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Pediatric emergency asthma presentations in Southwest Victoria: a retrospective cross-sectional study 2017 to 2020

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ABSTRACT

Objectives: Australia has one of the highest prevalence of asthma globally, and accessible emergency asthma presentation data remains vital, however, is currently underreported in regional and rural areas. Utilizing the Rural Acute Hospital Data Register (RAHDaR) which includes previously non-reported data, the aim of the study is to provide a more accurate understanding of asthma emergency presentation events, while investigating the factors associated with these presentations.

Methods: A retrospective cross-sectional study collected de-identified emergency asthma presentation data from nine health services in regional Victoria for children aged 0 to 14 years between 2017 and 2020. Demographic and presentation data were collated along with government datasets. Asthma emergency presentations incidence rates and predictor variables were analyzed using hierarchical multiple regression after adjusting for smoking and sex. Significance was determined at $p < 0.05$.

Results: Of the 1090 emergency asthma presentations, $n = 369$ occurred at health services who did not previously report data. This represents a 33.86% increase in our understanding of emergency asthma presentations and demonstrating a rate of 16.06 presentations per 1000 children per year. Key factors such as age, population density, and private health insurance were associated with asthma emergency presentation events among both sexes, while socioeconomic status and rurality were not predictive.

Conclusions: Although some findings are consistent with current research, the study highlights previously unrecognized specific factors that are predictive of asthma among 0–14-year-old children. These findings provide more accurate insights for healthcare workers and policymakers as they seek to support people with asthma and accurately address health inequities.

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Introduction

Asthma, a chronic airway inflammation associated with reversible airway narrowing and obstruction, is a response to varied and often unrelated stimuli (1,2). It persists as a significant disease internationally; Australia being considered one of the countries with the highest prevalence of asthma globally, with 2.7 million individuals (11.2% population) diagnosed in 2017–2018 (3). Although asthma-related hospitalization and mortality rates are relatively low in Australia and have declined over the past three decades, asthma rates remain high compared to other countries (2,4). These high rates significantly impact healthcare costs, particularly as many sufferers continue to seek asthma care at hospital despite asthma education, self-management, and action plans aimed at symptom control (1,2,5).

Globally, particularly in rural areas, children and adolescents shoulder the bulk of asthma-related health interactions, including both primary health and hospital care (1,4). Previous research suggests the reasons people seek hospital care during periods of asthma exacerbations include: poor primary healthcare access, prohibitive out-of-pocket costs at the primary health care level, poor self-management or action plan compliance, or inappropriate or inadequate medication use (1,2,4–6). Although preventative measures are at the forefront of the Australian response, the characteristics and severity of asthma means emergency care and hospitalization is, at times, appropriate, and vital (7).

Current literature remains insightful and informative regarding the improvement in asthma hospitalizations, while also guiding primary and tertiary care

policy and protocols. In their Australian study, Terry et al. (1) examined asthma presentations between 2010 and 2015 using the Victorian Admitted Episodes Dataset (VAED) and Victorian Emergency Minimum Dataset (VEMD), two Victorian Department of Health and Human Services (DHHS) datasets. They found the only predictor of hospitalization among either rural and metropolitan children aged 0–14 was being male. Further, it was found that metropolitan males had a significantly higher odds of being admitted to hospital with asthma than their metropolitan female counterparts.

While insightful, limitations were noted given the VAED only captures morbidity data on admitted patients at all private and public hospitals throughout Victoria. In addition, the VEMD only aggregates episode-level data on patients presenting to one of the 38 public hospitals in Victoria with a designated 24-h Emergency Department. In contrast, episode-level emergency presentation data from Urgent Care Centers (UCC) at one of the 67 smaller health services, located in more rural regions of the state, is not routinely captured within the VEMD (8,9). Urgent Care Centers provide urgent or critical access services as first-line emergency care, including emergency resuscitation, stabilization, and when clinically appropriate, prepare patients for transfer to a higher level of care (8,9). Given the lack of consistent data reporting, this raises questions about the VEMD's capacity to provide a complete picture, particularly among the rural and regional health services (4,9–11).

