnesses in children, including early life risk factors as predictors of future lung health. These include overcrowding, malnutrition, exposure to tobacco smoke, young maternal age, low birthweight, anaemia, poverty, illiteracy, overcrowding, parental smoking, pollution, socioeconomic status, social behaviours, cultural exposure, family history, and a history of prior illness [42]. While the above factors are highly visible in Aboriginal and Torres Strait Islander communities in both urban and remote settings, little research has been done to specifically examine the effects, interactions and relative importance of these factors with respect to respiratory health.

### Prenatal and antenatal factors

The first environment a child is exposed to is the in-utero environment during foetal development; this means that whatever the mother is exposed to has the potential to affect the foetus. Sources of in-utero exposure include maternal disease and maternal exposure to toxins and infectious agents. Maternal asthma has been shown to have adverse developmental effects including low birthweight and intrauterine growth retardation [43]. Maternal exposures (particularly tobacco and infectious organisms) nutrition, stress and the quality of antenatal/postnatal care are important predictors of infant outcomes, including respiratory health.

### Exposure to tobacco smoke during pregnancy

Maternal smoking and passive exposure to environmental tobacco smoke during pregnancy is a significant risk factor for respiratory illnesses in the mother, the foetus and the baby [44]. Smoking during pregnancy has also been associated with sudden infant death syndrome, childhood cancers, high blood pressure, asthma, obesity, lowered cognitive development and psychological problems [45]. It can also result in poor health outcomes for the newborn, including low birthweight, intrauterine growth restriction, prematurity, placental complications, birth defects, lung function abnormalities and respiratory symptoms and perinatal mortality [46-48]. The effects of smoking during pregnancy persist into infancy and childhood [49-51]. Maternal smoking is of particular concern as high rates of smoking have been reported for Aboriginal and Torres Strait Islander mothers [52]. In 2015, almost half of Aboriginal and Torres Strait Islander mothers (45%) reported smoking during pregnancy, compared with 12% of non-Indigenous mothers.

## **Maternal immunisation during pregnancy**

Maternal vaccinations can influence acute respiratory illness/infections (ARI) rates. Among infants born during the influenza season, maternal vaccination has been associated with reduced risk of preterm delivery, small-for-gestational age at birth, and foetal death [53], likely due to the prevention of maternal respiratory illness, particularly pneumonia, that has been negatively associated with these birth outcomes [54]. Maternal vaccination in pregnancy may be an effective strategy for protecting infants against influenza prior to six months of age and it is now recommended in several countries including Australia [55, 56]. However, maternal influenza vaccination uptake remains poor and is associated with a number of factors [57]. Demographic factors appear to have little influence on influenza vaccine uptake during pregnancy; however, factors related to antenatal care provision and access (antenatal care type, hospital of delivery and parity) can influence uptake [58]. In a small pilot study of urban Aboriginal and Torres Strait Islander women, 9 out of 53 women had been vaccinated in their pregnancy and only 21 women had been offered the vaccine [58]. Data collected in the study through yarning circles suggested perceived benefits to the women and their infants were important factors in the decision to be vaccinated but that there was insufficient information available to women to make an informed choice [58]. These data differ from a study of Aboriginal mothers in WA where 56/94 (56%) of women received the vaccine during pregnancy; rural mothers were more likely than metropolitan mothers to have been vaccinated (odds ratio (OR) 4.1, 95% confidence interval (CI), 1.7-10.2) [59]. Influenza vaccine coverage during pregnancy in NT Aboriginal women participating in a randomised controlled trial was 16% (35/214), however when comparing periods before and during an influenza pandemic, uptake increased from 2.2% to 41% [60].

Pertussis (whooping cough) is an important respiratory infection in young infants and hospitalisation rates for pertussis in Aboriginal and Torres Strait Islander children are up to three times higher than non-Indigenous children [61]. Pertussis vaccine is recommended in the third trimester of pregnancy to assist in the protection of very young infants before they complete their primary series of pertussis vaccines in the first six months of life. There are limited data on pertussis vaccine uptake in pregnant Aboriginal and Torres Strait Islander women. A study of 93 women in WA [59] reported that 63% had been vaccinated and, as for influenza vaccine, rural women were more likely to have received the vaccine than urban women (OR 3.1, 95% CI, 1.2-7.6). Perinatal data for all women who gave birth in the NT in 2015 identified 24% of Aboriginal and Torres Strait Islander mothers had received a pertussis vaccine during their pregnancy, similar to non-Indigenous mothers (22%) [62].

## **Air pollution**

A major source of foetal environmental exposure is the mother's external environment; air pollution has been linked to infertility, early pregnancy loss, premature labour and low birthweight [63]. There are some data suggesting social inequity in the distribution of industrial air pollution with Indigenous and other similarly socioeconomically disadvantaged communities disproportionately represented in areas with significant air pollution, including the number of different types, volume and toxicity of emissions [64]. A NT study identified that the effects of ambient air pollution from bushfires on respiratory and cardiovascular illnesses are greater in Indigenous people compared with non-Indigenous people [65].

## **Maternal nutrition**

Evidence from several studies with respect to the relationship between maternal nutrition and dietary behaviours during pregnancy and the development of wheeze, asthma and atopy in offspring is conflicting. A systematic review of 32 studies that assessed vitamins, trace minerals, food groups and dietary patterns during pregnancy [66] found a protective effect of vitamin D, vitamin E and zinc intake against childhood wheeze but results were inconsistent for asthma and other atopic conditions. Maternal Vitamin D concentration in particular is receiving increased interest internationally with several studies suggesting associations with infant health. A meta-analysis of data from 34 observational studies indicated prenatal exposure to Vitamin D was inversely associated with the risk of respiratory infections in childhood (pooled odds ratio (pooled OR) 0.64, 95% CI, 0.47-0.87) [67]. A study of 109 NT Aboriginal and Torres Strait Islander mother-infant pairs [68] reported cord blood concentrations of Vitamin D at birth were about half those in maternal blood during the third trimester of pregnancy (about seven weeks earlier). Cord-blood concentrations of infants hospitalised with acute lower respiratory infection (ALRI) during the first 12 months of life ( $n = 7$ ) were lower than infants who were not hospitalised ( $n = 77$ ) ( $p = 0.025$ ) [68].

## **Maternal stress**

Stress during pregnancy is highly prevalent in Aboriginal and Torres Strait Islander women [69-71]. Maternal stress prior to and during pregnancy has been linked to several health outcomes in offspring [72, 73], including adverse birth outcomes such as prematurity and low birthweight [74], which are recognised risk factors for a number of diseases of childhood, including respiratory illness. The effects are thought to be due to epigenetic influences on gene expression and hence an alteration of disease risk [75]. Further, chronic stress has been linked to immune suppression and an increased susceptibility to infections [76]. Maternal life-time and antenatal stress has been associated with wheezing and asthma [75, 77] and early infection, including respiratory infections, in children [73]. Stress is also a key influence on health behaviours such as smoking during pregnancy, including for Aboriginal and Torres Strait Islander women [78, 79].

## Antenatal/postnatal care

As illustrated above, both physical and psychological exposures during and after pregnancy are associated with the risk of respiratory illness in infants and children. The importance of quality antenatal and postnatal care with respect to a broad range of maternal and infant health outcomes is well established. Such care allows the opportunity to screen for and manage a number of problems, as well as undertake health promotion activities and implement strategies to reduce potential or actual identified risks. High quality antenatal care is seen as a right of all women to safeguard their health and that of their infants, providing opportunities for risk factor intervention.

The Australian Government Department of Health recommends 10 antenatal care visits for first-time pregnancy without complications and seven visits for subsequent uncomplicated pregnancies [80]. In 2015, pregnant Aboriginal and Torres Strait Islander women attended an average of nine antenatal visits [52]. Over half (57%) of these women attended the first antenatal visit during the first trimester of pregnancy. In 2014, 99% of Aboriginal and Torres Strait Islander mothers accessed antenatal care services at least once during their pregnancy, similar to non-Indigenous mothers [35]. However, Aboriginal and Torres Strait Islander mothers, on average, accessed services later in the pregnancy and had fewer antenatal care sessions than non-Indigenous mothers.

## The child's home environment

There is a large body of work on home environmental factors that could impact maternal and child health. A recent review on the effects of household air pollution is discussed below [81]. Indoor residential risk factors with links to respiratory health include exposure to dust-mites, cockroaches, pet dander, moisture, mould, combustion of biomass and solid fuels, tobacco smoke, gas and wood stoves, kerosene or gas heaters, mosquito coils, BBQs, candles, overcrowding, and volatile organic compounds that are found in household items such as cleaners, furnishings and paint [81-83]. Many of these are strongly associated with the development of asthma and allergies and increased risk of severe respiratory infections.

