Hospitalisations related to lower respiratory tract infections in Northern Queensland

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Abstract

Objective: To investigate the admission characteristics and hospital outcomes for patients admitted with lower respiratory tract infections (LRTI) in Northern Queensland.

Methods: We perform a retrospective analysis of the data covering an 11-year period, 2006–2016. Length of hospital stay (LOS) is modelled by negative binomial regression and heterogeneous effects are checked using interaction terms.

Results: A total of 11,726 patients were admitted due to LRTI; 2,430 (20.9%) were of Indigenous descent. We found higher hospitalisations due to LRTI for Indigenous than non-Indigenous patients, with a disproportionate increase in hospitalisations occurring during winter. The LOS for Indigenous patients was higher by 2.5 days [95%CI: -0.15; 5.05] than for non-Indigenous patients. The average marginal effect of 17.5 [95%CI: 15.3; 29.7] implies that the LOS for a patient, who was admitted to ICU, was higher by 17.5 days.

Conclusions: We highlighted the increased burden of LRTIs experienced by Indigenous populations, with this information potentially being useful for enhancing community-level policy making.

Implications for public health: Future guidelines can use these results to make recommendations for preventative measures in Indigenous communities. Improvements in engagement and partnership with Indigenous communities and consumers can help increase healthcare uptake and reduce the burden of respiratory diseases.

Key words: lower respiratory tract infections, Indigenous health, socioeconomic disadvantage, health policy

Lower respiratory tract infections (LRTIs) are the fifth leading cause of illness globally.[1] Despite causing an estimated 2.6 million deaths in 2017 and being ranked the fourth most common cause of death globally, LRTIs do not affect populations uniformly.[2] The burden of LRTI has been heterogeneous with respect to socioeconomic and environmental characteristics with disadvantaged populations experiencing higher loss of life-years.[3] LRTIs are responsible for a large proportion of the morbidity and mortality faced by Indigenous people globally.[4] In Australia, the prevalence of respiratory diseases is reported to be higher for all age groups of Aboriginal and Torres Strait Islander people than for non-Indigenous people.[5] This is despite the 'Closing the Gap' strategy that aims to reduce the disadvantage of Aboriginal and Torres Strait Islander people (respectfully referred to as Indigenous from herein) with respect to health, education and employment outcomes. The health disparities between Indigenous and non-Indigenous children are even more pronounced, with Indigenous children experiencing up to six times higher LRTI-related hospitalisations and having a higher prevalence of co-morbidities.[6-8]

The analysis of health inequalities for LRTIs between Indigenous and non-Indigenous communities has largely focused on children. This has been partly warranted as the large proportion of lung diseases and complications in adults stem from childhood, when these respiratory conditions are treatable and preventable.[9] However, Indigenous and non-Indigenous adults also experience significant disparity in rates of respiratory illnesses, which disproportionately affects health outcomes and quality of life. In this study, we extended the literature and investigated the epidemiology of LRTI and associated hospital admissions and health outcomes for Indigenous and non-Indigenous populations using a tertiary hospital admissions database for the 11-year period between 2006 and 2016. We also described the dynamics of LRTI-related diseases for hospital admissions across time and identified the patterns in hospital admissions during the disease outbreaks. As we are now amid the COVID-19 pandemic (as of December 2020), this empirical analysis is potentially useful in highlighting the importance of preventative strategies and the promotion of protective measures among vulnerable populations, such as Indigenous communities.

