Childhood asthma in New Zealand: the impact of ongoing socioeconomic disadvantage (2010–2019)

Deborah Schlichting, Tayaza Fadason, Cameron C Grant, Justin O'Sullivan

ABSTRACT

AIM: To document trends in number and cost of asthma hospital admissions and asthma prescriptions in children (0–14 years) from 2010–2019 in New Zealand.

METHOD: A retrospective analysis of public hospital admission and pharmaceutical prescription data.

RESULTS: The dataset included 39,731 hospitalisations with asthma as a discharge diagnosis and 5,512,856 prescriptions for asthma medication in children ≤14 years old. From 2010 to 2019, there was a 45% reduction in the number of asthma hospitalisations and an 18% reduction in prescriptions attributable to asthma. Declines were evident for both Māori and non-Māori children. However, Māori children were hospitalised with asthma at twice the rate of non-Māori children (7.2/1,000 versus 3.5/1,000, p<0.001), and a larger proportion of Māori children had an asthma readmission within 90 days of their first admission (18% versus 14%, p <0.001). Asthma admission rates for children from families living in the highest deprivation areas were, on average, 2.8 times higher than in the least deprived areas. We estimate that the combined cost of asthma hospitalisations and prescriptions was $165m. Of this, $103m was for hospital admissions and $62m was for prescriptions.

CONCLUSIONS: Although hospitalisations and prescriptions attributable to asthma have declined, there are clear inequities in the health outcomes of New Zealand children with asthma. Our analysis indicates that many New Zealand children, particularly Māori children and those living in areas of high deprivation, are not receiving levels of primary care for asthma that are consistent with prevention.

Globally, asthma is the most common chronic disease in children.[1] The global prevalence, morbidity and mortality related to childhood asthma among children has increased significantly over the last 40 years.[2] Asthma is among the top 20 chronic conditions for global ranking of disability-adjusted life years in children; in the mid-childhood ages 5–14 years it is among the top 10 causes.[1] Asthma is also the leading cause of chronic disease-related school absenteeism.[3] A range of comorbidities is associated with childhood asthma: compared to children without asthma, children with asthma have a higher prevalence of hay fever or respiratory allergies, eczema or skin allergies, sinusitis and food or digestive allergies.[4]

The evidence base for effective treatment of asthma is well established, and much of it can be delivered by an accessible, high-performing primary care system and the appropriate use of preventer medication.[5,6] Therefore, high rates of hospital admission with asthma are considered an indicator of problems with quality of, or access to, primary care.[6] Nevertheless, many other factors (prevalence, severity and adherence among them) add significantly to risks for hospital admissions.

At 65/100,000 population, New Zealand ranked 30th out of 38 OECD countries for its rate of avoidable adult asthma hospital admissions in 2019. The OECD average was

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41/100,000.[6] The prevalence of childhood asthma in New Zealand in 2019 was estimated to be 13% by the New Zealand Health Survey, which used a case definition dependent on each child's parents or caregivers having ever been told by a doctor that the child has asthma and whether the child is currently taking treatments for asthma (inhalers, medicine, tablets or pills).[7] The asthma prevalence among Māori children (16%), New Zealand's indigenous population, was higher than that observed for children of non-Māori ethnicities. That Māori children have higher asthma morbidity[8] and mortality[9] rates was already documented over thirty years ago. Critically, in 2019, the Global Burden of Disease[10] reported the rate of deaths due to childhood asthma in New Zealand was nearly four times higher than the global rate for children in the 10–14-year age group, at 3.06% compared to 0.70%.[10] For children aged 5–9 years, the proportion of disability-adjusted life years (DALY) due to asthma in New Zealand (8.95% of total DALYs) is 3.6 times higher than the global rate for children aged 5–9 years.[10]

There exist various efforts to assess the evidence on resource use and costs among people with asthma in New Zealand.[11–14] A 1989 estimate[11] put the combined cost of asthma hospitalisations and medications in New Zealand at $102.3m per annum. The annual cost of asthma hospitalisations and medications in New Zealand was estimated to be $349m per annum in 2001,[14] $799m[12] in 2015 and over $1 billion in 2018.[13] Therefore, the costs of asthma treatment appear to be increasing. However, because they differ in their methods, it is difficult to make comparisons between these studies. These differences include asthma case definition, the population studied (eg, adult or child) and cost types included. Moreover, each study focussed on a single year period, making it difficult to discern temporal changes.

The objective of this study was to characterise patterns in asthma hospitalisations and prescription medication and to estimate the direct costs of asthma in New Zealand's child population (aged 0–14 years) from 2010–2019.

Methods

Ethics

Permission to use the data was provided by the Ministry of Health. This study did not require submission to the Health and Disability Ethics Commission (HDEC) as it is not within the scope of HDEC review. Confirmation of this was received from HDEC on 9 August 2019.

New Zealand administrative health data

De-identified New Zealand administrative health data from January 2010 to December 2019 were accessed through the Ministry of Health. All paediatric administrative data from across New Zealand were analysed for patterns of hospitalisation and medication prescription for asthma among children aged 0–14 years. All demographic information was extracted using the national health index number (NHI), a unique identifier assigned to each individual in New Zealand at birth or on their first contact with the healthcare system. These demographic data included an individual's sex, date of birth, self-reported prioritised ethnicity and NZDep2013,[15] an indicator of neighbourhood socioeconomic deprivation derived from variables collected at the New Zealand 2013 national census. Neighbourhood socioeconomic deprivation was categorised into quintiles.

De-identified child data were stratified by age and ethnic group. Age groups were ≤4 years, 5–9 years and 10–14 years. Neonates (age <29 days) were excluded. We follow the methods of the Health Quality and Safety Commission (HQSC) in selecting the age range of 0–14 years in the analysis of asthma,[5] acknowledging the difficulties in diagnosing and treating asthma in children age <5 years. The HQSC notes that, given both their high rate of admissions and that some will go on to develop asthma, it is informative and appropriate to present these data.[5]

Hospitalisation and prescription data

Using anonymised national health index (NHI) numbers, we retrieved hospitalisation data from the National Minimum Dataset

(NMDS)[16] and prescription data from the Pharmaceutical Collection.[17]. The Pharmaceutical Collection records all subsidised prescription medications dispensed from community pharmacies in New Zealand. In New Zealand, all prescription asthma medications are subsidised for children.