Exposure to indoor tobacco smoke is of particular concern in Aboriginal and Torres Strait Islander children. In 2014–2015, 57% of Aboriginal and Torres Strait Islander children aged 0–14 years lived in a household with members who were current daily smokers; 73% in remote areas and 53% in regional and urban areas [84]. For those children living with a daily smoker, 13% were living in households where people smoked indoors. In a study in an urban community, 76% of Aboriginal and Torres Strait Islander children were regularly exposed to environmental tobacco smoke (including indoor, outdoor and in-the-car exposures) [39]. Environmental tobacco smoke exposure in the home increases the incidence of middle-ear disease, asthma, wheeze, cough, phlegm production, bronchitis, bronchiolitis and pneumonia [85].

Crowding may increase the risk of respiratory infection by increasing the opportunity for cross-infection amongst the family. Respiratory pathogens are readily transmitted, usually through air by droplets or aerosols, in crowded and ill-ventilated rooms where people are sneezing and coughing [86, 87]. There have been limited studies that have quantified the link between living conditions and ARI in Aboriginal and Torres Strait Islander children, particularly in urban children. Overcrowding is a well-known concern in Aboriginal and Torres Strait Islander communities and is a result of a complex interplay of social and economic factors. Overcrowding results in a greater intensity of exposure to agents of respiratory disease and facilitates transmission of infectious organisms. In 2014–2015, 16% of Aboriginal and Torres Strait Islander people reported that they were living in overcrowded households compared with 6% of non-Indigenous people [88]. This figure was particularly high for Aboriginal and Torres Strait Islander people living in state owned and managed Indigenous housing, with 23% of people living in an overcrowded household. On a positive note; in 2014-2015, 7% of Aboriginal and Torres Strait Islander adults reported overcrowding as a stressor, down from 21% in 2002 [35]. This change was greatest in very remote areas.

## The child's external physical environment

The external physical environment of the child include factors such as childcare, school attendance, and exposure to industry and air-pollution as well as natural environments that may increase the risk of respiratory illness (e.g. pollen concentrations and dust).

A child's attendance at a childcare facility can account for an increased frequency and severity of episodes of ARI associated with a broad range of respiratory pathogens [89-92]. Children in childcare are also considered to be important transmitters of pathogens to their siblings, parents, extended families and care workers [91, 93]. There are limited data on the relative importance of childcare to the risk of respiratory diseases in Aboriginal and Torres Strait Islander children although it is likely to play a role given the large body of data associating childcare with respiratory illness. A study of 200 urban children, of whom 90% were Aboriginal and Torres Strait Islander, reported childcare attendance as an independent risk factor for chronic cough (> four weeks duration) following an ARI with cough as a symptom (adjusted relative risk (aRR) 3.56, 95% CI, 1.28 – 9.92). Childcare attendance was not associated with recurrent illnesses [39].

Other external physical environment exposures include particulate matter from industry, motor vehicles, natural sources (e.g. dust storms), diesel exhaust particles, sulphur compounds and ozone. Exposure to particulate matter can have long-term health effects, particularly respiratory diseases, for children [94, 95], with effects starting early in the prenatal period [96]. Post-natal exposure has been associated with childhood chronic cough, wheeze, sore throat, allergy, bronchitis and an increased prevalence of asthma and exacerbations of asthma [94]. There are few studies that have examined physical external environments with respiratory diseases in Aboriginal and Torres Strait Islander children. Many Aboriginal and Torres Strait Islander communities are in areas with high levels of geogenic (i.e. resulting from geological processes) dust particles due to geography, the weather and lack of infrastructure such as sealed roads. There are however, limited studies examining the role of dust in respiratory health in these communities. A WA study indicated that geogenic dust may increase the attachment and invasion of human airway cells by non-typeable *Haemophilus influenzae*, a bacteria of major importance in human respiratory infections [97].

## The child's social environment

Among Aboriginal and Torres Strait Islander children, important social health factors include household income, the educational and employment status of parents/carers, family structure (i.e. single parent families), school attendance and achievement and the consequences of disadvantage and social disconnectness such as the mental health issues and the misuse of alcohol and illicit substance abuse which are related to an increase in all-cause mortality [98]. Aboriginal and Torres Strait Islander people endure not only the ill health associated with poverty but also the chronic diseases that come with the lifestyle in industrialised countries; a situation that is directly attributable to loss of land and traditions and the resultant move to urban environments. Many remote Aboriginal and Torres Strait Islander communities have schools and health centres available but a disparity still exists in health and education status.

The effects of transgenerational trauma due to loss of culture and identity, especially the effects of the Stolen Generations [99], are now increasingly being recognised as important influences on the determinants and outcomes of poor health in Aboriginal and Torres Strait Islander communities [29, 100-102]. Studies that have formally quantified a relationship between historical factors and respiratory illness are limited. A single centre study of ARI in urban Aboriginal and Torres Strait Islander children aged < five years registered with a primary health care centre reported children with an ARI at time of enrolment were approximately three times more likely to have family members from the Stolen Generation (adjusted odds ratio (aOR) 3.47, 95% CI, 1.33-9.03) or not know family history (aOR 3.35, 95% CI, 1.21-9.26), than those without ARI [103]. Given the limitations of this cross-sectional study, further studies are needed.

## Tobacco smoking

As described above, exposure to environmental tobacco smoke and smoking during pregnancy is of major concern with respect to the health of Aboriginal and Torres Strait Islander children. In addition to passive smoking, active smoking, and commencing smoking at an early age is also problematic. Nationally, in 2012–2013, 23% of Aboriginal and Torres Strait Islander youth aged 15-17 years were current daily smokers [104], compared with 4.1% of non-Indigenous youth of the same age. In 2008, the Australian Secondary Students' Alcohol and Drug (ASSAD) Survey reported approximately 35% of Aboriginal and Torres Strait Islander youth aged 12–15 years old had ever smoked, with 12% smoking in the week before the survey [105]. Smoking prevalence in Aboriginal and Torres Strait Islander people aged 15 years and over are 2.6 times higher than non-Indigenous people [104]. The prevalence is also higher in remote communities than urban settings.

Similarly, cannabis smoking has also been associated with an increased risk of respiratory infections and airway damage [106]. In 2012–2013, 19% of Aboriginal and Torres Strait Islander people aged 15 years and over reported having recently used cannabis [104], with its use considered endemic in some remote Aboriginal and Torres Strait Islander communities [107]. Aboriginal and Torres Strait Islander youth begin using earlier, persist longer, and take greater quantities of cannabis than their non-Indigenous contemporaries [108]. Further, the practice of mixing tobacco with cannabis by Aboriginal and Torres Strait Islander youth, and the resultant coalition of dependencies, has been raised as a particular concern with respect to consequent pulmonary and central nervous system pathology in the future.

## Family history

Family history of both malignant and non-malignant respiratory diseases has been shown to be an independent risk factor for a number of respiratory diseases including asthma [109], chronic obstructive pulmonary disease [110] and lung cancer [111], even after accounting for age and tobacco smoke exposure. This suggests a genetic predisposition to disease although the causal pathways are complex and the subject of a large body of ongoing research. Separating genetics from the multi-factorial determinants of respiratory health in Aboriginal and Torres Strait Islander children is problematic, not least because of the concerns about genetics-based research raised by Aboriginal and Torres Strait Islander people [112].

## Medical history

The general physical health and wellbeing of infants from birth throughout childhood are important determinants of respiratory health. Pre-existing or co-morbid conditions are important determinants of the development and outcomes of respiratory diseases. Low birthweight and prematurity are well established risk factors as are congenital conditions (e.g. congenital neonatal lung disease), neurological disorders such as Down syndrome and cerebral palsy [113, 114] as well as swallowing disorders such as oropharyngeal dysphagia [115]. Other early childhood infections such as gastroenteritis can predispose children to respiratory infections given impacts on nutritional status and immune function [116], and the role of the gut microbiome in the pathogenesis of respiratory diseases in children is a burgeoning area of research [117]. Gastro-oesophageal reflux and the consequent medications used to treat the disease (e.g. gastric acid inhibitors) have been associated with community-acquired pneumonia in children [118]. There is increasing evidence that particular acute respiratory infections in infancy, particularly respiratory syncytial virus (common cause of bronchiolitis) and rhinovirus, are associated with the development of asthma and bronchiectasis in later years [119, 120], including in Aboriginal and Torres Strait Islander children [121, 122].