In their study, Terry et al. (1), had identified a number of asthma hospitalization “hotspots” in Southwest Victoria, which included the Local Government Areas (Counties) of Warrnambool and Moyne. However, key data gaps were highlighted and could not be addressed, which may have masked or, in some way, underestimated how significant an issue asthma is among children in the region. These gaps in the data did not provide a full appreciation of the emergency asthma presentation incidence rate in more rural areas, the key factors that may contribute to the occurrence of asthma in this region, or key factors influencing asthma hospitalizations at the time.

Since this initial study, one solution in understanding the genuine emergency asthma presentation incidence rate in rural Victoria was the Rural Acute Hospital Data Register (RAHDaR). RAHDaR collates data from health services in the region that provide mandated reporting to the government that appears in the VEMD. RAHDaR also collects data from less-resourced facilities with UCCs that are not currently

mandated to report episode-level emergency data to the DHHS, classified here as non-VEMD data (9,10). RAHDaR, as a resource, seeks to fill the data gaps such as those recognized as unavailable in the initial study by Terry et al. (1). The DHHS states that VEMD data is collected for epidemiological purposes, health service planning and coordination, policy assessment and formulation, clinical research, and quality improvement and patient management. However, without the data from non-VEMD reporting UCCs that manage in excess of 140,000 emergency cases annually (9), the accuracy of the data currently available is open to question. This is particularly evident as at least a third of emergency asthma presentation data are currently not being captured within VEMD (9). RAHDaR provides one solution to address these inaccuracies inherent in the VEMD reporting system (10). As such, it seeks to provide a more complete understanding of asthma and to address inequities among rural, regional and urban patients that contribute to increased morbidity and mortality (12–16).

Within the context of the current statewide reporting gap, the aim of the study is to provide a more accurate understanding of asthma emergency presentation events, which includes previously unreported data, and to investigate the factors associated with these presentations.

Methods

The retrospective cross-sectional study collected de-identified asthma emergency presentation data for a three-year period from 1 February 2017 to 31 January 2020 for children aged 0 to 14 years. Data were obtained from nine healthcare facilities across South West Victoria; where children's place of residence was classified as Large Rural Towns, Medium Rural Towns, and Small Rural Towns as defined within the Modified Monash Model (MMM). The MMM combines both population size and remoteness to provide a more accurate understanding of Australian rurality (17).

Data collection

All pediatric asthma emergency presentation events across the three year period were collected through RAHDaR (10), which collates data from participating healthcare facilities providing emergency or urgent care across the six Local Government Areas (LGA) in the region. Extracted emergency presentation data were based on the Victorian Emergency Minimum Dataset (VEMD version 22 for 2017–2018) where the

principal diagnosis was indicated to be asthma-related (ICD-10-AM: J45.0, J45.1, J45.8, J45.9, and J46.0) (18). Emergency asthma presentation data included sex; age; LGA; postcode; time and date of arrival and departure; and departure status (admitted, transferred, and discharged).

As guided by the work of Terry et al. (1) and Ansari et al. (19), additional LGA level data were obtained from the most recent 2016 Australian Census of Population and Housing, and the Victorian and Regional Health Profile 2015 data containing merged data from a number of government agencies. These include Australian Bureau of Statistics (ABS), Commonwealth Department of Health and Ageing, Commonwealth Department of Health, Victorian Department of Health and Human Services (VicHealth), and the Commonwealth Department of Planning and Community Development (20–23). This pool of available data contains information on each LGA, including 2017–2020 population data to accommodate for demographic evolution of the population over the three-year period. In addition, it included annual average income, unemployment rate, proportion of adult smokers (18 years of age and older), median house prices, and numbers of general practitioners (GP) per 1000 population (21). In addition, the data pool contains information regarding the proportion of people in each LGA purchasing private health insurance, which ranges from 33.9% (Glenelg LGA) to 46.3% (Moyne LGA) of residents.

The data also includes the four subsets of the Socio-Economic Indexes for Areas (SEIFA) which include: Index of Relative Socio-Economic Disadvantage (IRSD), Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), Index of Economic Resources (IER), and Index of Education and Occupation (IEO) (20). Lastly, the level of remoteness data was measured using the Accessibility and Remoteness Index of Australia 2011 (ARIA+) (24), and MMM to classify Large Rural Towns (MM3), Medium Rural Town (MM4), and Small Rural Town (MM5) across the region (17).

Ethical approval

Ethical approvals were obtained from South West Healthcare Human Research Ethics Committee, Federation University Human Research Ethics Committee, and Deakin University Human Research Ethics Committee (SWH-2019-167567, FUHREC E19-005, and DUHREC 2019-135).