Asthma hospitalisations were defined as any admission to a public hospital with a discharge diagnosis of asthma. Asthma was defined using ICD-10-AM[18] system clinical codes (Table 1). Admissions with a diagnosis of wheezing (R06.2) were not included in asthma admissions.

Asthma-medication prescriptions were identified in the pharmaceutical claims data using the PHARMAC schedule[19] and the New Zealand Formulary for Children (NZFC)[20] (Appendix Table 1). PHARMAC, New Zealand's national drug-buying agency, classifies all medications by therapeutic group. We used a three-stage identification process: (1) prescriptions were selected first from 'Respiratory system and allergies' in Therapeutic Group 1; (2) medications specific to paediatric asthma were identified in Therapeutic Group 2; (3) asthma medication was stratified into preventer and reliever groups based on classification in the NZFC.[20] Not all medications used in the treatment of asthma are listed under the respiratory systems therapeutic group. Therefore, additional medications (ie, prednisone and prednisolone (from therapeutic group 'Hormone preparations') and omalizumab (from therapeutic group 'Oncology agents')) were included in this analysis to capture the full spectrum of asthma medication used to treat paediatric asthma.

Cost of illness

We use a cost-of-illness approach to estimate the cost of paediatric asthma in New Zealand. Consistent with published studies on the cost of asthma in New Zealand,[11] we included only the major direct costs of prescription medication and hospital admission. In contrast to others,[21] we did not include indirect or intangible costs.

Hospitalisation costs, adjusted for inflation and reported in 2019/20 financial year terms ($FY2019/20), were derived by multiplying the case weight of each admission (supplied in the NMDS) by the annual purchase unit price for 2019/20 (Appendix Table 2).[22]

The Ministry of Health pharmaceutical claims data includes information on the cost of each prescription. The cost value used in this analysis is the GST-exclusive subsidy, as listed in the Pharmaceutical Schedule, that district health boards reimburse pharmacies. These values were inflation adjusted, and all prescription costs are reported in real values for the financial year 2019/20 ($FY2019/20). We retrieved inflation data from Stats NZ[23] using the first quarter of 2010 as the index base period.

Statistical methods

For conventional statistical tests, continuous variables were compared using Mann–Whitney tests, and categorical data were compared using Fisher's exact tests and chi-squared tests. Simple linear regression and a nonparametric loess regression were performed to assess whether changes in best practice and public health policy measures may have

Table 1: ICD-10-AM codes for identifying asthma admissions, including primary and secondary diagnoses, for children aged 0–14 years in New Zealand, 2010–2019.

ICD10 code	Definition	Number of admissions 2010–2019
J45.0	Predominantly allergic asthma	307
J45.1	Non-allergic asthma	389
J45.8	Mixed asthma	3
J45.9	Asthma, unspecified	37,681
J46	Status asthmaticus (including acute severe asthma)	1,351
Total		39,731

contributed to the observed reductions in childhood-asthma hospitalisation and prescription. Statistical significance was set at p≤0.05. All analysis for this study was generated using SAS Enterprise Guide software v7.15.[24]

Results

Discharge codes identified 32% of all childhood hospitalisations (2010–2019) as having ICD-10-AM codes related to the respiratory system. Asthma accounted for 4% of paediatric hospitalisations and 11% of paediatric respiratory hospitalisations. There were 39,731 paediatric admissions to hospital with an asthma discharge diagnosis (2010–2019).

Asthma admissions as a proportion of all respiratory admissions declined from 16% (n=5,104, 2010) to 8% (n=2,811, 2019). At the population level, there was a 62% reduction in asthma admissions for the youngest children (those age <5 years), a 21% reduction for those age 5–9 years and a 3% reduction for those age 10–14 years at time of admission (Figure 1).

Māori children were consistently hospitalised with asthma at more than double the rate of children of non-Māori ethnicities (Figure 2). Asthma admissions for children of non-Māori ethnicities decreased from 4/1,000 (2010, n=3,048) to 2/1,000 (2019, n=1,602), while admissions for Māori decreased from 9/1,000 (2010, n=2,056) to 5/1,000 (2019, n=1,209; Figure 2A). The ratio of Māori to non-Māori admissions was greater than 1.5:1.0 in all age groups in all years (Figure 2B). This is despite an aggregate 47% reduction in asthma hospitalisation rates, across all groups, between 2010 and 2019.

Poverty is a known risk factor for respiratory illness and asthma.[25] Consistent with this, asthma admission rates for children from families living in the most deprived quintile of neighbourhoods were, on average, 2.8 times higher than for children living in the least deprived areas (Figure 3). The difference between admissions for children in families from the least and most deprived areas deprivation scores remained constant between 2010 and 2019.

Seasonal fluctuations in number of asthma admissions were larger for children living in the most versus the least deprived quintile of neighbourhoods and were evident from 2010–2019 (Figure 4). The difference in number of asthma admissions between children living in households in the most versus the least deprived quintile of households was larger during winter months (June–August).

Duration of hospital stay

Sixty-five percent of asthma admissions were inpatients for at least one night (Figure 5A). In comparison with children of non-Māori ethnicities, Māori children admitted to hospital with asthma spent at least one night in hospital at twice the rate of non-Māori children (Figure 5B). The proportion of children hospitalised with asthma who were readmitted within 90 days

Figure 1: Hospital admissions with an asthma diagnosis, children aged 0–14 years, 2010–2019. Number of admissions in which discharge diagnosis ICD-10-AM code was 'Asthma', from all public hospitals in New Zealand. Age groups were defined by age at admission.