## Nutrition

Malnutrition is a recognised, important risk factor for respiratory disease in children globally [42]. The nutritional status of a child from birth is a core determinant of the development of a healthy and functional immune system to fight infection and other agents of disease and the ability to deal with and recover from illness. Low birthweight, a factor of maternal nutrition, means the child is disadvantaged from birth and is associated with several adverse health outcomes over the lifespan [123]. Adequate and quality nutrition in the first year of life, particularly via breastfeeding, is a key determinant of infant and child health. Breastfeeding early in infancy is critical to both the transfer of maternal antibodies to protect an infant from infection but also to the delivery of essential nutrients the infant needs to support growth.

A detailed review of the nutritional status of Aboriginal and Torres Strait Islander people, and factors contributing to nutrition such as food security is available [124], and readers are referred to that document for an in-depth presentation of the key data. Of note is that, while for a long period, underweight was a predominant indicator of nutritional status in Aboriginal and Torres Strait Islander children there is now growing evidence that overweight and obesity are becoming problematic [124]. Obesity is a particular problem in chronic lung diseases such as asthma, obstructive sleep apnoea, chronic obstructive pulmonary disease and bronchiectasis [125].

## Exercise

The benefits of regular exercise to general health and wellbeing are well known and exercise is also important to respiratory health. Current guidelines recommend that children aged 2–4 years are physically active for at least three hours every day and that children aged 5–17 years do at least 60 minutes per day of moderate to vigorous intensity physical activity [126].

In the 2012–13 AATSIHS, Aboriginal and Torres Strait Islander children aged 2–4 years living in non-remote areas spent an average of 6.6 hours per day participating in physical activity and spent more time outdoors than non-Indigenous children in the same age group (3.5 hours compared with 2.8 hours) [127]. Aboriginal and Torres Strait Islander children aged 5–17 years living in non-remote areas spent an average of two hours per day participating in physical activity (exceeding the recommendation of one hour per day); this was 25 minutes more than non-Indigenous children. Around half (48%) of Aboriginal and Torres Strait Islander children met the recommended amount of physical activity, compared with 35% of non-Indigenous children.

There are limited studies addressing exercise and respiratory health in Aboriginal and Torres Strait Islander children. A qualitative study of Aboriginal and Torres Strait Islander parents/carers of children focussed on the perceptions of risk for respiratory illnesses from an Indigenous perspective [41]. Families considered exercise to be a positive and proactive way of managing respiratory illnesses that the child had control over, and the loss of traditional lifestyles that has led to sedentary behaviours contributed to poor health.

## Microorganisms responsible for respiratory infections in children

There are a large number of organisms responsible for respiratory infections in children including bacteria, viruses and fungi. There is also an increasing focus on the role of bacteria-bacteria, bacteria-virus and virus-virus interactions in respiratory infections. It is beyond the scope of this review to discuss these in detail; rather the focus is on the most common bacteria and viruses identified in children.

Despite the burden of respiratory disease in Aboriginal and Torres Strait Islander children, there are surprisingly few contemporary studies that have examined the role of specific organisms in disease; particularly lower respiratory tract infections in the era of pneumococcal conjugate vaccines. This is partly because of the difficulty in obtaining the most appropriate specimens, challenges related to transport and storage of samples from remote areas. Upper airway specimens including nasal swabs and nasal aspirates are often used to identify potential respiratory pathogens. However relating the presence of a particular organism to an illness that is present at the time the specimen is collected is complicated as many of the organisms causing disease are also found in the upper airways of healthy Aboriginal

and Torres Strait Islander children [128, 129]. Two small studies that examined nasal specimens from Aboriginal and Torres Strait Islander children in urban [129] and remote areas [130] detected the prevalence of multiple viruses and bacteria and associations with respiratory symptoms [129, 130].

The most common bacteria associated with respiratory infections in children are *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Moraxella catarrhalis*, *Staphylococcus aureus* and *Bordetella pertussis*. *S. pneumoniae*, *H. influenzae* and *M. catarrhalis*, which are prominent in the upper airways of Aboriginal and Torres Strait Islander children in both urban and remote settings with prevalences of > 75% [129-132]. The most common viruses are human rhinoviruses, adenovirus, respiratory syncytial virus, influenza virus and parainfluenza virus [128-130, 133-136] although there are limited data in Aboriginal and Torres Strait Islander children. Aboriginal and Torres Strait Islander infants in remote areas are densely colonised with high loads of bacteria associated with respiratory infections very early in life [137-139], and this is associated with the high rates of otitis media reported in these children [137, 138]. Therefore, early carriage is likely a key factor in the high rates of respiratory infections in Aboriginal and Torres Strait Islander infants. There are very few studies that have longitudinally studied respiratory viruses in Aboriginal and Torres Strait Islander infants, although one WA study reported the median age at the time of virus identification was younger in Aboriginal than non-Aboriginal children [134]. Interventions that address early life infection are important; vaccines are currently only available for *S. pneumoniae*, *B. pertussis* and influenza virus.

## Extent of respiratory disease among Aboriginal and Torres Strait Islander children

### Acute respiratory infections

Acute respiratory infections are illnesses of less than 14 days duration and are classified into either upper respiratory tract infections (URTI) or lower respiratory tract infections (LRTI). URITs include the common cold, sinusitis, croup, pharyngitis and tonsillitis. LRTIs include pneumonia, bronchitis, croup and bronchiolitis. URITs often lead to LRTIs and many of the viruses and bacteria associated with ARIs can cause both upper and lower airway infections, for example, influenza virus. URITs are generally mild and self-limiting while LRTIs are often associated with illnesses of higher severity and longer duration. LRTIs are predominant causes of poor health and death in children worldwide. Recurrent ARIs, particularly early in childhood, are associated with the development of chronic lung diseases [9-11, 51].

### Prevalence and incidence

The prevalence of ARI refers to the proportion of children in a population who have an ARI at any particular point in time. There are few data on the prevalence of ARI and respiratory symptoms in Aboriginal and Torres Strait Islander children. In an urban single centre study [103], 33% of children (n = 180) presenting to a primary health care centre for any reason (including accompanying someone else) had symptoms of an ARI however, only 22% of children specifically presented to the centre for that illness [103]. A cross-sectional study of 651 children from remote communities in the NT reported that, at the time of assessment, 59% of children had a runny nose and 39% had a cough [132].

The incidence of ARI refers to the number of new cases of ARI that occur during a given time. Despite the importance of ARI and ARI outcomes, there are surprisingly few comprehensive studies that have examined ARI incidence at the community level in Aboriginal and Torres Strait Islander children. A recent study of urban children (90% Aboriginal and Torres Strait Islander), registered with a single primary health care provider, reported an incidence of ARI with cough as a symptom, of 25 episodes per 100 child-months at risk (95% CI, 22.3-27.5). This likely underestimates all ARI incidence as the study focussed on episodes with cough. In five remote communities in the NT, children had a median of three (interquartile range (IQR) 2-5) presentations to the clinic over a 12-month period for LRTI and six (IQR 3-10) presentations for URTI, respiratory illnesses [140].

### Health service utilisation

The characteristics of patients presenting to different health services in Australia will vary and be influenced by socioeconomic and population demographics. Understanding the characteristics of Aboriginal and Torres Strait Islander communities in the primary health care context is important as it is essential to closing the health gap for Aboriginal and Torres Strait Islander people [141, 142]. The lack of contemporary, prospectively collected health service utilisation data in urban and remote Aboriginal and Torres Strait Islander children limits the ability to evaluate change over time and assess whether initiatives to improve access are working. Further, the Aboriginal and Torres Strait Islander population within and between Australian settings is not homogenous and composite statistics that are available are unlikely to reflect this diversity and identify groups that may be at risk of being lost within the system.

## General practice and primary health care utilisation

There are scarce data on general practice attendances for ARI in Aboriginal and Torres Strait Islander children. While many of the differences between Aboriginal and Torres Strait Islander and non-Indigenous health outcomes can be attributed to social determinants, it is known that the accessibility of good primary health care is important to both the prevention and management of disease [143].

Utilisation of primary health care services that are culturally appropriate is important as the determinants of good health and health behaviours are broader than socioeconomic issues. These determinants include history, the quality and quantity of relationships and connection to culture [27]. There is evidence to suggest that Aboriginal and Torres Strait Islander people are less likely to access health services and encounter more barriers in the use of health services [144, 145]. This leads to delays in diagnosis and treatment or lack of exposure to health education and promotion programs.