Table 1. Demographic data.

Factor	Number	Percentage
Where care received		
• VEMD service	721	66.15%
• Non-VEMD service	369	33.85%
Age		
• 0–4 years	493	45.23%
• 5–9 years	385	35.33%
• 10–14 years	212	19.44%
Gender		
• Female	480	44.04%
• Male	610	55.96%
Departure status		
• Home	701	64.31%
• Admitted	331	30.36%
• Transferred	42	3.85%
• Left emergency at own risk	13	1.19%
• Other	2	0.20%
• Not stated	1	0.09%
Length of stay		
• Non-VEMD	2hrs 13 minutes	
• VEMD	3hrs 14 minutes	

Note: Victorian Emergency Minimum Dataset (VEMD).

Data analysis

Population figures at the LGA level were used to calculate asthma emergency presentation incidence rates across the six LGAs. Episodes were divided by the corresponding population estimates for each year according to gender, age group, and LGAs to obtain age standardized asthma emergency presentation incidence rates (25,26).

Emergency asthma presentation incidence rates and predictor variables were analyzed by LGA using Statistical Package for the Social Sciences (SPSS, Version 25.0). Hierarchical multiple regression was used to examine the association between emergency asthma episodes and the predictor variables, which included both ANOVA and t-tests. In addition, multivariable weighted least squares regression was also performed to account for any violations of assumption of equal variance of observations between populations. The initial analysis was conducted to ensure there was no violation of the assumptions of normality, homoscedasticity, linearity were present where scatterplot of standardized residuals met the assumptions, while multicollinearity met correlation coefficients greater than 0.8 and variance inflation factors less than 10, as described in Pallant (27). Significance was determined at two tailed $p \leq 0.05$.

Results

Of the 1090 emergency asthma presentations, 33.86% ($n = 369$) of all presentations occurred at non-VEMD health services, 55.96% ($n = 610$) were male, and the highest number of emergency asthma episodes was among the 0–4 year age group (45.23%, $n = 493$) (Table 1). Forty-two (3.85%) individual episodes were transferred to a larger health service.

Table 2. Asthma emergency presentation according to rurality of town of residence.

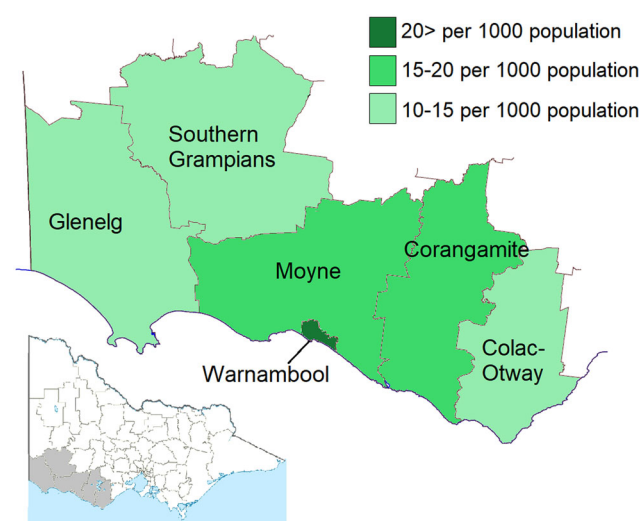
Hospital attended	Presentations according to rurality of Town of residence			Total
	Large Rural (MM3)	Medium Rural (MM4)	Small Rural (MM5)	
Non-VEMD	9	169	191	369
VEMD	473	86	162	721
Total	482	255	353	1090

Note: Victorian Emergency Minimum Dataset (VEMD), Modified Monash Model (MM).

Table 3. Asthma emergency presentation incidence rate at LGA level 2017 to 2020.

LGA	n	Percentage of asthma in LGA	Emergency asthma presentation incidence rate*	95% CI
Warrnambool	400	2.11%	21.08	20.76–21.39
Moyne	191	1.84%	18.37	18.00–18.74
Corangamite	141	1.61%	16.06	15.71–16.42
Colac-Otway	147	1.26%	12.58	12.34–12.82
Glenelg	112	1.17%	11.72	11.47–11.96
Southern Grampians	99	1.17%	11.67	11.41–11.93
Total	1090	1.61%	16.06	15.93–16.19

*Presentations per 1000 children per year; Note: Local Government Area (LGA).