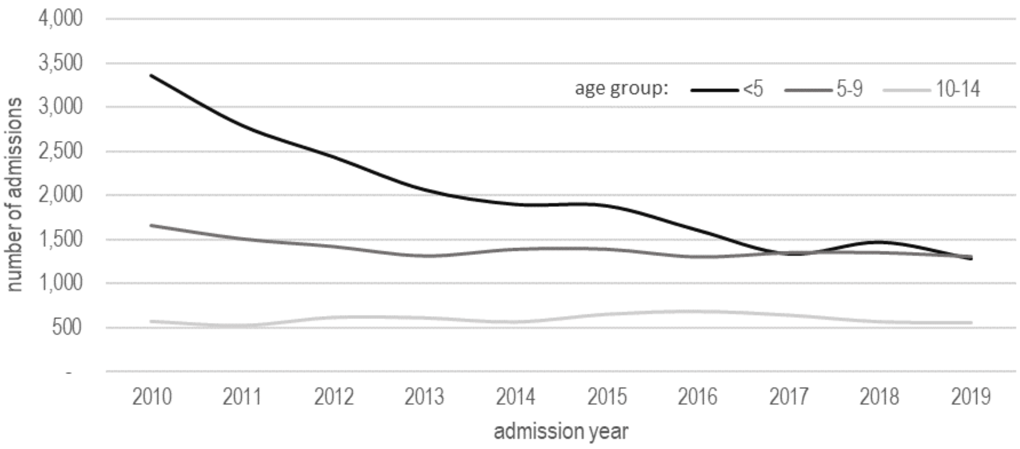


Figure 2: Asthma hospitalisation rates in New Zealand children by ethnic group and age group. (A) Asthma hospitalisation rates for children of Māori and non-Māori ethnicities age 0–14 years, 2011–2019. (B) Ratio of Māori to non-Māori for asthma hospitalisation rates by age group, 2010–2019.

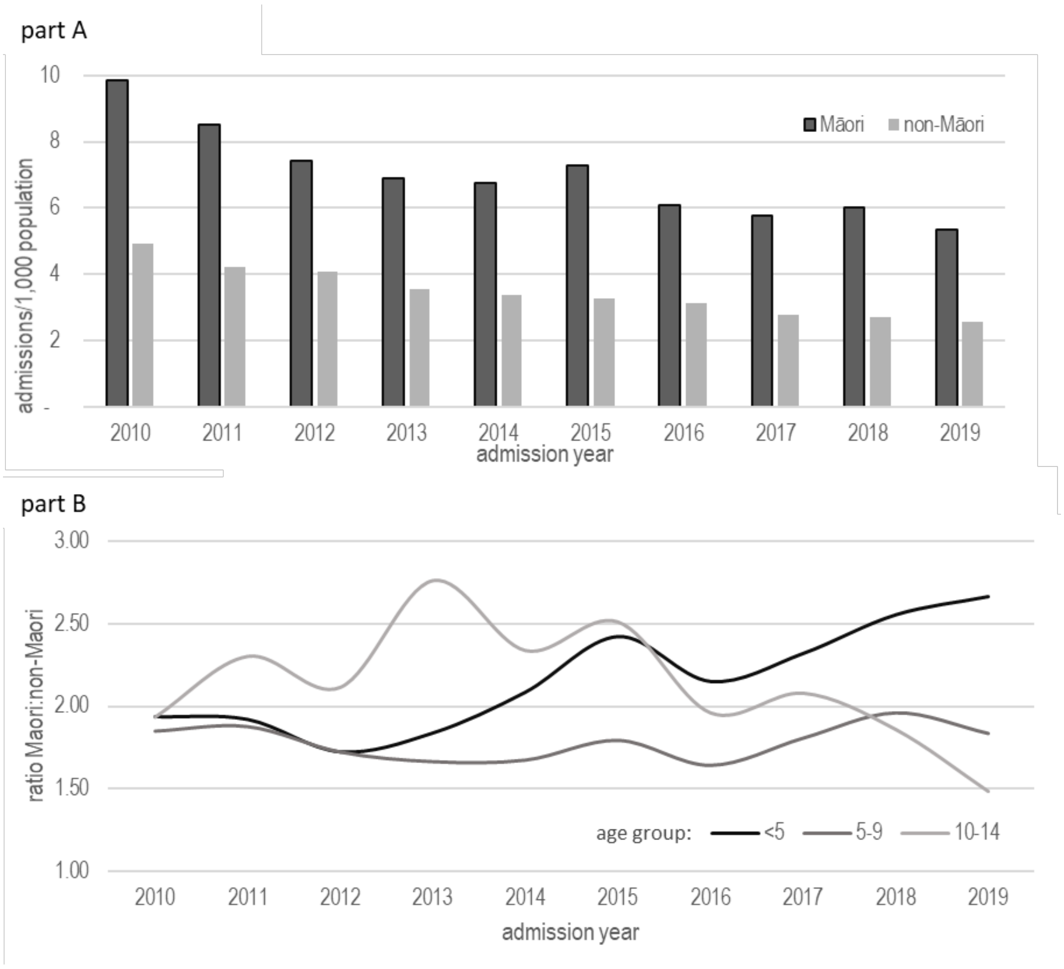
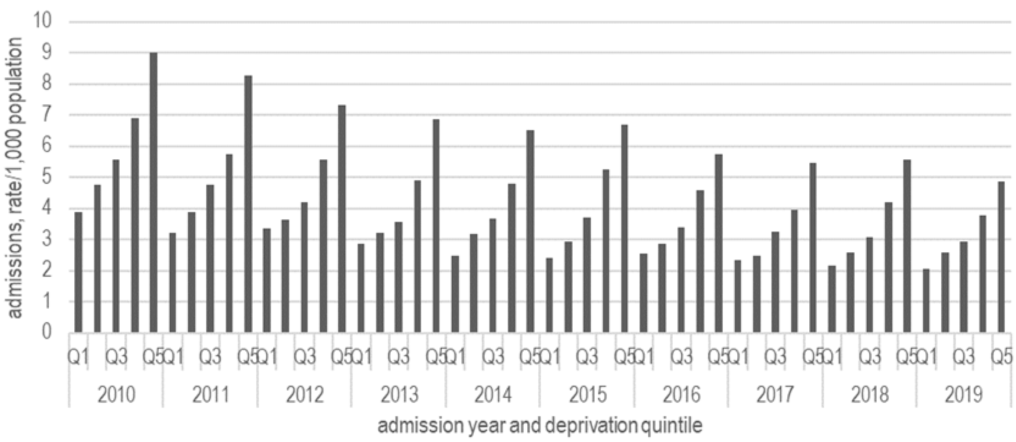


Figure 3: Number of admissions for asthma, children aged 0–14 years, by neighbourhood deprivation, 2010–2019.



of their first admission was larger for children of Māori (18%) compared with non-Māori (14%) ethnicity (p<0.001) (Figure 5C).