Data from a decade of surveys of general practitioner (GP) activity suggests that 1.2% of patients visiting GPs identified as being of Aboriginal and Torres Strait Islander origin [146]. In 2015–2016, among 97,328 total GP encounters reported in the Bettering the Evaluation and Care of Health (BEACH study), the rate of encounters for Aboriginal and Torres Strait Islander people was 1.5 per 100 (95% CI, 1.2–1.8) [147]; data specific to Aboriginal and Torres Strait Islander children were not presented. Aboriginal and Torres Strait Islander people have higher rates of long or complex consultations, higher rates for management of diabetes, infections, asthma and drug use, lower rates of management for cardiovascular disease and hypertension, and lower rates of preventative health care services such as immunisations and cardiac check-ups [148]. In 2014–15, a GP or doctor was the most common health service utilised for Aboriginal and Torres Strait Islander children aged < 15 years (58% of services utilised), followed by an Aboriginal medical health service (25% of contacts) [6].

Nationally, little is known about the differences in primary health care service utilisation between Aboriginal and Torres Strait Islander and non-Aboriginal and Torres Strait Islander children [38, 149, 150]. Ou et al. [149]<sup>6</sup>, analysed data collected in 2004 from children aged < 12 months in the Longitudinal Study for Australian Children. They found the proportion of Aboriginal and Torres Strait Islander infants in the first 12 months of life accessing a health service was lower than non-Indigenous infants (2.5% compared with 3.1%). For Aboriginal and Torres Strait Islander infants, maternal and child health services were less likely to be utilised (68% compared with 83% respectively). However, a higher proportion of Aboriginal and Torres Strait Islander infants presented to hospital outpatient clinics (16% compared with 9.7% respectively) and a higher proportion were hospitalised (17% compared with 9.9% respectively).

Clucas et al. [151] retrospectively reviewed clinic records in two remote NT primary health care clinics. They reported children presented to the community clinics an average of two times per month in the first 12 months of life. Kearns et al. [140] conducted a retrospective review of clinic presentations of 320 children living in five remote Aboriginal communities in the NT. The median number of presentations per child for any cause in the first year of life was 21 (IQR 15–29). The most common infectious presentations per child were URTI (median 6, IQR 3–10); diarrhoea (median 3, IQR 1–5); ear disease (median 3, IQR 1–5); LRTI (median 3, IQR 2–5); scabies (median 3, IQR 1–5); and skin sores (median 3, IQR 2–5).

A prospective cohort study in first-born non-Indigenous infants by Goldfeld et al. [152] conducted in two middle socioeconomic urban areas of Melbourne found that, in the first 12 months of life, children had approximately 35 health service visits (average of 2.9 per month), with 31% being visits to GPs and 42% to maternal and child health nurses. Hall et al described health service utilisation amongst a cohort of 180 urban Aboriginal and Torres Strait Islander children in South East Qld registered with a primary care service [153]. The overall incidence of health service utilisation was 52 episodes per 100 child-months (95% CI, 48.7–56.5); 81% of encounters were with GPs. Presentation rates were the highest for ARI (31 episodes per 100 child-months, 95% CI, 27.8–33.9). The next most common source of care was hospital emergency departments [153].

## Hospitalisation

National and state hospitalisation rates for ARI for Aboriginal and Torres Strait Islander children are difficult to interpret given most published data reports hospitalisations for respiratory diseases overall and hence include chronic illnesses such as asthma. Further, the majority of reports of ALRI hospitalisations are based on one or more combinations of International Classification of Diseases or (ICD) codes for pneumonia and influenza, with specific causative organisms for the former infrequently reported.

For July 2013 to June 2015 respiratory disease hospitalisation rates for Aboriginal and Torres Strait Islander children aged 0–4 years were 78 per 1,000 population compared with 48 per 1,000 population for non-Indigenous children [35]. The corresponding rates for children

6 A limitation of Ou et al's study was its clustered sampling design of postcodes, which excluded remote postcodes, postcodes on Aboriginal and Torres Strait Islander lands, and postcodes with a population in which more than 50% of children were Aboriginal and Torres Strait Islander.

aged 5–14 years were the same for Aboriginal and Torres Strait Islander and non-Indigenous children, 12 per 1,000. The respiratory disease hospitalisation rate for Aboriginal and Torres Strait Islander males 0–4 years was 90 per 1,000 compared with 57 per 1,000 for non-Indigenous males. For Aboriginal and Torres Strait Islander females 0–4 years, the rate was 65 per 1,000 compared with 38 per 1,000 for non-Indigenous females. For Aboriginal and Torres Strait Islander and non-Indigenous males 5–14 years the rates were both 13 per 1,000. For Aboriginal and Torres Strait Islander females and non-Indigenous females 5–14 years the rates were both 12 per 1,000.

Aboriginal and Torres Strait Islander children have higher rates of hospitalisation for ARI than non-Aboriginal and Torres Strait Islander people regardless of their geographical location [154]. In WA, hospital admission rates per 1,000 live births (infants born between 1990 and 2000) for ALRI before age two years were 7.5 (95% CI, 7.2-7.7) times higher in Aboriginal than non-Indigenous children (337 compared with 45 per 1,000 live births); pneumonia rates were 13.5 (95% CI, 12.8-14.4) times higher and bronchiolitis rates were 5.8 (95% CI, 5.3-6.0) times higher [155]. However, over that time, ALRI hospitalisation rates declined in Aboriginal children aged 12-23 months (4% per year,  $P = 0.003$ ) predominantly reflecting a decline in pneumonia rates [155]. Between 1997 and 2005, the rates of hospitalised, radiologically diagnosed pneumonia in Central Australian Aboriginal children aged < five years were 27 per 1,000 population per year (95% CI, 25.3-27.9); 58 per 1,000 per year in infants aged 1–11 months, 38 per 1,000 per year in those aged 12–23 months, and 13 per 1,000 per year in those aged 24–59 months [156]. Rates in Central Australian children were twice that of Top End children and were amongst the highest reported worldwide. For NT infants aged < 12 months born between 1999 and 2004, ALRI hospitalisation rates were 427 episodes per 1,000 child-years (95% CI, 416.2-437.2) and the median age at first admission for an ALRI was 4.6 months (IQR 2.6-7.3). Between 2007 and 2011, hospitalisation rates for children aged < 15 years admitted to the Mt Isa Base Hospital were almost five times higher among Aboriginal and Torres Strait Islander children compared with non-Indigenous children (24 compared with 4.5 per 1,000 population per year) [157]. In an urban Aboriginal and Torres Strait Islander cohort of children aged < five years, the hospitalisation rate for an ARI with cough was 1.5 per 100 child-months of observation [39].

National influenza hospitalisation rates for the period 2005–2010 were 2.9 times higher for Aboriginal and Torres Strait Islander children aged < five years than non-Indigenous children (2.1 per 1,000 compared with 0.7 per 1,000 population per year) and 2.6 times higher for children aged 5 - < 15 years (0.4 per 1,000 compared with 0.2 per 1,000 population per year) [61]. The data however, included influenza diagnoses in which no influenza virus was identified. Hospitalisation rates for pertussis (whooping cough) over the same period were 3.3 times higher in Aboriginal and Torres Strait Islander children aged < five years than non-Indigenous children (0.9 compared with 0.3 per 1,000 population per year) and 1.8 times higher for those aged 5 - < 15 years (0.02 per 1,000 compared with 0.01 per 1,000 population per year).

Bronchiolitis is a predominant cause of hospitalisation in young children worldwide, including Aboriginal and Torres Strait Islander children [156, 158]. There are some data suggesting the rates are rising [158]. Aboriginal and Torres Strait Islander children with bronchiolitis have more severe disease and higher rates of re-admission than non-Indigenous children [159]. The persistence of symptoms following hospitalisation for bronchiolitis was associated with an increased risk of the development of bronchiectasis in the 24 months following discharge in Aboriginal infants in the NT (OR 3.0, 95% CI, 1.1-7.0,  $P = 0.03$ ) [122]. Between 2007 and 2011, the average annual bronchiolitis hospitalisation rate to Mt Isa Base Hospital for Aboriginal and Torres Strait Islander children was 71 per 1,000, compared with 15 per 1,000 for non-Indigenous children [157]. In the NT for Aboriginal infants born between 1999 and 2004, the incidence of bronchiolitis hospitalisations was 227 per 1,000 child-years in the first year of life [156]. In WA, Aboriginal children born between 1990 and 2000 were approximately 5.8 times (95% CI) more likely to be hospitalised with bronchiolitis in the first two years of life than non-Indigenous children [158]. More recent data on Aboriginal and Torres Strait Islander children are lacking nationally.