**Figure 1.** Asthma emergency presentations by LGA—Children 0–14 years of age 2017 to 2020.

Among the 721 presentations at VEMD health services in larger centers, 34.39% ($n=248$) were children from either Medium or Small Rural Towns, and 162 (45.89%) small town resident presentations had occurred at VEMD health services (Table 2).

Rates of emergency asthma presentations at VEMD healthcare services were indicated to be 10.62 presentations per 1000 children per year for the region. However, when non-VEMD healthcare service data is included it is highlighted the region's asthma rate increases to 16.06 presentations per 1000 children per year. This represents a difference in asthma presentations of 5.44 presentations per 1000 children per year, or a 33.86% difference in our current understanding of emergency asthma presentation incidence rates in the region.

Access to more comprehensive data (VEMD and non-VEMD data) more accurately illustrates emergency

asthma episodes, with the highest rates among 0–14 year old children occurring in the Warrnambool LGA (21.08 presentations per 1000 children per year) compared to the lowest child emergency asthma episode rates in Southern Grampians LGA (11.67 presentations per 1000 children per year; Table 3). In addition, LGA asthma rates were significantly different ($p=0.000$), except those between Glenelg and Southern Grampians ($p=0.993$).

Geographically it is demonstrated that emergency asthma presentation incidence rates decrease with increasing distance from the single, more densely populated regional center of Warrnambool (Figure 1).

When examining emergency asthma presentations among male and female children, the highest rates occurred in males 0–4 year of age (26.24 presentations per 1000 children per year), with the lowest rates occurring among 10–14-year-old female children (10.85 presentations per 1000 children per year; Table 4). Differences between both male and female asthma rates were significant ($p=0.000$), except the rates among 10–14-year-old males and females ($p=0.208$).

When examining presentations by age group, the highest rates were specifically among males aged 0–4 years from Corangamite (36.99 presentations per 1000 children per year), followed by Warrnambool females (33.08 presentations per 1000 children per year) and males (30.23 presentations per 1000 children per year). Conversely, the lowest emergency asthma presentation rates across the region occurred among males aged 10–14 from Corangamite (3.62 presentations per 1000 children per year), with the second lowest rates observed in Glenelg (4.83 presentations per 1000 children per year; Table 5). Again, differences between both male and female asthma rates for each LGA were significant ($p=0.000$).

Table 4. Asthma emergency presentation incidence rate between age groups 2017 to 2020.

Age (years)	Female				Male			
	n	%	Emergency asthma presentation incidence rate*	95% CI	n	%	Emergency asthma presentation incidence rate*	95% CI
0–4	254	7.87%	20.22	19.81–20.63	239	6.07%	26.24	25.72–26.72
5–9	181	4.62%	13.53	13.26–13.80	202	4.06%	15.41	15.12–15.70
10–14	117	3.37%	10.85	10.64–11.06	98	3.26%	11.25	11.04–11.46
Total	552	5.19%	14.72	14.55–14.89	539	4.42%	17.30	17.11–17.49

*Per 1000 children per year.

Table 5. Asthma emergency presentation incidence rate by gender and age group at LGA level.

Age group (years)	Emergency asthma presentation incidence rate*							
	Female				Male			
	0–4	5–9	10–14	Total	0–4	5–9	10–14	Total
Warrnambool	33.08	14.14	16.35	20.98	30.23	9.32	24.73	21.16
Moyne	20.01	25.13	6.36	16.74	28.29	23.34	9.58	19.93
Colac-Otway	15.05	8.82	8.34	10.69	19.26	17.33	6.33	14.28
Corangamite	10.02	17.06	8.40	11.93	36.99	28.52	3.62	19.84
Glenelg	16.48	10.24	7.93	11.53	17.38	15.22	4.83	11.89
Southern Grampians	13.24	3.02	13.98	10.15	23.78	8.83	7.58	13.05
Total	20.22	13.53	10.85	14.72	26.24	15.41	11.25	17.30

*Per 1000 children per year.

Table 6. Regression analysis associated with asthma emergency presentations 2017–2020.