Methods

Data description

We conducted a retrospective analysis of the data from the Townsville Hospital and Health Service (THHS), which is located in regional North Queensland and provides tertiary

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level care for 670,000 people. A cohort of inpatients for this study was identified based on ICD-10-AM discharge codes for influenza (J09-J11), pneumonia (J12-J18), bronchitis (J20, J21), and other LRTI (J22). Our data are a subset of the large relational dataset that contains information on all inpatients with infectious disease diagnoses. Details of the data and linking procedures have been described in detail elsewhere.[10]

To control for socioeconomic and environmental measures that may explain the variation in the health outcomes between Indigenous and non-Indigenous populations, we used the Index of Relative Socio-Economic Disadvantage (IRSD) from Socio-Economic Indexes for Areas (SEIFA), which summarises information about the economic and social conditions of people and households within geographical areas. Using the residential postcode information of patients and the year of admission, we supplemented our dataset with the IRSD values that are based on information from the five-yearly Census (2006, 2011, 2016). The year of admission was matched with the closest census year.

Statistical analysis

We presented the results as frequencies and percentages for categorical variables and means with standard deviation (SD) for continuous variables of patient characteristics and admissions measurements. T-test and chi-square tests were used for comparisons between Indigenous and non-Indigenous groups after checking the distributions of the measurements.

We also explored the length of hospital stay (LOS) by using a negative binomial model and checked heterogeneity between Indigenous and non-Indigenous groups. We selected a negative binomial regression over a Poisson model to study LOS in days due to the presence of overdispersion in the data, which is confirmed by the chi-square test (p-value <0.001). Because the model is non-linear, we used marginal effects to interpret the impact on the predicted counts due to the changes in the explanatory variables. A z-test of the second difference was used to test interaction effects between Indigenous status and diagnosis groups.

As the number of cases and severity of acute LRTI episodes potentially depend on seasonality, we adjusted for month and year fixed effects in all models. Standard errors were clustered by patients to account for autocorrelation within individuals who had multiple admissions during the observation period. The results are presented in log-ratios and marginal effects. The data were analysed using R software environment (RStudio 1.2.5033) and Stata (version 15.1).

Ethical approval

This research is part of the project (HREC/16/QTHS/221), which was approved by the Townsville Hospital and Health Service (THHS) Human Research Ethics Committee. A waiver of consent for access to anonymised historical data was approved under the Queensland *Public Health Act* (RD007802). We note that patients or members of the public were not involved in the design or implementation of this research and that anonymised historical data extraction did not require any patient recruitment.

Results

Descriptive statistics for hospital admissions

Table 1 presents the characteristics of the patients included in this study. During the study period, 11,643 patients were admitted to the Townsville hospital with LRTI-related diagnosis. Of these patients, 14 patients were excluded as they did not have information on their Indigenous status. About 20.8% (2430/11,629) of patients were of Indigenous descent with slightly more males than females admitted to the hospital. The proportion of the patients in our sample identified as Indigenous is higher than in the population of the Townsville region (during 2006–2016, the percentage of Indigenous peoples varied from 7.1% to 7.8%).[10,11] Indigenous patients were significantly younger than non-Indigenous, with an average age difference of more than 20 years (38.7 years vs. 59.4 years). This also corresponds to the census data that report a 16-year difference in the median age between Indigenous and non-Indigenous Queensland populations.[12]

Our data also show that the majority of patients from both groups had pneumonia-related diagnoses and the proportions of influenza and other LRTI diagnoses among Indigenous and non-Indigenous groups were similar. On the other hand, the proportion of bronchitis cases for Indigenous patients (10.5%) were more than twice than for non-Indigenous (5.1%). This was largely driven by the higher proportion of Indigenous infants and toddlers (17.7% vs. 8.6%) who were admitted to the hospital. The average LOS and time in ICU for Indigenous (11.4 days and 192.9 hours) and non-Indigenous (10.7 days and 171.5 hours) are not significantly different. We found evidence that Indigenous patients lived in more disadvantaged areas measured by the IRSD score (957.7 vs. 990.6). The hospital Emergency Department was the main pathway to hospital admission for both Indigenous and non-Indigenous patients, 67.7% and 72.0%, respectively. A higher proportion of Indigenous patients were transferred from other hospitals (17.3% vs. 7.4%). More patients who are non-Indigenous received admission through other channels such as residential aged care services. The age profile is also associated with mortality. More than 82% (883) of all deaths in our sample involved patients aged 60 years or older. We also found significant differences in the care type, with more non-Indigenous patients using palliative care (2.0% vs. 0.6%) and rehabilitation care (1.5% vs. 0.6%) than Indigenous patients.