## **Other health service providers**

There are insufficient data on the utilisation of other health service providers beyond hospitalisations and GPs for Aboriginal and Torres Strait Islander children with ARI. In 2015–16, around 6% of emergency department (ED) presentations (462,000) were reported for Aboriginal and Torres Strait Islander people (excludes the ACT) [35] however, data specific to children were not reported. Duncan et al. [160], conducted a review of ED presentations by Aboriginal and Torres Strait Islander children to Sydney Children's Hospital between 2005 and 2008; 1,252 presentations were made by 435 children aged 0-15 years. The majority of presentations were for children aged < one year of age and 30% of presentations were for respiratory illnesses. The review found that nearly 45% of presentations were potentially preventable and could have been referred to allied health services or to a GP.

A retrospective population-based study conducted by Moore et al. [155], used the Western Australia Data Linkage System (WADLS) of live singleton births followed up to nine years of age in WA to examine ED presentations for ALRI. ALRI accounted for 53% of all presentations. Of Aboriginal children, 14% presented at least once to ED before age five years compared with 6.5% of non-Aboriginal children. Aboriginal and Torres Strait Islander children born in an urban area had a higher proportion of ED presentations for ARI (15%) compared with urban born non-Aboriginal and Torres Strait Islander children (7.2%).

In the South East Qld urban cohort of Aboriginal and Torres Strait Islander children aged < five years [153], presentation rates to EDs for any cause were 1.6 per 100 child-months (95% CI, 1.0 – 2.4) of observation; ARI presentations were 1.4 per 100 child-months (95% CI, 0.8 – 2.1). Overall, presentation rates to ‘other’ services for ARI (including pharmacies, maternal and child health nurses, natural therapists and traditional healers) were 2.8 episodes per 100 child months (95% CI, 2.0 – 3.8).

## Non-fatal disease burden

Non-fatal disease burden refers to years lived with ill health or disability and is a measure of the relative importance and impact of disease, that does not result in death, to the health and wellbeing of a population. It is commonly combined with years of life lost due to premature death from a disease (fatal disease burden) to produce a measure known as a disability-adjusted life year which counts the total years of healthy life lost from disease and injury [3]. In 2011, upper respiratory conditions were the 8th leading cause of non-fatal disease burden in Aboriginal and Torres Strait Islander males and females aged < five years and for those aged 5 - < 15 years, the 10th leading cause in males and 7th leading cause in females. Lower respiratory infections ranked 9th and 10th for males and females aged < five years respectively and were not in the top 10 for those aged 5 – 14 years. Caution is required in interpreting these data as acute respiratory illnesses and upper respiratory diseases can include chronic conditions such as chronic sinusitis and lower respiratory infections can include chronic infections associated with chronic lung diseases.

## Mortality and fatal disease burden

Data on deaths due to ARI in Aboriginal and Torres Strait Islander children are scarce as most reports use the composite category of ‘respiratory illness/disease’, and mortality due to ARI in these children has been declining over recent decades and is now rare [3, 35], likely a result of improved and early diagnosis and management. In a national report for the period 2006–2010 there were no deaths due to influenza as the underlying cause in children aged < five years [61]; deaths in older children were not reported separately to adults, nor were deaths due to pneumonia reported. As mortality due to ARI in Aboriginal and Torres Strait Islander children is rare, those illnesses do not contribute significantly to fatal disease burden (i.e. years of life lost) [3].

## Total disease burden

In 2011, lower respiratory tract infections were the 8th leading cause of disability adjusted life years in Aboriginal and Torres Strait Islander females aged < five years (3.1% of total disease burden) and upper respiratory conditions were the 10th leading cause in females aged 5 - < 15 years (2.6% of total disease burden) [3]. Neither conditions were in the top ten conditions contributing to total disease burden for Aboriginal and Torres Strait Islander males in either age group. The reasons for this discrepancy by gender are not clear.

## Chronic respiratory diseases

Chronic respiratory diseases of importance in Aboriginal and Torres Strait Islander children include recurrent protracted bacterial bronchitis (PBB), chronic suppurative lung disease (CSLD), bronchiectasis, particularly non-cystic fibrosis bronchiectasis and asthma. Recurrent PBB, CSLD and bronchiectasis are thought to exist on a spectrum of disease characterised by chronic lower airway infection and inflammation [161]. PBB is characterised by a chronic wet or productive cough without signs of an alternative cause and responds to two weeks of appropriate antibiotics [162]. Recurrent episodes occur [163] and this is thought to lead to chronic suppurative lung disease and bronchiectasis [163]. CSLD is characterised by recurrent episodes of prolonged wet cough and may be accompanied by other problems such as recurrent chest infections, difficulty breathing on exertion, growth failure and, occasionally, wheeze [164]. Bronchiectasis is clinically similar to CSLD however and is diagnosed on the basis of high-resolution computed tomography (HR-CT) which reflects dilatation (widening) of the peripheral airways [161]. Bronchiectasis is a major concern in Indigenous children in Australia, Alaska and New Zealand with common risk factors amongst the three populations [165], particularly premature birth and frequent/severe respiratory infections in early childhood. Asthma is defined by the presence of both excessive variation in lung function and respiratory symptoms (e.g. wheeze, shortness of breath, cough and chest tightness) that vary over time [166].

Mortality and morbidity from chronic respiratory diseases are greater for Aboriginal and Torres Strait Islander people than for non-Indigenous people [3]. Falling mortality rates [167] in the context of increasing hospitalisation and self-report of disease may reflect better diagnosis and disease management. However, the possibility of increasing disease prevalence cannot be discounted in the absence of comprehensive community based data.

## Prevalence and incidence

Despite the burden of chronic respiratory infections in Aboriginal and Torres Strait Islander children with respect to hospitalisations, there is a paucity of data on the prevalence of disease, largely reflecting a widespread lack of research that covers different regions of Australia. The incidence of chronic respiratory diseases in Aboriginal and Torres Strait Islander children is largely unknown outside a very small number of studies in selected regions of the country. There are no data on the incidence or prevalence of CSLD or recurrent PBB in Aboriginal and Torres Strait Islander children. As recurrent PBB and CSLD are likely precursors to bronchiectasis, the prevalence of those diseases are likely to be much higher than bronchiectasis.

### Bronchiectasis

There is only one study to date that has estimated the prevalence of bronchiectasis in Aboriginal and Torres Strait Islander children. This study of Central Australian children reported a prevalence of approximately 15 per 1,000 children [168]. The only data on bronchiectasis incidence in Aboriginal and Torres Strait Islander children are from studies that reflect those predominantly living in remote areas. In the early 2000s, the average annual incidence of bronchiectasis among children living in Central Australia was 735 per 100,000 population [169]. In a population based study of ALRI hospitalisations in Aboriginal and Torres Strait Islander infants born between January 1999 and December 2004, the incidence of first diagnosis for bronchiectasis in the first year of life was 1.2 per 1,000 child-years (95% CI, 0.60-2.16) [156, 170]. In a prospective study of 157 Aboriginal and Torres Strait Islander infants hospitalised for bronchiolitis (median age at admission was five months), 30 (19%) were subsequently diagnosed with bronchiectasis within 24 months of admission [171].

A national bronchiectasis register has been established and this is likely to improve estimates of bronchiectasis burden in the coming years [172].

### Asthma

There are uncertainties around the accuracy of prevalence data for asthma in children as other chronic respiratory diseases are commonly misdiagnosed as asthma [173]. In 2012–2013, approximately 15% of Aboriginal and Torres Strait Islander children aged < 15 years were reported as having asthma, compared with 9.3% of non-Indigenous children [104]. Asthma prevalence is higher in Aboriginal and Torres Strait Islander children in urban and regional areas compared with those in remote areas. A north Qld study extrapolated data from children presenting to a paediatric outreach service (n = 3,562) between 2001 and 2006 [174] to the census population of the relevant communities and estimated the prevalence of asthma in Aboriginal children to be 32 cases per 1,000 Aboriginal children and 20 cases per 1,000 Torres Strait Islander children. A number of limitations with the study are the likely explanation for the lower prevalence reported in national studies. Overall, national data suggest the prevalence of asthma in the Aboriginal and Torres Strait Islander population has reportedly not changed since 2001 [104].

There are no data on the incidence of asthma in Aboriginal and Torres Strait Islander children, possibly in part due to the difficulties in accurately diagnosing asthma in young children with symptoms of cough and wheeze [175]. A small study of 47 Aboriginal children admitted to Royal Darwin hospital evaluated the accuracy of reporting of cough by their carers [176]. It compared carer report to a 24-hour digital recording of the child's cough and found carer report to be unreliable, highlighting the need for community education.