Prescriptions

Between 2010 and 2019, 16% of all paediatric prescriptions dispensed from community pharmacies were classified in the respiratory systems therapeutic group of the PHARMAC schedule. Of the prescriptions for respiratory medication, 75% (n=5,517,888) were categorised as asthma treatment drugs. However, it is worth noting that some of these medications may be used to treat non-asthma conditions (eg, omalizumab is also used to treat chronic idiopathic urticaria).[26] Within the asthma treatment drug category, reliever medications for acute onset of asthma accounted for 50% of prescriptions.

Forty-three percent (n=2,385,864) of all asthma-medication prescriptions from 2010–2019 were for corticosteroids. The proportion of asthma medications per year that were corticosteroids ranged between 45%–41% (2010 and 2019, respectively). Notably, Māori children consistently received corticosteroid prescriptions as a smaller proportion of their asthma prescriptions (Figure 6).

Prescriptions for asthma-preventer medications and asthma-reliever medications accounted for 25% (n=1,857,816) and 50% (n=3,660,072) of respiratory prescriptions, respectively. Prescriptions for beta-adreno-receptor agonists (eg, salbutamol/Ventolin), which are used primarily for acute management (reliever medications), accounted for 33% (n=2,431,048) of all respiratory prescriptions. Medication classified as 'Corticosteroids and related agents for systemic use' (n=1,190,502) accounted for the balance of reliever medications.

Māori children living in the most deprived quintile of neighbourhoods had the highest rates of asthma-reliever medication prescriptions (averaging 377/1,000 between 2010 and 2019; Figure 7). This was ~40% higher than for Māori children living in the least deprived quintile areas (271/1,000) and ~16% higher than for children of non-Māori ethnicities living in the most deprived quintile areas (326/1,000).

By contrast, Māori children living in the most deprived quintile of neighbourhoods received asthma-preventer medication prescriptions at an average rate 7% lower than Māori children living in the least deprived quintile of neighbourhoods (208/1,000) but almost the same as non-Māori children living in the most deprived quintile of neighbourhoods (198/1,000).

Costs

Between 2010 and 2019, the total expenditure on dispensing prescriptions to the paediatric community was $490m, of which respiratory and asthma medications accounted for $77.6m and $61.6m, respectively. Of the $61.6m spent on asthma medications, $34.8m was for spent on preventers and $26.7m was spent on relievers (Figure 8), reflecting the ratio of

Figure 4: Monthly patterns of asthma hospitalisations for children living in the least and most deprived neighbourhoods.

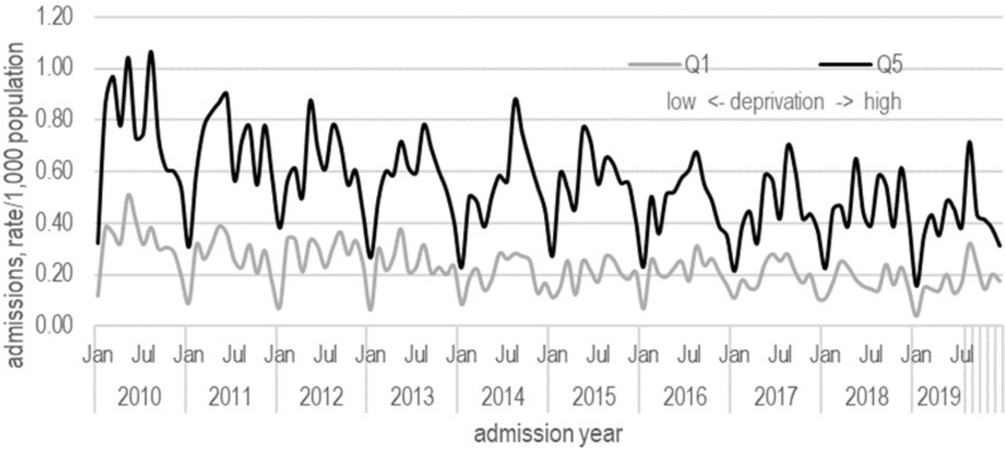


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Figure 5: (A) Length of hospital stay for children (0–14 years) admitted to hospital with asthma by admission year (2010–2019). (B) Comparison of length of hospital stay for children of Māori and non-Māori ethnicities from 2010–2019. (C) Proportions of children readmitted with asthma within 90 days of first hospital discharge, by admission year.