Dynamics of hospital admissions

Figure 1 reflects the seasonal nature of LRTI and significant variation in the number of hospital visits depending on disease characteristics, particularly during the influenza season. There is an increasing general trend in the use of health services associated with LRTIs with progressively more admissions and winter surges throughout the study.

Figure 2 describes the monthly dynamics for pneumonia, influenza, bronchitis and other LRTIs by Indigenous status. The counts of hospital admissions are transformed to the admission rates per 10,000 residents of respective population groups using yearly Townsville resident population statistics. For all diagnosis groups and almost all monthly time periods, the rates were significantly higher for the Indigenous population. Thus, the admission rates for pneumonia and influenza for Indigenous patients were up to seven times higher than for non-Indigenous patients. Figure 2 (B) also highlights that, particularly during significant influenza outbreaks, the Indigenous population is highly exposed to the infection and many people are likely to be admitted to the hospital for treatment.

Determinants of length of stay (LOS) of LRTI-related hospitalisations

Furthermore, we examined whether there were significant differences in LOS between Indigenous and non-Indigenous patients after controlling for available confounders. We used the ICU attendance to account for severity and type of care provided to differentiate between acute and palliative treatments.

The results from Model I in Table 2 showed that Indigenous status associated with LOS for Indigenous patients was higher by 2.4 days (95%CI: -0.2, 5.1) than for non-Indigenous patients. This represented a relatively large increase compared to the mean LOS value of 10.9 days in the full sample. ICU treatment was also a significant covariate and positively related to LOS. The average marginal effect of 17.5 (95%CI: 15.3, 19.7) implies that the LOS for a patient who was admitted to ICU was higher on average by 17.5 days. Furthermore, females and younger patients are predicted to spend significantly less time in the hospital for LRTI-related hospitalisation than males and older people, respectively, which may be associated with underlying health conditions and co-morbidities.

The LOS was not uniformly associated among diagnosis groups. For example, if a patient was admitted to hospital for pneumonia in comparison to influenza, the LOS was longer by 3.6 days (95%CI: 2.3, 4.8). Even more interesting findings relate to the relatively high burden of other LRTIs. Here, the higher average marginal effects in comparison to influenza indicate that the LOS on average was higher for the other LRTI by 3.1 days (95%CI: 1.2, 4.9).

We were interested in whether the Indigenous status gap was bigger or smaller for patients with different LRTI diagnosis. To test this potential heterogeneity, we included an interaction term between Indigenous status and diagnosis groups (Model II). Overall, the results for socio-demographic covariates from Model II in Table 2 are qualitatively and quantitatively similar to the ones from Model I. In Table 3, we reported the LOS by Indigenous status and diagnosis groups and showed that there was no significant Indigenous status gap across diagnosis groups.

Discussion

In the present study of a linked dataset describing an 11-year period, hospitalisations

Table 1: Characteristics of LRTI-related hospital admissions, 2006-2016.