## Health service utilisation

### General practice attendances

There are no data on general practice attendances for PBB, CSLD and bronchiectasis in Aboriginal and Torres Strait Islander children. Similarly, data are lacking on GP use by Aboriginal and Torres Strait Islander children for asthma. A randomised controlled trial of an asthma education intervention for 88 Torres Strait Islander children with asthma [177], with unscheduled asthma presentations i.e. hospitalisations or GP attendances for asthma exacerbations over a 12 month period as the primary endpoint, reported 44% of children in the control group (n = 53) had at least one presentation with 4% having three or more presentations. There were no differences in presentation rates between the intervention and control groups.

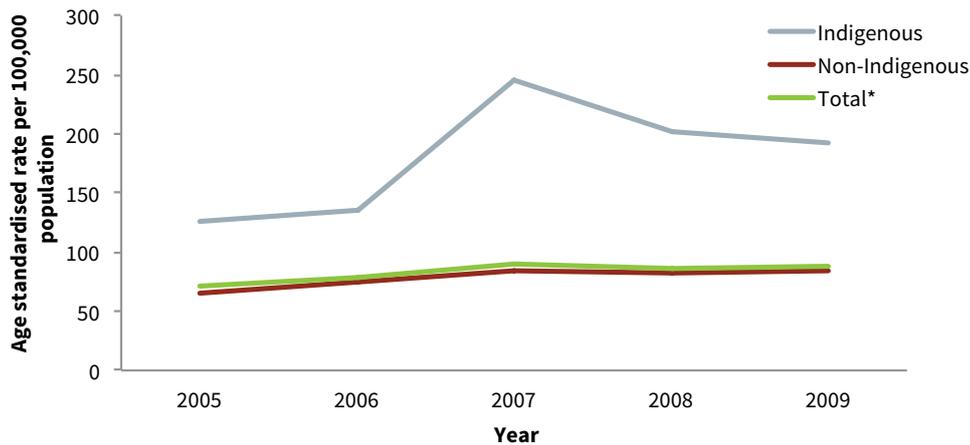
### Hospitalisation

#### Protracted bacterial bronchitis, chronic suppurative lung disease and bronchiectasis

There are no published data on PBB and CSLD hospitalisation rates in Aboriginal and Torres Strait Islander children, and limited data on bronchiectasis hospitalisations. The accuracy of currently available paediatric hospitalisation data is questionable given there is some evidence that paediatric bronchiectasis was being coded as chronic obstructive pulmonary disease given the lack of a diagnosis related

group (DRG) code for bronchiectasis [178]. This limitation will change in July 2018 when a new DRG for bronchiectasis comes into effect (Goyal V, personal communication, March 2018). O'Grady et al., analysed age-standardised hospitalisation rates for bronchiectasis in Qld for the period 2005–2009. Over that period, bronchiectasis hospitalisation rates increased in all age groups and in all years (Figure 2) and rates were, on average, two times higher for Aboriginal and Torres Strait Islanders than non-Aboriginal and Torres Strait Islanders. In children aged 0–4 years, average annual rates were 46 per 100,000 for Aboriginal and Torres Strait Islander children compared with 15 per 100,000 for non-Indigenous children (Table 1). Data were not presented by urban versus remote residence. A retrospective chart review conducted during 2007–2011 at the Mount Isa Base Hospital in Qld, reported an average annual bronchiectasis hospitalisation rate of 410 per 100,000 in children < two years of age [157].

**Figure 2: Age-standardised hospitalisation rates per 100,000 population for bronchiectasis, by year and Indigenous status, Queensland, 2005–2009**



Notes: 1. Includes 690 episodes in which Indigenous status was not stated  
2. Directly standardised to the 2007 Australian Estimated Resident Population.

Source: O'Grady KF, Revell A, Maguire G, Millonig R, Newman M, Reid D, Hill DC, Chang AB, 2010 [178].

**Table 1. Table 1: Bronchiectasis average annual age-standardised hospitalisation rates per 100,000 population by Indigenous status, Queensland, 2005–2009**

Age group (years)	Indigenous	Non Indigenous	Total
0–4	46	15	17
5–9	29	29	29
9– 4	56	37	38
15–19	26	44	44
20–24	26	51	52
25–29	27	39	41
30–34	19	31	31
35–39	41	19	21
40–44	48	19	20
45–49	104	16	19
50–54	180	33	37
55–59	224	88	95
60–64	293	124	131
65–69	281	200	211
70–74	204	311	325
75+	1,488	423	450
<b>ASR Total</b>	<b>180</b>	<b>78</b>	<b>83</b>

Notes Directly standardised to the 2007 Australian Estimated Resident Population.

Source: O'Grady KF, Revell A, Maguire G, Millonig R, Newman M, Reid D, Hill DC, Chang AB, 2010 [178].

## Asthma

There are limited reliable and specific data on asthma hospitalisations in Aboriginal and Torres Strait Islander children, including trends over time, and the data that are available are largely limited to national composites. In 2014-2015, asthma hospitalisation rates for Aboriginal and Torres Strait Islander children aged 0-14 years were 4.3 per 1,000 population compared with 4.5 per 1,000 for non-Indigenous children (Steering Committee for the Review of Government Service Provision, 2016). Rates for Aboriginal and Torres Strait Islander youth/young adults aged 15-24 years were 1.2 per 1,000 population compared with 0.8 per 1,000 for non-Indigenous youth/young adults (Steering Committee for the Review of Government Service Provision, 2016).

## Non-fatal disease burden

Data on chronic respiratory disease non-fatal burden (i.e. years of life with disability (YLD)) in Aboriginal and Torres Strait Islander children are only available for asthma. In 2011, asthma ranked as the 3rd leading cause of YLD in male and female children aged < five years and 2nd for children aged 5 - < 14 years [3]. For males aged < five years, asthma accounted for 15% of total YLD and 13% of total YLD for those aged 5 - < 15 years. The corresponding proportions for females were 8.1% and 13%.

## **Mortality and fatal disease burden**

As with ARI, there are limited data specifically reporting mortality due to chronic respiratory diseases in Aboriginal and Torres Strait Islander children. In The Australian Burden of Disease Study, focusing on the disease burden of Aboriginal and Torres Strait Islander people in 2011 [3], respiratory diseases were not in the top five contributors to fatal disease burden (i.e. years of life lost) in children.

## **Total disease burden**

In 2011, asthma ranked as the 8th leading contributor to total disease burden in Aboriginal and Torres Strait Islander males aged < five years (3.6% of total burden) and 2nd in males aged 5 - < 15 years (10% of total burden) [3]. For females, asthma was not in the top ten contributors to total disease burden for those aged < five years but was leading contributor in those aged 5 - < 15 years (10% of total disease burden). The total disease burden of other chronic respiratory diseases in children was not reported in the top ten.

## **Prevention and management**

As expressed previously, a focus on both children's lung and general health is required to reduce the burden of chronic respiratory illness in later life and in adulthood. However, a systematic overview of interventions addressing the social determinants of health found a striking lack of reliable evaluations of the various potential interventions [179]. Where evidence was available, the health improvement associated with interventions was modest or uncertain.

## **Prevention**

The prevention of respiratory illnesses in Aboriginal and Torres Strait Islander children, or at the very least a closure of the gap in disease burden between them and their non-Indigenous contemporaries, will be largely dependent on ongoing changes in socioeconomic disparities and a reduction in modifiable risk factors. Preventing recurrent ARIs and addressing risk factors early in life is likely to translate to long-term health benefits, particularly the prevention of chronic lung disease. In this section, we do not differentiate between prevention of acute and chronic illnesses as the important determinants of disease are largely the same. Further, whilst socioeconomic change is critical, it will take time and a focus on more readily modifiable risk factors is necessary [180, 181].

The critical factors to address are maternal health and wellbeing (before, during and after pregnancy) to improve neonatal and infant outcomes from birth, infant and child nutrition, reductions in exposure to environmental tobacco smoke and other pollutants, prevention of the uptake of smoking in youth, timely provision of recommended vaccines during pregnancy, infancy and early childhood (particularly influenza, pertussis and pneumococcal vaccines) and the education and empowerment of parents/carers to recognise abnormal respiratory signs and symptoms and to seek timely care. Enabling parents/carers to feel confident in seeking care and discussing their concerns with health care providers is important given data suggesting some families feel they are not taken seriously by their provider [41]. The prevention of chronic respiratory infections can be facilitated by adequate follow-up following illness, particularly following lower respiratory infections such as pneumonia and bronchiolitis and when illness progresses to chronic cough (> four weeks duration) [181]. Further, educating parents on the importance of seeking care for persistent symptoms and completing courses of prescribed medications, including antibiotics, is important. There are scarce data on parent/carer knowledge of cough and medication use for ARI. In an urban study of Aboriginal and Torres Strait Islander children [39], 95% of parents (n = 180) were aware that persistent and wet cough was abnormal, however 13% incorrectly reported antibiotics should only be taken until there were no more symptoms present suggesting more education is required.