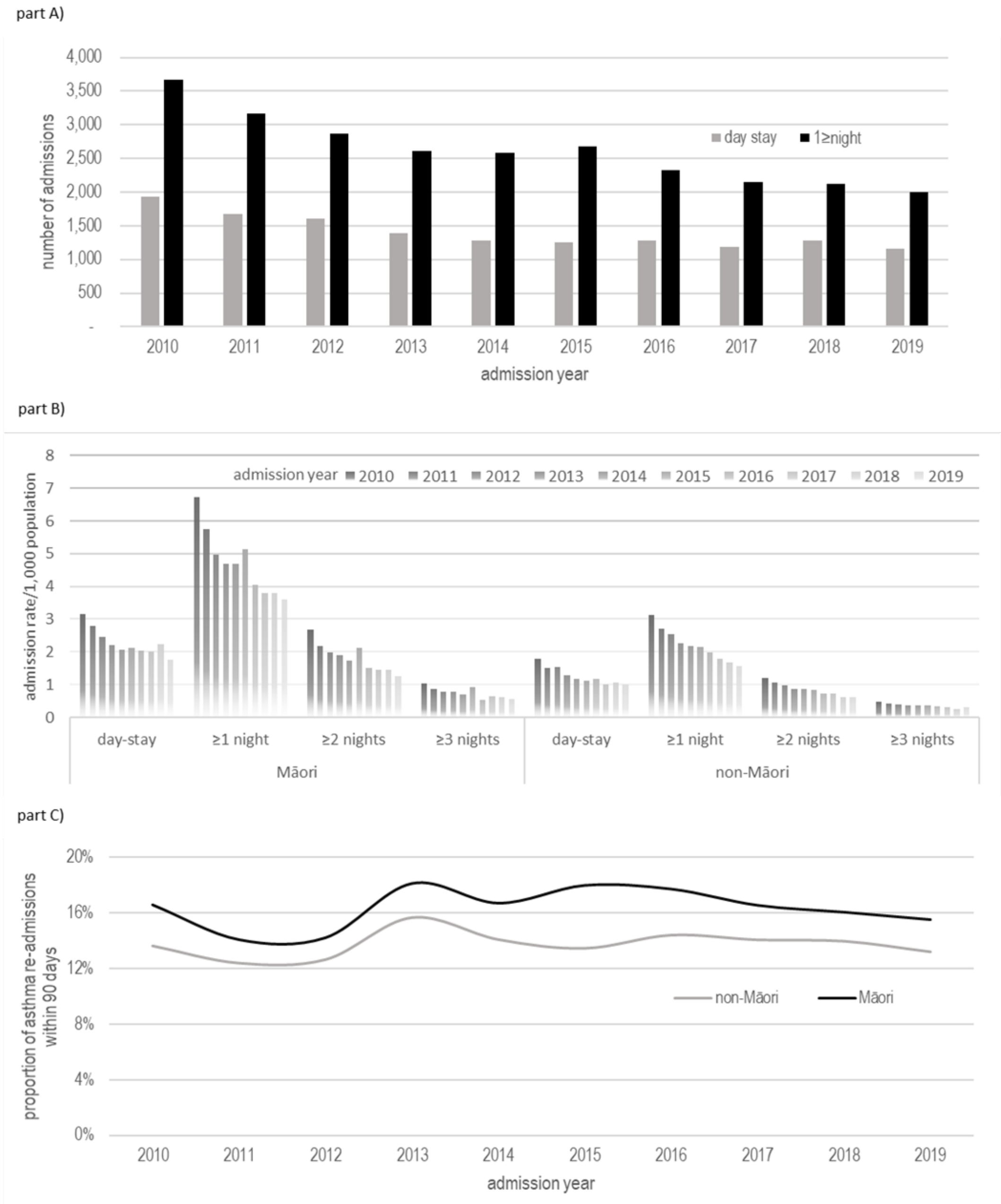

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Figure 6: Corticosteroids as a proportion of child asthma prescriptions by ethnic group from 2010 to 2019.

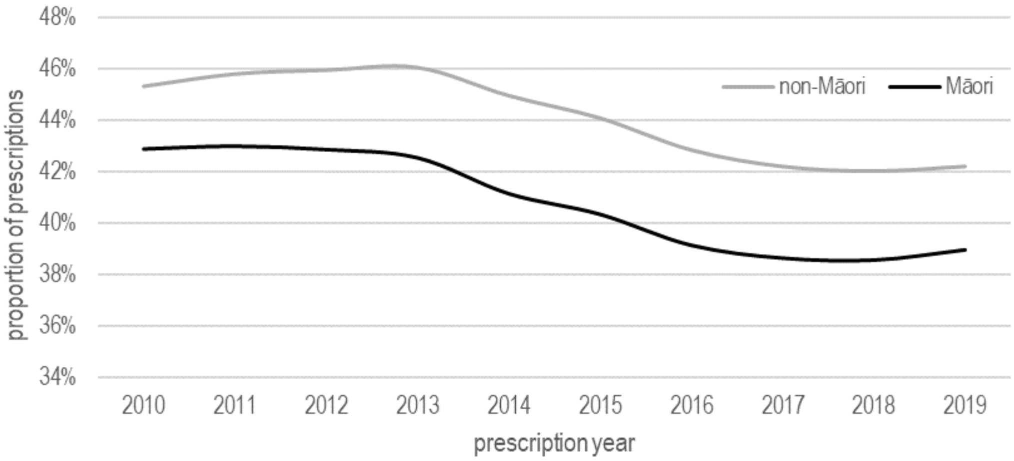


Figure 7: Prescriptions for asthma-preventer and -reliever medications: children of Māori versus non-Māori ethnicity, in most and least deprived neighbourhood quintile of deprivation areas, 2010–2019. (Panel A) Māori children in the least deprived quintile. (Panel B) Māori children in the most deprived quintile. (Panel C) Non-Māori children in the least deprived quintile. (Panel D) Non-Māori children in the most deprived quintile.

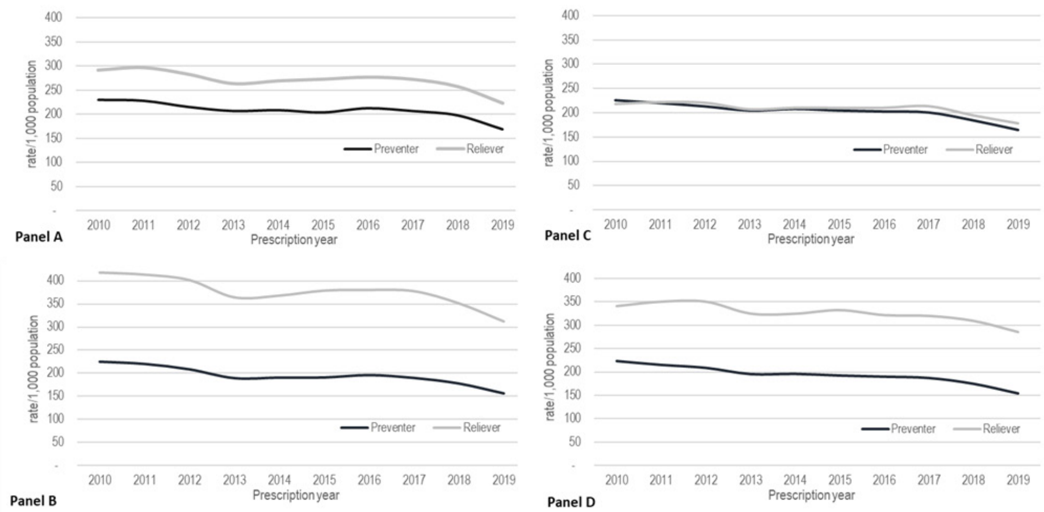
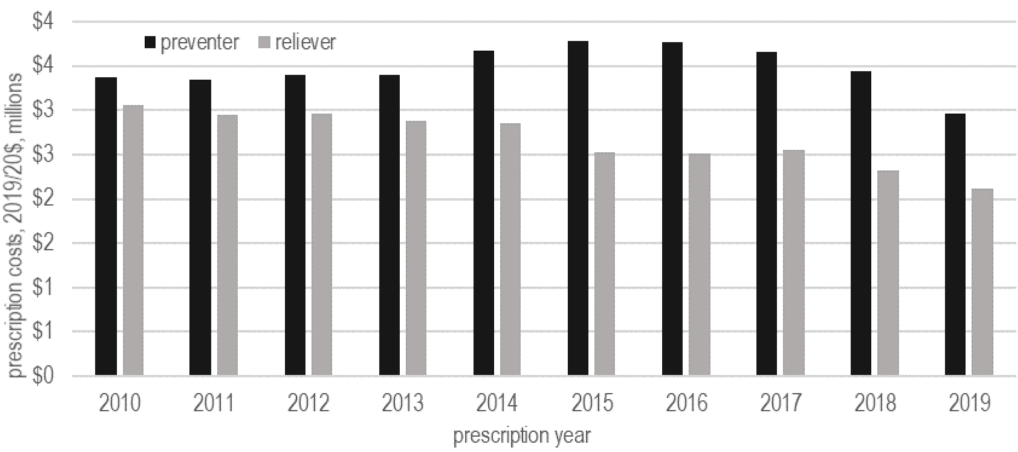