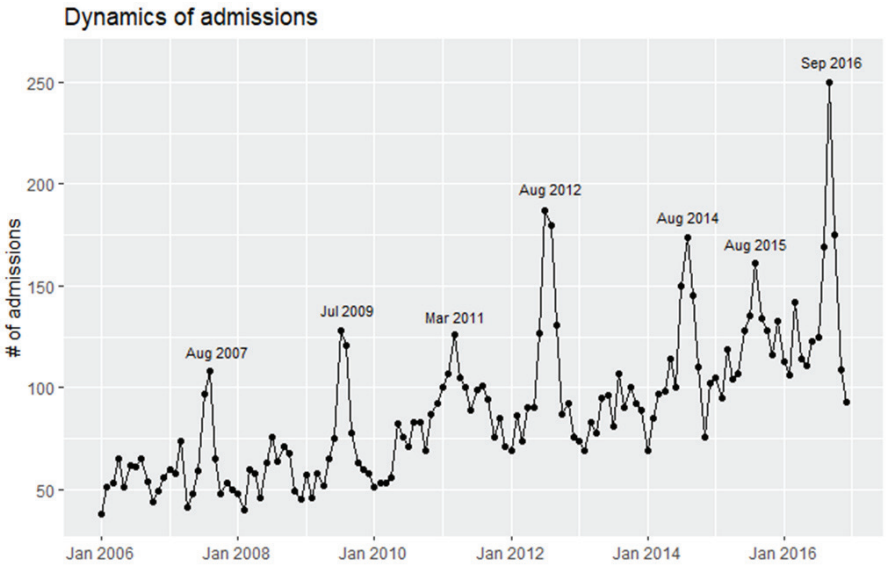
Characteristics	All patients		Non-indigenous		Indigenous	
Overall	11,629	100%	9,199	79.1%	2,430	20.9%
Age in years (mean, SD) ***	55.0	28.1	59.4	27.4	38.7	24.5
Age groups in years, n (%) ***						
0 < age < 3	1,233	10.6%	796	8.7%	437	18.0%
3 ≤ age < 20	634	5.5%	454	4.9%	397	16.3%
20 ≤ age < 40	1,057	9.1%	660	7.2%	180	7.4%
40 ≤ age < 60	2,451	21.1%	1,501	16.3%	950	39.1%
60 ≤ age < 85	4,852	41.7%	4,408	47.9%	444	18.3%
85 ≤ age	1,402	12.1%	1,380	15.0%	22	0.9%
Gender, n (%)						
Male	6,279	54.0%	5,023	54.6%	1,256	51.7%
Female **	5,350	46.0%	4,176	45.4%	1,174	48.3%
Diagnosis groups, n (%) ***						
Influenza	1,065	9.2%	850	9.2%	215	8.8%
Pneumonia	7471	64.2%	6,031	65.6%	1440	59.3%
Bronchitis	731	6.3%	472	5.1%	259	10.7%
Other	2362	20.3%	1,846	20.1%	516	21.2%
Length of stay (LOS) in days (mean, SD)	10.9	23.8	10.7	19.1	11.4	36.5
ICU in hours, if > 0 (mean, SD)	178.1	246	171.5	222.3	192.9	292.3
IRSD SEIFA (mean, SD) ***	983.7	55.1	990.6	38.6	957.7	89.7
Mortality, n (%) ***	877	7.5%	793	8.6%	84	3.5%
Admission source, n (%) ***						
Hospital's ED	8,264	71.1%	6620	72.0%	1,644	67.7%
Hospital's outpatient department	726	6.2%	591	6.4%	135	5.6%
Transferred from another hospital	1,098	9.4%	677	7.4%	421	17.3%
Other	1,541	13.3%	1,311	14.3%	230	9.5%
Care type, n (%) ***						
Acute	10,970	94.3%	8,611	93.6%	2,359	97.1%
Palliative care	201	1.7%	186	2.0%	15	0.6%
Rehabilitation care	155	1.3%	141	1.5%	14	0.6%
Other	303	2.6%	261	2.8%	42	1.7%

Notes:

*Differences in the means or proportions are tested between Indigenous and non-Indigenous samples (*** significant at 1%; ** significant at 5 %; * significant at 10%).*

IRSD SEIFA: Index of Relative Socioeconomic Disadvantage (IRSD) from Socioeconomic Indexes for Areas (SEIFA).

Figure 1: Monthly dynamics of LRTI-related hospital admissions.