## Management

In managing illnesses among Aboriginal and Torres Strait Islander people, the commonly encountered paradigm of a defeatist approach of 'minimal treatment' needs to be changed to a 'best possible care of intensive and appropriate treatment'. The major improvement in longevity of people with cystic fibrosis over the last three decades is not related to major technological or genetic breakthroughs, but related to improved clinical care through better attention to nutrition, airway clearance and intensive treatment of infections. If Aboriginal and Torres Strait Islander children receive optimal treatment (including a system-wide approach that includes multi-disciplinary, evidence-based, culturally appropriate, management pathways), the clinical outcomes should be similar to their non-Indigenous counterparts. Readers are referred to specific management guidelines for individual conditions.

### Early detection

There are no specific respiratory risk assessment tools for Aboriginal and Torres Strait Islander children that have been developed and evaluated. However, there are many symptoms suggestive of chronic lung disease. In children, the most common is cough. Indeed, chronic cough is one of the earliest symptoms of airway disease and may reflect an underlying serious disorder [173]. It is also one of the most common symptoms presenting to respiratory (lung) specialists. Delayed diagnosis of an underlying disorder may cause further chronic morbidity [173], while early diagnosis leads to appropriate management and subsequent resolution of cough and improved quality of life (QoL) [173, 182]. In a national multicentre study, 18% of the 346 children newly referred for chronic cough had a serious underlying diagnosis (bronchiectasis, aspiration, cystic fibrosis) and 41% (n = 142) of children had PBB, a likely pre-bronchiectasis condition [162] in children at high risk of CSLD. The 31 (9%) children who had bronchiectasis were significantly more likely to be Indigenous than non-Indigenous (OR = 4.4, 95% CI, 1.9, 10) [173]. Importantly, 70% of the cohort were misdiagnosed as asthma [173]. In another study where children who presented to the ED were recruited, a new and serious chronic lung disease was diagnosed in 36 of the 117 (31%) followed-up for their persistent cough on day 28 [183]. Therefore, management of chronic cough is paramount to early diagnosis of an underlying lung disorder. Obtaining the correct diagnosis also reduces the morbidity from incorrect medications used.

### Primary health care setting

Use of appropriate cough pathways or algorithms is one strategy that leads to earlier diagnosis of underlying chronic illness and reduce the morbidity of chronic cough and unnecessary costs. In a multi-centre randomised controlled trial based in referral centres [182], it was found that use of a cough management pathway embedded within a guideline improved clinical outcomes (improved QoL and reduced the duration of cough i.e. earlier diagnosis and management of the aetiology of the cough). A systematic review [184] and an expert panel report [185] found high quality evidence that the use of cough management protocols improves clinical outcomes in children with chronic cough (> four week duration).

The presence of chronic wet cough in children implies lower airway infection and intense inflammation, as seen in PBB [164, 186]. In an NT-based follow-up study, Indigenous children with persistent wet cough (n = 30) after an acute hospitalisation for an ALRI were significantly more likely to have bronchiectasis compared with those without a cough (n = 126), (OR = 3, 95% CI, 1.1, 7, p = 0.03) [122]. Treatment of the endobronchial infection present in these children with chronic wet cough [185] would likely halt the ongoing infection and inflammation and prevent CSLD [187]. In children from a population at risk of chronic lung disease, a model of care that follows up (and treats when required) children post-hospitalisation for a lung illness could prevent development of CSLD.

### Models of care

Established models to support and enhance lung health care ideally encompasses:

- One-to-one health education for adult caregivers of children with an acute (as they are at risk of chronic lung disease) or a chronic lung illness, using culturally appropriate tools.
- Follow-up of the child in the clinic at least 3–4 weeks post lung hospitalisation to determine resolution of all lung symptoms and signs. Earlier studies found that very few children were followed up post hospitalisation yet approximately 25% had persistent lung symptoms. Those with persistent wet cough after hospitalisation were significantly more likely to have bronchiectasis compared with those without a cough, (OR=3, 95% CI, 1-7, p = 0.03) [122]. Ideally a systems approach is required whereby all children are recalled back to the local clinic for a review 3–4 weeks post-hospitalisation and post-medical presentation for any ARI.
- Inclusion of an Indigenous health or community worker/health aide around the discharge process (pre or post) and health education [177, 188, 189]. This model is supported by evidence from a Cochrane review [190]. In a randomised controlled trial in the Torres Strait region of an asthma education model that included an Indigenous health worker, improvements were seen in some important

asthma outcomes (e.g. missed school days due to wheezing, parent knowledge) in those randomised to the intervention compared with controls [177]. The improved outcomes included children missed fewer school days due to wheezing, improvement of carers knowledge of asthma medication. In the exploration of the benefits of the model [191], common themes were expressed by community members. The most important themes were around ‘service delivery quality’ and ‘clear transfer of knowledge and education/clinical knowledge of asthma’. The parent/carer responses strongly valued the high level of communication, professional approach and rapport. Parents/carers also indicated their appreciation of access to a specialist in the community, the interaction experienced with the health professionals was positive and their sense of empowerment evident by learning how to manage their child’s asthma.

## Working in partnership with the local community

In chronic diseases, individualised and multi-disciplinary case management operating within an inter-professional framework is optimal [192]. One of the recommendations in the bronchiectasis guidelines (pp. 23), [161] states ‘Coordination of care among health care providers is necessary’. Specialist evaluation is recommended if bronchiectasis is suspected to confirm diagnosis, investigate aetiology, assess baseline severity and to develop management plans [193]. Those with moderate or severe disease are best managed using a multi-disciplinary approach to chronic care with individualised case management. Clinical deterioration should prompt early referral to services with CSLD/bronchiectasis expertise.

## Aboriginal and Torres Strait Islander specific resources for lung conditions

Health education is a key component in improving clinical outcomes [194] but there are limited data on the best method of providing health education. Different settings likely require different approaches, championed locally and undertaken in conjunction with local Aboriginal and Torres Strait Islander partners. An assessment of resources for lung health for Aboriginal and Torres Strait Islander Queenslanders [195] and a qualitative study of parent/carer perceptions of respiratory illnesses in Aboriginal and Torres Strait Islander children [41] both identified the lack of appropriate educational resources as important barriers to the prevention and management of disease. A lack of education and accessible information was also identified as a contributor to maternal uptake of influenza vaccine in Aboriginal and Torres Strait Islander women [58]. One NT-based study found that carers of Indigenous children hospitalised with common serious respiratory illness had low knowledge of respiratory conditions and that using culturally appropriate educational flipcharts improves the knowledge of these respiratory conditions [196]. These resources are available at the Australian Indigenous HealthInfoNet web site (<https://healthinonet.ecu.edu.au>) and have also morphed to adult-specific Aboriginal and Torres Strait Islander resources available on the Menzies School of Health Research website (<https://www.menzies.edu.au/page/Resources>). Lung-specific education is important in the remote Aboriginal and Torres Strait Islander setting as cough is under reported by Aboriginal and Torres Strait Islander carers of children hospitalised for a lung illness [176]. While flipcharts are well-received educational resources in Aboriginal and Torres Strait Islander health, it is likely that, but remains unknown if, interactive app-based resources lead to better health education specific for Aboriginal and Torres Strait Islander people.

## Programs and services

Generically, as most Aboriginal and Torres Strait Islander people prefer using culturally specific services such as Aboriginal community controlled health organisations, it is assumed that people with lung conditions also prefer accessing those services however there are no specific data available to support the assumption. As found in Qld however [195], the specific services and resources available for Aboriginal and Torres Strait Islander people with lung diseases are limited and those that do exist are, with the exception of asthma, largely directed at adults with chronic lung diseases.

## Government-based programs and services

A Qld state-based review of lung health and service provision highlighted the lack of data on disease and the limited available services for Aboriginal and Torres Strait Islander Queenslanders [178]. Subsequently, in Qld, a specific Indigenous Respiratory Outreach Care program funded by the Aboriginal and Torres Strait Islander Unit of Queensland Health through Federal funds started in 2011 [197]. In this program, teams are dedicated to each area of service with individualised plans (including educational and community activities) developed in conjunction with the local area services. The program provides dedicated paediatric and adult teams. A quarterly specialist paediatric respiratory clinic also operates in one Aboriginal Medical Service in WA however, whether other similar services operate elsewhere is unknown.