Figure 8: Asthma-preventer and -reliever medication costs, prescriptions for children aged 0–14 years, 2010–2019.



reliever to preventer prescriptions (1.97). Asthma-medication treatment costs for children in the most deprived quintile of neighbourhoods were double those for children living in the least deprived quintile of neighbourhoods (Figure 10), suggesting that their asthma is more symptomatic and they require more asthma medications and/or for longer.

The total hospitalisation cost for children (aged 0 to 14 years) admitted for all respiratory conditions was $1.2bn between 2010 and 2010. Asthma hospitalisation costs ranged from $2,436/admission (2010) to $2,798 (2015), for an average annual spend of $10.3m from 2010–2019 (Figure 9).

In total, we estimate that from 2010 to 2019 the direct costs of paediatric asthma treatment, made up of hospital admissions and community pharmacy prescriptions, was $165m. Of this, $103m was for hospital admissions and $62m for community pharmacy prescriptions (Table 2). Notably, there was a 32% reduction in the annual hospital admission costs from 2010 to 2019.

At a per capita level of spending on asthma prescriptions, there was little difference between prescription spending for children of Māori versus non-Māori ethnicity. However, asthma hospitalisation costs for Māori children were typically double that of a non-Māori child (Figure 11). This indicates that Māori children require longer and/or more complex care for their asthma.

Figure 9: Average cost per asthma hospitalisation, children aged 0–14 years, 2010–2019.

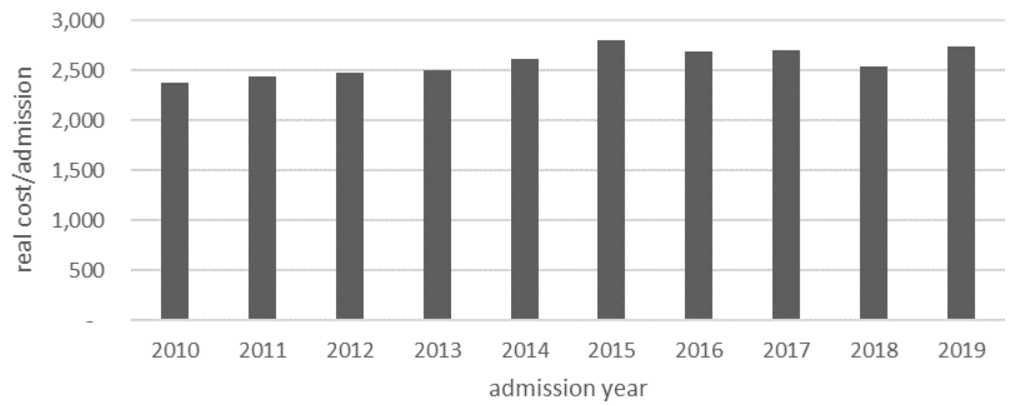
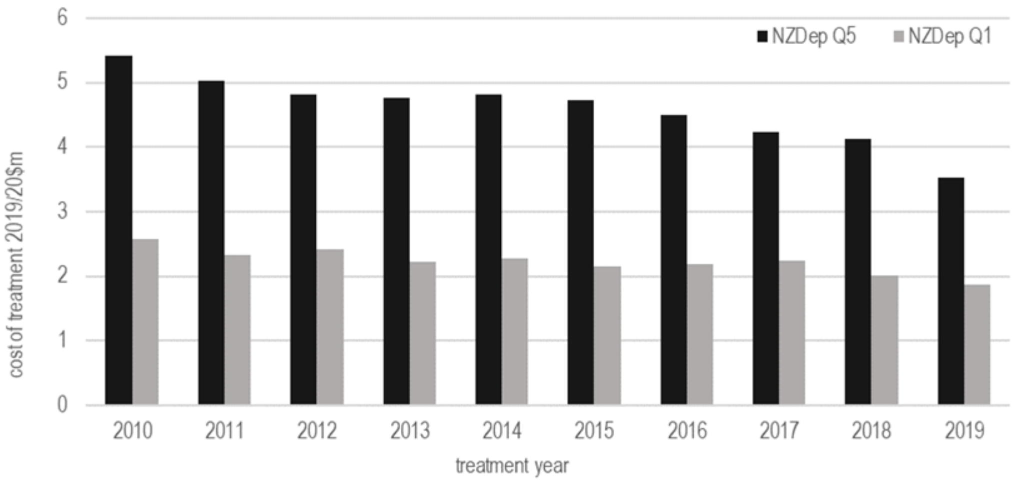


Figure 10: Total combined direct costs of asthma treatment (hospital admissions and community pharmacy prescriptions) for children age 0–14 years living in the most (NZDep Q5) and least (NZDep Q1) quintile of neighbourhoods, 2010–2019.



