

Statewide prevalence of school children at risk of anaphylaxis and rate of adrenaline autoinjector activation in Victorian government schools, Australia

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Background: The prevalence of school students at risk of anaphylaxis in Victoria is unknown and has not been previously studied. Similarly, rates of adrenaline autoinjector usage in the school environment have yet to be determined given increasing prescription rates.

Objectives: We sought to determine time trends in prevalence of school children at risk of anaphylaxis across all year levels and the annual usage rate of adrenaline autoinjectors in the school setting relative to the number of students at risk of anaphylaxis. **Methods:** Statewide surveys from more than 1,500 government schools including more than 550,000 students were used and prevalence rates (%) with 95% CIs were calculated.

Results: The overall prevalence of students at risk of anaphylaxis has increased 41% from 0.98% (95% CI, 0.95-1.01) in 2009 to 1.38% (95% CI, 1.35-1.41) in 2014. There was a significant drop in reporting of anaphylaxis risk with transition from the final year of primary school to the first year of secondary school, suggesting a change in parental reporting of anaphylaxis risk among secondary school students. The number of adrenaline autoinjectors activated per 1000 students at risk of anaphylaxis ranged from 6 to 8 per year, with consistently higher activation use in secondary school students than in primary school students.

Conclusions: Statewide prevalence of anaphylaxis risk has increased in children attending Victorian government schools. However, adrenaline autoinjector activation has remained fairly stable despite known increase in the rates of prescription. (J Allergy Clin Immunol 2016;■■■:■■■-■■■.)

Key words: Prevalence, anaphylaxis, adrenaline autoinjector, school students

The incidence of anaphylaxis continues to rise in Australia, the United Kingdom, and the United States, with Australia having the highest population anaphylaxis admission rates.^{1,2} A recent study has shown that the overall trend in anaphylaxis admission rates in Australia has continued to accelerate, with the highest rates still occurring in children aged 0 to 4 years but the greatest fold-increase occurring in older children aged 5 to 14 years when comparisons were made across 2 time periods between 2005 and 2006 and 2011 and 2012.³

There have also been time trend increases in adrenaline autoinjector (AAI) prescriptions. During the period 1998 to 2006, the rise in AAI prescriptions was 650% in Australia alone, leading some experts to argue that the rise in AAI prescriptions was faster than the rate of increase in food allergy itself, raising questions about overprescription.⁴ Similar controversy regarding AAI overprescription has also been reported in the United Kingdom.⁵ However, it is also possible that AAIs were previously underprescribed and AAI prescriptions are now catching up to increasing rates of food allergy.

In 2008, the state government of Victoria, Australia, was among the first in the world to legislate anaphylaxis management plans in schools (Children's Services and Education Legislation Amendment [Anaphylaxis Management] Act 2008).⁶ This law required schools to implement an anaphylaxis management policy, which would include actively collecting information on how many enrolled students are at risk of anaphylaxis and development of an individualized anaphylaxis management plan for each such student. Using data systematically collected from the Victorian government schools' annual census, we aimed to examine the age and regional distribution and temporal trends in prevalence of school children at risk of anaphylaxis across all year levels. The annual usage rate of AAIs in the school environment was also captured and compared with the number of students at risk of anaphylaxis.

METHODS

Victorian school system

School education is compulsory in Victoria for children between the ages of 6 and 16 years and students attend school for a total of 13 years.⁷ Primary schools cater to children aged approximately 5 to 12 years over 7 years, with classes divided into Prep and Years 1 to 6. Secondary schools cater to children aged approximately 12 to 18 years over 6 years, with classes divided into Years 7 to 12. Approximately two-third of the population attends

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Abbreviations used

AAI: Adrenaline autoinjector

DET: Department of Education and Training

government schools, whereas the rest are in independent or private schools. Within the government school system, schools may be primary, secondary, combined primary and secondary (Prep to Year 12 schools), special schools, or language schools. In general, the primary school environment consists of a home class teacher teaching a variety of subjects and overseeing a set number of students in a class, whereas in the secondary school setting, each subject is taught by individual teachers and each secondary school student will have a number of different teachers.

Department of Education and Training (Department of Education and Early Childhood Development) school census survey

The Department of Education and Training (DET) (formerly the Department of Education and Early Childhood Development) is the management authority for all government schools in Victoria. With the implementation of the anaphylaxis legislation in 2008, yearly surveys or school census of government schools was administered from 2009 to 2014 (2012 affected by industrial action; thus, data on anaphylaxis were not available for all schools) with a series of questions regarding anaphylaxis. Each school collected data on individual grade levels (Prep to Year 12) from 2009 to 2013, whereas data from 2014 were reported in groupings of 4 cohorts (Prep to Year 2, Years 3-6, Years 7-9, and Years 10-12).