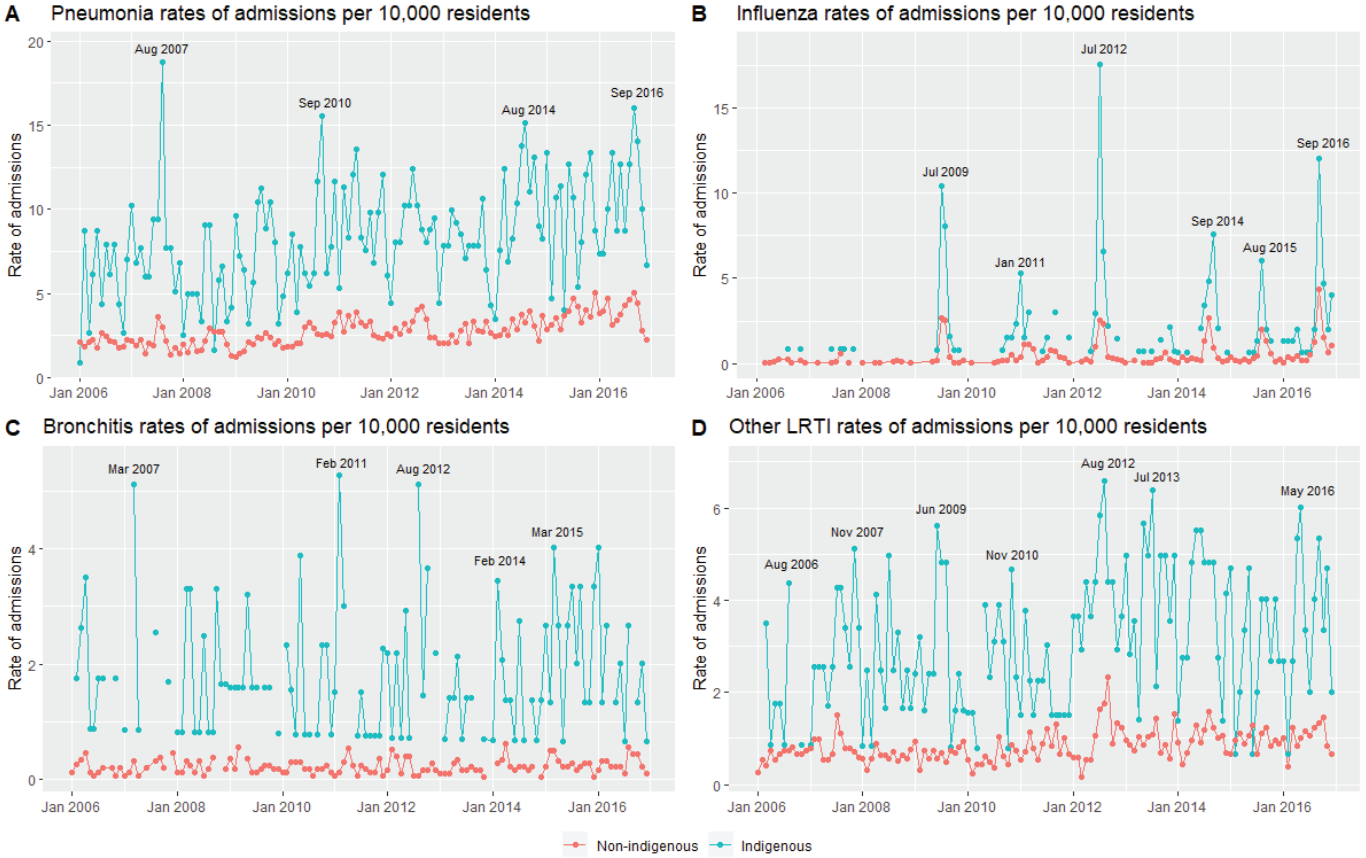


due to LRTIs were mostly for pneumonia (64.3%), influenza (9.1%) and bronchitis (6.2%). There was a general upward trend in LRTIs (influenza, pneumonia and bronchitis) during the 11-year study period. The population of the Townsville region increased by more than 21% during the sample period and this is a likely contributor to the increasing trend in hospital admissions. The burden of respiratory illnesses was disproportionately large for the Indigenous population, being the fourth most common cause for hospitalisation. This diagnosis was the seventh most common for the non-Indigenous population.[5] The burden of LRTIs can also be exacerbated as they can aggravate chronic respiratory and medical conditions, such as asthma[13] and heart failure,[14] which are also more prevalent in the Indigenous population. LRTIs have major public health and costs implications as they are common infections, especially during colder months, and can be a direct or indirect cause of illness. Heath policies directed at early identification of LRTIs and raising awareness of the LRTIs within regional communities can reduce the current and future burden of disease on the Indigenous and non-Indigenous populations. Furthermore, as a larger proportion of Indigenous than non-Indigenous patients reside in rural and remote communities, they are more likely to require inter-hospital transfer due to the limited health services available.[15] Timely access to care is important to promptly identify and treat LRTI to avoiding the development of greater morbidity.

We found admission rates (per 100,000 people) for pneumonia, influenza and bronchitis to be higher among Indigenous patients than non-Indigenous patients. Notably, the H1N1 swine flu epidemic in 2009 disproportionally affected the Indigenous population in this study, as has been found elsewhere,[16] not only in the area serviced by the Townsville hospital, but also the Top End of northern Australia.[17,18] During this epidemic, Indigenous patients experienced a hospitalisation rate that was eight to 12 times higher, respectively, to that experienced by the non-Indigenous population.[17,18] This is comparable to other studies outside Australia that found higher rates of LTRIs among minority populations including Black adults in the US,[19,20] Maori in New Zealand[21] and Pakistanis in Scotland.