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Policy influence on asthma incidence

Various health-related policy measures were implemented over the period 2010–2019, some of which may potentially have exerted an influence on paediatric asthma hospitalisations. For example, lowering the age for free general practitioner (GP) care and changes in the asthma diagnosis protocol for children. Best practice guidelines for children aged <5 years presenting with wheeze changed in 2012, and they are now less likely to be diagnosed with, and therefore treated for, asthma than previously.[27] Other obvious policy candidates include extending free GP care in New Zealand to children age <13 years in 2016 and to <14 years in 2018, as well as the Warm Up NZ Healthy Homes programme, which started in 2009. Notably, neither a simple linear regression nor a nonparametric Loess regression could identify any obvious changes in the pattern of asthma admissions that align with the implementation of these notable public policies (Figure 12).

Discussion

We identified a 45% reduction in the number of hospitalisations attributed to asthma between 2010 and 2019, and the number of prescriptions attributable to asthma declined by 18% over the same period. There are clear inequities in the health outcomes of New Zealand children with asthma. To the extent that prescription patterns reflect primary care patterns and hospital admissions reflect shortfalls in primary care,[6] our analyses suggest that many New Zealand children are not receiving sufficient quality healthcare to optimise management of their asthma. Māori children and children living in the most deprived neighbourhoods receive more asthma-medication prescriptions; they are hospitalised more frequently with asthma; and they are readmitted with asthma more frequently than non-Māori children and those living in less deprived neighbourhoods. Seasonal fluctuations are also evident, further compounding these inequities, particularly in winter. However, the ratio of prescriptions to hospitalisations for asthma conditions is consistently lower for Māori children. This indicates asthma healthcare spending skews towards acute care for Māori. Other studies[28] on child health inequality in New Zealand (that have included a wider range of costs in their estimates) suggest that health sector spending is skewed towards non-Māori children despite evidence of greater Māori need. Our results are not inconsistent with this finding, although we have not assessed primary costs beyond prescriptions.

Table 2: Estimated direct costs of asthma treatment, children aged 0–14 years, 2010–2019.

	Asthma treatments, real direct costs, FY2019/2020, $m		
Treatment year	Hospital admissions	Prescriptions	Total cost
2010	$13.24	$6.44	$19.68
2011	$11.74	$6.30	$18.04
2012	$11.09	$6.36	$17.45
2013	$10.00	$6.28	$16.28
2014	$10.07	$6.53	$16.60
2015	$10.99	$6.30	$17.29
2016	$9.65	$6.28	$15.93
2017	$9.02	$6.21	$15.23
2018	$8.61	$5.77	$14.38
2019	$8.67	$5.08	$13.75
Total	$103.08	$61.56	$164.64

Figure 11: Per capita real costs of asthma treatment: hospitalisations and prescriptions for children of Māori and non-Māori ethnicity aged 0-14 years, 2010–2019.

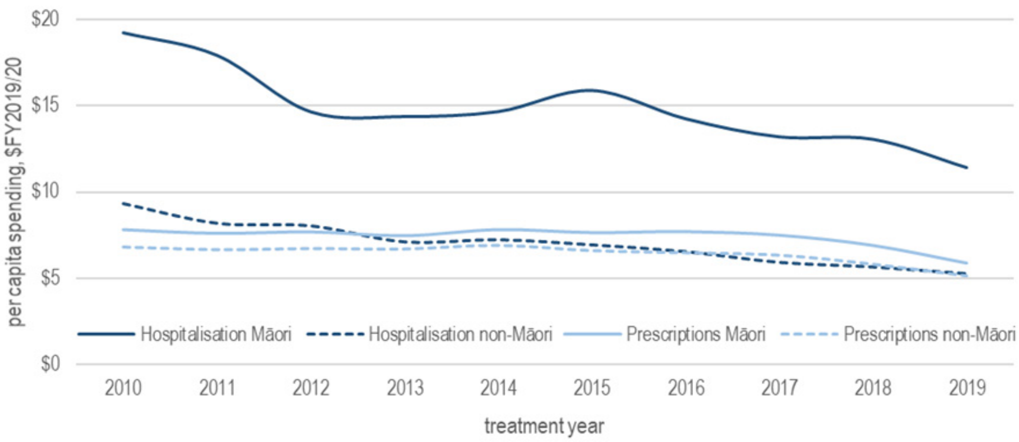
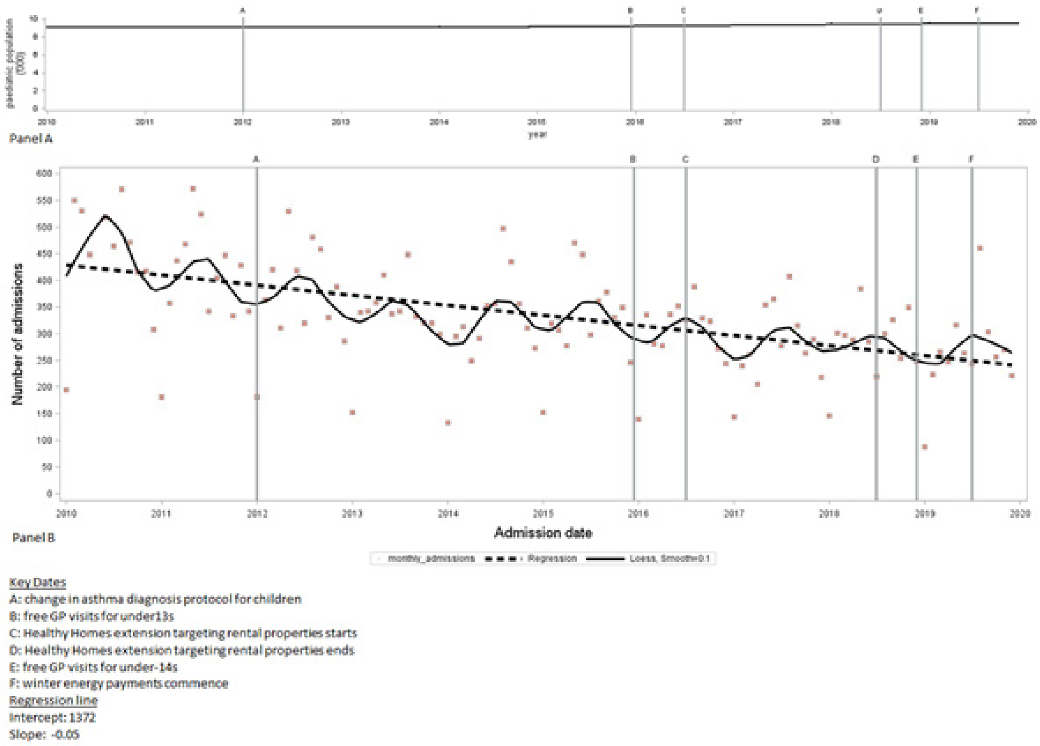


Figure 12: (Panel A) Paediatric population, children age 0–14 years. (Panel B) Monthly admissions to hospital with an asthma diagnosis, children age 0–14 years, and public health policy measures, 2010–2019. The scatter plot is fitted with a LOESS and linear regression curves.