Predictor	Males				Females			
	B	OR(adj) [†]	95% CI	p-value	B	OR(adj) [†]	95% CI	p-value
• Age	−6.496	0.002	0.001–0.003	0.000**	−5.312	0.005	0.003–0.009	0.000*
• Adult Smoking (proportion)	−.386	0.680	0.416–1.111	0.123	.668	1.950	1.221–3.114	0.005*
• GP ratio (per 1000)	.327	1.387	1.324–1.451	0.000**	−.027	0.973	0.930–1.019	0.250
• Population Density	−.014	0.986	0.975–0.996	0.008**	.059	1.061	1.0491.071	0.000**
• ABTSI	.020	1.020	1.001–1.033	0.035*	.007	1.007	0.990–1.024	0.432
• Private insurance	.029	1.029	1.025–0.003	0.000**	.009	1.009	1.005–1.012	0.000**

* $p \leq 0.05$, ** $p \leq 0.001$; Adjusted odds ratio, OR(Ad)).[†]Adjusted for sex and age.

Multiple regression analyses highlighted several significant predictors of asthma emergency presentation among both males ($F(5, 604) = 127.805$, $p = 0.000$) and females ($F(5, 474) = 156.779$, $p = 0.000$). After controlling for age, it was indicated that other variables explained 56.0% and 65.5% of the variance in attributes impacting emergency presentations among females and males respectively.

As outlined in Table 6, older female children were less likely to present at an ED or UCC with asthma. In addition, as the proportion of adult smokers, population density, and levels of private health insurance increased, so did the likelihood of presenting at and ED or UCC with asthma. Conversely, older male children were less likely to present at an ED or UCC with asthma. In addition, as the number of GP per head of population, the proportion of Aboriginal and Torres Strait Islander people in the community, and levels of private health insurance increased, so did the likelihood of presenting at and ED or UCC with Asthma. Notably among male children, as population density increased, the likelihood of presenting at and ED or

UCC with asthma would decrease. No other factors, including SEIFA, IRSD, IRSAD, IER, IEO, or level of rurality were significant among females and males.

Discussion

Using both VEMD and the previously unavailable non-VEMD data, it was demonstrated that among the 1090 asthma emergency presentations, $n = 369$ (33.86%) occurred at non-VEMD health services. Further, it was demonstrated that the VEMD, or “known,” emergency asthma presentation rates were 10.62 presentations per 1000 children per year, which increased to 16.06 presentations per 1000 children per year when data not captured within VEMD was included. This represented a 33.86% difference in our current understanding of emergency asthma presentation incidence rates in the region and indicates the number of asthma emergency presentation events is much larger than currently appreciated. In addition, it was indicated that key factors such as population density, age, and private health insurance were

associated with asthma emergency presentation events among both sexes, while GP ratio for males and proportion of smoking adults among females were additional factors that were associated with asthma emergency presentation events.

Of particular interest, almost half of all small-town residents had presented at VEMD health services in larger regional towns. Previous research has suggested parents or EMS may bypass a smaller rural health service for a larger health service, particularly with respiratory-related or chronic health conditions (28–30). This requires further investigation to determine factors influencing this decision. With respect to age, asthma presentations for both males and females declined consistently across the sample and is an unremarkable finding given our current understanding of asthma events among age groups and sexes (6,31).

Previous research has identified that smoking was one of the strongest predictor variables associated with increased rates of hospitalizations for asthma in the 15–85 year old groups (32). While the research conducted by Terry et al. (1) did not identify a significant association between asthma and proportion of smoking adults, within the present study a significant relationship was identified between proportion of smoking adults and females who presented for emergency care. Access to the previously missing emergency asthma presentation data provides a much richer insight into the links between the proportion of smoking adults and childhood asthma when compared to previous research in the state (1,9). Despite this finding, it was indicated that proportion of smoking adults was not a determining factor among males.

Another important finding was differences in male and female emergency asthma presentation incidence rates in the context of population density. Previous studies (1) explored the links between population density and asthma presentations in rural and regional areas, and did not show a significant correlation. However, the current study has identified a direct relationship between emergency asthma presentations among females and increasing population density; a finding similar to other studies conducted in metropolitan areas (1). This may be associated with the greater levels of direct (including maternal exposure) outdoor air pollution, such as fine particulate matter ($PM_{2.5}$ and PM_{10}) from dust, wood smoke and industrial emission; and Nitrogen dioxide (NO_2), ambient ozone (O_3), and carbon monoxide (CO) from vehicle exhaust. These have been shown to have a significant impact on asthma hospitalizations among rural and metropolitan children, particularly among low-income

families (32–36). Of particular interest, however, is the study conducted by Zein and Erzurum (37) who found that females had lower Forced Expiratory Volume in the first second (FEV1) than their male counterparts when exposed to particulate matter or secondhand smoking. In addition, they found younger females, aged 3 to 12 years of age with allergic tendencies, experienced greater number of respiratory symptoms than their male counterparts and is suggested to be an effect modifier which may explain the differences between sexes.