[22] The 2012 influenza season, predominantly driven by the H3N2 strain,[23] was particularly burdensome for the Indigenous population with the hospitalisation rate increasing by 70% (17.5 admissions per 10,000 Indigenous residents) compared to the 2009 epidemic. Disproportionately high rates of pneumonia admissions for the Indigenous population with large increases in presentations occurring in the winter season[24] across our observation period is also concerning, as pneumonia is a significant contributor to Indigenous respiratory-related deaths.[25] There has not been a consistent trend in the reduction of these differences over time. Thus, the higher prevalence of respiratory infections in the Indigenous population suggests the health gap is not closing.

Significant gaps in socioeconomic characteristics between Indigenous and non-Indigenous populations also contribute to a higher prevalence of respiratory illnesses.[26] In 2017, 39% of the disparity in health outcomes between Indigenous and non-Indigenous populations was linked to social determinants, including employment status, education outcomes and household

Figure 2: Rates of admissions by diagnosis status and Indigenous status.



income level.[25] In this study, more Indigenous than non-Indigenous patients lived in areas that were more socioeconomically disadvantaged. The indigenous population is more likely to face housing problems, such as overcrowded dwellings with poor ventilation, which contribute to the increased risk of LRTIs among Indigenous people. Without addressing socioeconomic disadvantage, reducing poverty and improving living conditions, it would be difficult to change health behaviours and reduce the burden from respiratory infections, including LRTIs.

Smoking (including passive exposure) is another important contributor to the increased risk of LRTIs among Indigenous people. The prevalence of smoking among the Indigenous population is almost three times higher (38%) than among the non-Indigenous population (13%).[27] Active smoking increases the risks of hospital admissions due to pneumonia and influenza-associated infections;[28,29] it is likely a contributing factor to the development of severe complications, and hence higher LOS, as a result of the higher burden of underlying chronic conditions and other non-communicable diseases Indigenous population experience. Previous studies have shown that public health messages about harms from smoking and social marketing anti-smoking campaigns can be effective and increase interest and participation from Indigenous community members in smoking cessation programmes if they involve local champions and are culturally and locally tailored.[30,31]