There is a specific spacer program for use with asthma medications for Aboriginal and Torres Strait Islander Australians [198]. Other government programs that Aboriginal and Torres Strait Islander people may benefit from are generally generic rather than specific for lung conditions. This includes Aboriginal and Torres Strait Islander specific Medical Benefits Schedule (MBS) items for check-ups (715 health check) and the Pharmaceutical Benefit Scheme's 'close the gap' initiative which provides medications at a reduced cost. The aim of the 715 health check is to ensure Aboriginal and Torres Strait Islander people receive appropriate primary health care that includes early detection, diagnosis and intervention for common and treatable conditions [199]. Arguably, this program is far too superficial for lung health as it does not include any specific measurement such as spirometry and recent data suggests the uptake of the health checks is poor [35]; in 2015–16, assessments were undertaken for only 26% of the paediatric target group (i.e. children aged 0–14 years). Only 33% of children aged 0–4 years who were regular clients of Commonwealth-funded Aboriginal and Torres Strait Islander primary health care organisations had received an assessment in the 12 months to May 2015.

With respect to immunisations that target respiratory infections, the National Immunisation Program [200] differs between Aboriginal and Torres Strait Islander children and non-Indigenous children with respect to; a) influenza vaccine (which is funded for the former from six months to < five years of age and for those aged 15 years and over), and; b) an extra dose of the 13-valent pneumococcal conjugate vaccine is scheduled for between 12 and 18 months of age for those living in high risk areas of the NT, Qld, WA and South Australia. The 23-valent pneumococcal polysaccharide vaccine is recommended for Aboriginal and Torres Strait Islander people aged 15 to 49 years with medical risk factors. As the Australian Childhood Immunisation Register (now known as the Australian Immunisation Register) has only just been expanded to include immunisation data on children over seven years of age, data on uptake and coverage in older children are limited. However, while the data are limited, uptake of influenza vaccine in Aboriginal and Torres Strait Islander children in some communities is poor [39, 201] and timeliness of all childhood immunisations in these children remains problematic [202, 203].

## Non-government based programs and services

The websites of both the Lung Foundation Australia and Asthma Australia have Aboriginal and Torres Strait Islander-specific components (<http://lungfoundation.com.au/patient-support/indigenous/>) and <https://www.asthmaaustralia.org.au/qld/education-and-training/i-am-a-health-professional/aboriginal-and-torres-strait-islander-health-services>.

## National initiatives

Overall, Aboriginal and Torres Strait Islander early child health and development is a priority in the Council of Australian Government's Close the Gap initiative [35]. The National Aboriginal and Torres Strait Islander Health Plan 2013–2023 [204] includes an expansion of the focus on child health to broader issues in child development. There are many national initiatives in Aboriginal and Torres Strait Islander health that may directly or indirectly reduce the burden of respiratory disease in children (e.g. housing initiatives, Aboriginal and Torres Strait Islander specific immunisation programs, programs to reduce tobacco smoke exposure and funding of key research organisations such as The Lowitja Institute and the new Central Australia Academic Health Science Centre, to name a few). Monitoring trends in disease over time is important and the regular collection, analysis and publication of relevant data occurs via studies such as the National Aboriginal and Torres Strait Islander health surveys, the Health performance framework reports and the Health and welfare of Aboriginal and Torres Strait Islander people reports. As described above, initiatives aimed at screening, and early detection and management of disease such as the 715 health checks are also operating at a national level. What is lacking however, are evaluations of the impacts of national initiatives on respiratory disease in Aboriginal and Torres Strait Islander children, other than monitoring broad trends in rates over time.

## Policies and strategies

As with the national initiatives described above there are a broad range of policies and strategies at national, state, local government and community levels that may directly and/or indirectly address the respiratory health of Aboriginal and Torres Strait Islander children. It is beyond the scope of this review to describe them all. Examples include the National Early Childhood Development Strategy [205] that aims to strengthen universal maternal, child and health services. Specific programs include: New Directions: Mothers and Babies Services, Australian Nurse Family Partnership, Strong Fathers Strong Families and Healthy for Life.

State governments have specific Aboriginal and Torres Strait Islander units and health strategies. At the community level, health service providers including Aboriginal community controlled health organisations, divisions of general practice, public health networks and not-for-profit organisations have various programs ranging from smoking interventions to healthy housing initiatives.

## Future directions and research needs

Despite the importance of respiratory diseases in Aboriginal and Torres Strait Islander children, and their long-term consequences, as highlighted throughout this review, the available data with which to inform and evaluate interventions are now ageing. Further, there are inadequate data on children in urban and regional areas compared with remote areas despite the majority of Australia's Aboriginal and Torres Strait Islander people living in such areas. Epidemiological studies to describe the burden of disease identify possible points of intervention, and monitor trends over time, are largely limited to hospitalisation data. There are very few clinical trials of interventions that have been or are being conducted in this population. Therapeutic studies that address the severity and consequences of common respiratory problems in young Aboriginal and Torres Strait Islander children are needed [181]. With advances in laboratory techniques, it is now becoming possible to better understand the role and relative importance of infectious organisms in lung disease in children, essential to informing the use of vaccines and antibiotics/antivirals. Ideally, longitudinal studies of infection and immunity in Aboriginal and Torres Strait Islander children that start in the antenatal period and continue throughout early childhood are required. Critically, these need to cover different geographic regions of Australia and incorporate the social and environmental determinants of disease. The development and evaluation of programs to support Aboriginal and Torres Strait Islander health care providers and community members in addressing lung health are urgently needed, as are the development and evaluation of educational resources for families in remote, regional and urban settings. Finally, larger studies conducted in different settings are needed to better understand Aboriginal and Torres Strait Islander perceptions of respiratory health from within an Indigenous paradigm to ensure programs, strategies and interventions are relevant and acceptable.

## Concluding comments

Respiratory illnesses in Aboriginal and Torres Strait Islander children are serious, important and the progression to chronic lung disease is mostly preventable. The burden of disease in some regions is comparable to that of low-income countries [36, 206]. However, the lung health of Aboriginal and Torres Strait Islander children receives scant attention compared with adult lung disease, cystic fibrosis, diabetes and cardiovascular disease. To reduce the burden of respiratory illness in Aboriginal and Torres Strait Islander children, best-practice medicine is essential in addition to improving socioeconomic factors, reducing harmful exposures, and addressing access to culturally acceptable health care and illness prevention programs that likely contribute to disease [181]. A detailed description of primary, secondary and tertiary preventative measures that addresses these points has been previously published [181]. Ultimately, significant change will only occur once the broader determinants of respiratory health in Aboriginal and Torres Strait Islander children are adequately addressed. However, much can be done now to enable them to 'breathe easy' throughout their lifetime.

## Glossary

### **adjusted odds ratio**

the odds ratio (see below) considers the effect of one variable in an analysis, the adjusted odds ratio takes into account the effect due to additional variables being included in the analysis

### **adjusted relative risk**

adjusts for confounding variables (e.g. age, gender) of the relative risk of an event occurring after exposure to a risk variable as compared with the likelihood of its occurrence in a control group

### **age-standardised**

age-standardised rates enable comparisons of rates of respiratory disease between two populations that have different age structures. It is often used when comparing Aboriginal and Torres Strait Islander people and non-Indigenous people because the Aboriginal and Torres Strait Islander population has a younger age structure than the non-Indigenous population

### **confidence interval**

gives an estimated range of values which is likely to include an unknown population parameter, the estimated range being calculated from a given set of sample data

### **interquartile range**

a measure of where the middle fifty is in a data set. Where a range is a measure of where the beginning and end are in a set, an interquartile range is a measure of where the bulk of the values lie

### **odds ratio**

a measure of association between an exposure and an outcome. The odds ratio represents the odds that an outcome will occur given a particular exposure, compared with the odds of the outcome occurring in the absence of that exposure

### **pooled odds ratio**

the combined odds ratio of several studies

## Abbreviations

**ALRI** – acute lower respiratory illness

**aOR** – adjusted odds ratio

**ARI** – acute respiratory illness/infection

**aRR** – adjusted relative risk

**CI** – confidence interval

**CSLD** – chronic suppurative lung disease

**ED** – emergency department

**IQR** – interquartile range

**LRTI** – lower respiratory tract infections

**OR** – odds ratio

**Pooled OR** – pooled odds ratio

**PBB** – protracted bacterial bronchitis

**QoL** – quality of life

**URTI** – upper respiratory tract infections

**YLD** – years of life with disability

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The Australian Indigenous Health*Bulletin* (ISSN 1445-7253) is the electronic journal of the Australian Indigenous Health*InfoNet*.

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FEATURED ARTWORK

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Core funding  
is provided by the  
Australian Government  
Department of Health