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It is difficult to make comparisons across cost-of-illness studies, primarily because of differences in the types of costs included in the analysis. Telfar Barnard et al[12] estimated that childhood asthma cost $24.4m in 2011, of which $7.8m was for prescriptions and $7.6m for hospitalisations (total $15.4m). In calculating these costs, Telfar Barnard et al included (1) ‘wheeze’ in the asthma classification, (2) estimates for work-days lost and (3) GP visits. A 2015 repeat of this study[13] estimated that childhood asthma cost $78.3m, of which prescriptions accounted for $2.1m and hospitalisations for $7.4m (total $9.5m). Our estimates are broadly comparable to these studies for the 2011 treatment year but, in comparison to 2015, are $3.86m higher for prescriptions and $1.2m higher for hospitalisations. We contend that this is because Telfar Barnard et al[12,13] estimated and deducted the rebate given to pharmaceutical companies. As this information is not publicly available, we were unable to account for the rebate.

This study, while being comprehensive, suffers from a number of limitations. Specifically: (1) The administrative health data are not well-positioned to inform on sociodemographic factors beyond neighbourhood deprivation. (2) The pharmaceutical data captures prescriptions that were dispensed but cannot determine whether these medications were filled or taken. (3) Inhaled corticosteroids are front-line medications for asthma, and non-adherence to treatment, overuse of bronchodilators and underuse of inhaled corticosteroids are problem areas of management.[29] In addition, inhaled corticosteroids are sometimes inappropriately prescribed for respiratory tract infections.[30,31] Therefore, it is difficult to interpret medication prescribing data with absolute certainty. (4) Further, this study has not specifically addressed the role of combination therapy. A more detailed analysis that covers combination therapy may yield further important insights. (5) The pharmaceutical cost data do not include many of the dispensing costs and other payments to pharmacies and therefore underestimate the cost of supplying medicine to patients. (6) The actual price that PHARMAC pays for pharmaceuticals is confidential. PHARMAC negotiates rebates with manufacturers, and therefore the list prices in the pharmaceutical schedule will overestimate the cost of supplying medicine.

Despite these limitations, there is a clear and obvious disparity in asthma rates and prescriptions and hospitalisation for asthmatic children in New Zealand. Speculating on the causes of these disparities would almost certainly point to socioeconomic differences, inequalities in accessibility and perhaps unconscious bias in treatment approaches. However, speculation is insufficient. Although the causes will undoubtedly be various, they must be identified. Only then will we be able to tailor our response and address the equity problem that exists in the care for childhood asthma.

Appendix

Appendix Table 1: Classification of asthma medication in the PHARMAC pharmaceutical schedule.

Therapeutic Group 1	Reliever or Preventer	Therapeutic Group 2	Chemical name
Respiratory System and Allergies	Reliever	Beta-adrenoceptor agonists	Salbutamol
			Terbutaline
		Methylxanthines	Theophylline
		Anticholinergic Agents	Salbutamol with ipratropium bromide
			Ipratropium bromide
Hormone Preparations		Corticosteroids and related	Prednisone
			Prednisolone
Respiratory System and Allergies	Preventer	Inhaled corticosteroids	Fluticasone
			Beclomethasone dipropionate
			Budesonide
		Inhaled Long-acting Beta-adrenoceptor Agonists	Salmeterol
			Eformoterol fumarate
		Inhaled Corticosteroids with Long-Acting Beta-Adrenoceptor Agonists	Fluticasone with salmeterol
			Fluticasone furoate with vilanterol
		Anticholinergic Agents	Tiotropium
		Leukotriene receptor antagonist	Montelukast
		Mast cell stabiliser	Sodium cromoglycate
			Nedocromil
	Combination Drugs	Combination drugs	Budesonide with eformoterol
Oncology Agents		Immunosuppressants	Omalizumab

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Appendix Table 2: Purchase Units for events included in casemix funding, adapted from Ministry of Health.[20]

Financial Year	Medical & Surgical
1998/99	2,433.62
1999/00	2,399.22
2000/01	2,487.16
2001/02	2,479.01
2002/03	2,617.72
2003/04	2,728.55
2004/05	2,854.88
2005/06	2,949.09
2006/07	3,151.01
2007/08	3,740.38
2008/09	3,985.32
2009/10	4,315.48
2010/11	4,410.38
2011/12	4,567.49
2012/13	4,614.36
2013/14	4,655.43
2014/15	4,681.97
2015/16	4, 751.58
2016/17	4,824.67
2017/18	4,921.16
2018/19	5,068.12
2019/20	5,216.21
2020/21	5,545.26

Competing interests:

Nil.

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Author information:

Deborah Schlichting, Research Fellow, Liggins Institute, The University of Auckland, Auckland.

Tayaza Fadason, Research Fellow, Liggins Institute, The University of Auckland, Auckland.

Cameron C. Grant, Professor, Head of Department of Department of Paediatrics: Child and Youth Health, The University of Auckland, Auckland.

Justin M. O'Sullivan, Associate Professor, Deputy Director, Liggins Institute, The University of Auckland, Auckland.

Corresponding author:

Deborah Schlichting, Research Fellow, Liggins Institute, The University of Auckland, Auckland
d.schlichting@auckland.ac.nz

Justin M O'Sullivan, Associate Professor, Deputy Director, Liggins Institute, The University of Auckland, Auckland
j.m.osullivan@auckland.ac.nz

URL:

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