The previous patterns of LRTI dynamics, particularly for pneumonia and influenza, can provide insights for Indigenous health experts and community leaders on the increasing burden of respiratory infections during epidemics. In the times of COVID-19, there have been growing concerns about the risks of COVID-19 spread in vulnerable populations, such as Indigenous people, who have a high prevalence of comorbidities and risk factors for LRTIs.[32] In response to these heightened risks, the Australian Government provided additional financial and health resources to support remote communities and facilitate culturally safe access to COVID-19 testing and healthcare.[33,34] Furthermore, successful implementation of evidence-based and culturally translated COVID-19 prevention messages, prepared and delivered by Aboriginal Community Controlled Health Organisations, helped to reduce the risks of COVID-19 community transmission.[35]

In this study, the use of palliative and rehabilitation care was lower among Indigenous people than the non-Indigenous population. In addition to the observed skewed demographic profile observed for Indigenous people due to premature adult deaths, environmental and contextual issues, institutional barriers, awareness, perceptions and interpersonal client–clinician interactions are notable challenges in healthcare and palliative care use among the Indigenous population.[36,37] However, the previous study

Table 2: Determinants of the LOS (in days) from the negative binomial model.

Variable	MODEL I Estimate [95%CI]	MODEL II Estimate [95%CI]
	Coefficients	
Female	-0.1712 ***	-0.1714 ***
	[-0.2572; -0.0853]	[-0.2581; -0.0846]
Age	0.0249 ***	0.0257 ***
	[0.0193; 0.0305]	[0.0200; 0.0314]
Age^2	-0.0001 ***	-0.0001 ***
	[-0.0002; -0.0001]	[-0.0002; -0.0001]
Indigenous	0.2073 **	0.3946 **
	[0.0054; 0.4091]	[0.0326; 0.7565]
ICU	1.0731 ***	1.0685 ***
	[0.9692; 1.1769]	[0.9659; 1.1711]
IRSD score	-0.0001	-0.0001
	[-0.0011; 0.0009]	[-0.0011; 0.0009]
Palliative care	-0.2761**	-0.2702 **
	[-0.5182; -0.0341]	[-0.5160; -0.0243]
Base: Influenza		
Pneumonia	0.3676***	0.4059 ***
	[0.2229; 0.5124]	[0.2619; 0.5499]
Bronchitis	0.0998	0.0806
	[-0.1060; 0.3056]	[-0.1670; 0.3281]
Other LRTI	0.3239***	0.4028 ***
	[0.1329; 0.5149]	[0.2191; 0.5865]
Base: Influenza*non-Indigenous		
Indigenous*Pneumonia		-0.1778
		[-0.5935; 0.2378]
Indigenous*Bronchitis		-0.0076
		[-0.4014; 0.3861]
Indigenous*Other LRTI		-0.3808
		[-1.0007; 0.2391]
	Average marginal effects	
Female	-1.8815 ***	-1.8821 ***
	[-2.8619; -0.9010]	[-2.8709; -0.8932]
Age	0.0892 ***	0.0866 ***
	[0.0628; 0.1157]	[0.0602; 0.1130]
Indigenous	2.4496	2.2895
	[-0.1526; 5.0517]	[-0.4135; 4.9925]
ICU	17.5028 ***	17.3906 ***
	[15.2933; 19.7123]	[15.2127; 19.5685]
IRSD score	-0.0013	-0.0010
	[-0.0126; 0.0100]	[-0.0123; 0.0104]
Base: Influenza		
Pneumonia	3.5624 ***	3.5186 ***
	[2.3112; 4.8135]	[2.2343; 4.8030]
Bronchitis	0.8417	0.6588
	[-0.9524; 2.6358]	[-1.1183; 2.4360]
Other	3.0666 **	2.9951 ***
	[1.2280; 4.9052]	[1.1368; 4.8535]

Notes:

*Total number of observations for all patients equals to 11,629. In all models, we include month and year fixed effects. Standard errors are clustered by patient. There is evidence of overdispersion tested by the χ^2 test with p-value < 0.001. *** significant at 1 percent; ** significant at 5 percent;.*

found that the uptake of these healthcare services can be improved through the well-established Indigenous medical facilities and teams.[38]

Engagement and partnership with Indigenous communities, including representation of Aboriginal and Torres Strait Islander health workers and liaison officers within THHS teams, have been important aspects of "developing and providing culturally appropriate, outcomes-oriented healthcare to Aboriginal and Torres Strait Islander patients".[39] Thus, the number of Aboriginal and Torres Strait health workers in the THHS has improved from 154 (2.9% of THHS workforce) in 2017 to 208 in 2019 (3.8% of THHS workforce).[40] The positive dynamic is encouraging and THHS has Indigenous Health Workers embedded in the maternity ward, children's ward, renal units, cardiac units, mental health services, and community health, sexual health and rural facilities. The hospital also employs Indigenous Hospital Liaison Officers to help Aboriginal and Torres Strait Islander clients, their families and carers to access culturally appropriate healthcare and services. Furthermore, in line with the Engagement strategy, THHS developed a Reconciliation Action Plan that aims to build better relationships with Indigenous communities and consumers, while implementing culturally appropriate healthcare service delivery. These practices can particularly benefit the elderly and improve their use of palliative and rehabilitation care in a culturally safe and appropriate environment. Overall, these efforts focus on reducing health disparities between Indigenous and non-Indigenous people.

The main strength of this study is the use of a large hospital linked database with high reliability of disease classification coding (ICD10-AM) due to strict internal and external controls of this process. However, one of the limitations is that the data are from a single hospital in tropical northern Australia. Hence, it cannot be generalised to the entire population of Australia. The second limitation is that this study was not based on lab-confirmed cases of LRTI but hospital coding. However, the use of ICD10-AM for diagnoses have been shown to show high specificity and sensitivity.[41] Lastly, we described 'Indigenous' as Aboriginal and Torres Strait Islander people. As stated in O'Grady et al.,[42] this descriptor encompasses a group of people with varying locations, socioeconomic status, cultures and belief systems that might influence their perception and treatment of respiratory disease. Despite the above-mentioned limitations, the findings LRTI dynamics and determinants of LOS across Indigenous and non-Indigenous regional populations will be useful in providing decision makers with empirical evidence that is needed for effective planning and control strategies.

Conclusion

In this study, we examined the differences in the rates of lower respiratory tract infections amongst Indigenous and non-Indigenous Australian hospital inpatients. We highlighted the increased burden of LRTIs experienced by Indigenous populations in the far north of Australia with this information potentially being useful for enhancing community-level policy making. A preventive emphasis on improved vaccination rates for pneumonia pathogens including influenza and smoking cessation programs may be helpful in reducing the burden of diseases and public health risks. These efforts can be complemented by the improvements in engagement and partnership with Indigenous communities, particularly increasing the number of Indigenous health workers. Raising the awareness of the availability of healthcare and palliative care by providing culturally appropriate health resources and promoting yarning circles can help Indigenous communities increase healthcare uptake and the use of palliative care, thereby reducing the burden of respiratory diseases.

Table 3: LOS by Indigenous status and diagnosis groups: marginal effects of Indigenous status and differences in effects of Indigenous status across diagnosis groups.

	Indigenous	Non-Indigenous	Indigenous Gap (AME of Indigenous status)
Influenza	10.1361	7.5141	2.6220
Pneumonia	12.7329	11.2763	1.4566
Bronchitis	10.9027	8.1445	2.7582
Other LRTI	10.3614	11.2410	-0.8796

Notes:

None of the average marginal effect (AME) of Indigenous status is statistically significant. No Indigenous status gaps are significantly different across diagnosis groups (second differences) at p-value < 0.10, two-tailed tests.

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