This finding is confirmed here with an inverse relationship being identified amongst males whereby emergency asthma presentation incidence rates decreased in areas of higher population density. Although, it is argued there are protective factors of small farm living on the development of asthma among rural children, living on or near large commercial farms can have the opposite effect (6). Currently, agricultural land accounts for 69% of land use in South West Victoria, with dairy, cattle, and sheep accounting for 91.8% of the region's agricultural farm production (38,39). This may provide some insight into the lower rates of emergency presentations by male children from higher density populations in this study (6). Although a number of inferences may be made regarding population density and asthma presentation differences between males and females, further investigation is required.

In contrast to popular assumptions and the published understanding, nationally and internationally (1,6,40), this study has highlighted that socioeconomic status and rurality were not predictive of child emergency asthma presentations within this geographical location. On the contrary, this study identified private health insurance ownership as a predictor of emergency asthma presentation. Higher private insurance levels were associated with a greater likelihood of emergency asthma presentation among both male and female children. While not a direct measure of socioeconomic advantage, it is demonstrated in Australia that individuals with higher levels of socioeconomic advantage have higher levels of private health insurance (78.4%) compared to their counterparts with higher levels of socioeconomic disadvantage and who have lower levels of private health insurance (33.0%) (39). Similarly, higher proportions of Australians living in major cities (60.1%) are more likely to have private health insurance than those in more rural and regions of Australia (47.0%). However, these differences between rural and urban centers may be more related to healthcare accessibility rather than

affordability (6). This finding suggests future research should aim to examine the impact of private health insurance on primary health care access for asthma management at the rural community level.

In conjunction with other studies, these findings provide direction for future research. In particular, research should aim to examine more closely the type of presentation (first time or exacerbation of existing asthma), the impact of private health insurance, as well as patient beliefs and self-efficacy. Lastly, future research should also examine the impact of primary health care on asthma management at the rural community level.

Limitations

Study limitations include using retrospective rather than prospective emergency presentation data, and a lack of arrival mode and acuity information that may help explain presentations to more distant larger facilities. An additional limitation within the study is the use of LGA data and not the individual characteristics of each participant. Nevertheless, a major study strength is the use of the previously missing 33.86% of UCC emergency presentation data (9). This data allows the development of vital asthma predictor information and can now target a program of research to understand and address the challenges children and families in rural and regional Victoria may encounter.

Conclusion

With some of the highest rates of asthma worldwide, there is a compelling need to prioritize both primary and tertiary care of people with asthma in Australia. The targeting of policy and practice-based interventions should be founded upon a solid foundation of accurate and accessible data. In rural Victoria, this has not been the case. Data pertaining to emergency presentations for asthma amongst children aged 0–14 years, of which 33.86% of overall data has been missing, demonstrates that emergency asthma presentation rates are much larger than previously appreciated. Although a number of findings are consistent with current research, the study highlights the specific factors that are predictive of emergency asthma presentations amongst children in South West region of Victoria. This data also highlighted that a higher percentage of emergency asthma presentations occurred in lower-resourced health services than was previously understood. These findings provide direction for future research regarding healthcare decision making,

patient compliance relative to distance from higher levels of care, conscientious self-management practices, and enhanced medication compliance. Chronic health conditions, such as asthma, also place enormous stress on the patient and their family. As such, this research provides more accurate insights for healthcare workers and policymakers as they seek to target and support people with asthma and to ensure that health inequities between smaller and larger health services are more accurately quantified, recognized and addressed.

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Conflict of interest

RAHDaR has been developed by Dr Kloot and Dr Baker at the Center for Rural Emergency Medicine, School of Medicine, Deakin University. We acknowledge that there may be a real or perceived conflict of interest with Dr Kloot as an author on this paper.

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