Data from the following questions were used in this study:

2009-2014

1. Does your school have any children diagnosed at risk of anaphylaxis/any students enrolled who report that they are at risk of anaphylaxis?
2. Indicate the number of students diagnosed/who report that they are at risk of anaphylaxis by year level.
3. Indicate the number of students who have an Australasian Society of Clinical Immunology and Allergy Anaphylaxis Management Plan, by year level (collected for 2013 only).

2010-2012

1. Has an AAI been used on a child or young person in the past 2 years?
2. What is the total number of AAIs used in the last 2 years?

2013-2014

1. Has an AAI been used on a child or young person in the past 12 months?
2. What is the total number of AAIs used in the last 12 months?

Individual schools collect these data on the basis of these DET questions from families of students and the school principal submits the information to DET. *Students at risk of anaphylaxis* are defined as those who have been prescribed an AAI by their health practitioner and accordingly have an Australasian Society of Clinical Immunology and Allergy Anaphylaxis Management Plan. AAI usage refers to AAI usage while the student is under the care of the school, which is recorded by the school. Data on AAI activation were not available for individual students or whether any particular student was responsible for multiple activations. A range of other information was obtained from the DET survey including school name, number of students per year level in the school, type of school, region (or location) of school, and Local Government Area (equivalent to city/shire council).

Statistical methods

Prevalence was calculated as the number of students at risk of anaphylaxis as a percentage of the total number of enrolled students, with 95% CIs calculated assuming a binomial sampling distribution. Temporal changes in

prevalence of students at risk of anaphylaxis were analyzed by both individual school year level (grade) and grouped by school grades within each calendar year. A further analysis using students only from combined primary-secondary schools (Prep to Year 12) was also performed on the basis of the assumption that students in combined schools are less likely to change schools when transitioning from primary to secondary levels, and that reporting might drop when starting a new school. To understand whether there are any differences in the prevalence of students at risk of anaphylaxis in terms of their geographical location, the analysis was also stratified by school location, defined as either urban (or metropolitan) or rural (or regional). Urban (metropolitan) or rural (regional) schools were classified by the school's location according to the Victorian Local Government Area as stipulated by DET.

The DET survey collected data on AAI usage from 2010 to 2012 by asking the number used in the past 2 years, whereas from 2013 to 2014 the survey collected data on the number used in the past 1 year. Taking this into consideration, the number of AAIs used per student at risk of anaphylaxis per year from 2010 to 2012 was calculated by dividing by 2 years. Microsoft Excel 2013 was used to collate and compile the DET survey data. Stata software (release 13.0; StataCorp, College Station, Tex) was used for all statistical analyses.

RESULTS

Prevalence of students at risk of anaphylaxis from 2009 to 2014

The total number of schools and students in Victorian government schools surveyed and the number of students at risk of anaphylaxis are tabulated in [Table I](#).

Overall prevalence of anaphylaxis risk across the years surveyed

The overall prevalence of students at risk of anaphylaxis has increased across the years surveyed from 2009 to 2014, with CIs not overlapping (χ^2 P value < .001; [Fig 1](#)). The exception was 2012, when the school survey was partially incomplete.

Temporal changes in prevalence across different grade levels (Primary school—Prep to Year 6 and Secondary school—Years 7-12)

The prevalence of students at risk of anaphylaxis decreases with increasing grade level (age cohort) of the student within each year surveyed from 2009 to 2013 ([Fig 2, A](#)). Temporal changes can be seen when the school grade levels were grouped according to individual calendar years in which the prevalence dropped in an almost step-like fashion with the commencement of secondary school (ie, Year 7). The CIs between primary school (end of Year 6) and secondary school (start of Year 7) prevalence are not overlapping ([Fig 2, B](#)). In the younger year levels (Prep to Year 2), there appeared to be an increase in prevalence between 2009 and 2011, whereas in the older year levels (Years 5 to 12), the prevalence increased further between 2011 and 2013. A similar trend was seen when the data were analyzed according to cohorts (Prep to Year 2, Years 3-6, Years 7-9, and Years 10-12) to allow comparison with the 2014 survey (data not shown). A subgroup (sensitivity) analysis of combined primary-secondary schools (Prep to Year 12) did not show the change or drop in prevalence from Year 6 to Year 7 (approximate number of combined schools, $n = 70$ with 40,000 students) (data not shown).

TABLE I. Summary of the number of schools surveyed and the overall prevalence of students at risk of anaphylaxis (%)

Summary variable	Year					
	2009	2010	2011	2012	2013	2014
Total no. of schools	1,575	1,550	1,538	1,535	1,525	1,524
Total no. of students	538,684	539,227	541,058	546,311	554,632	564,863
No. of students at risk of anaphylaxis	5,269	5,935	6,565	6,175	7,141	7,805
Overall prevalence of anaphylaxis risk (%)	0.98	1.10	1.21	1.13	1.29	1.38
(95% CI)	(0.95-1.01)	(1.07-1.13)	(1.18-1.24)	(1.10-1.16)	(1.26-1.32)	(1.35-1.41)

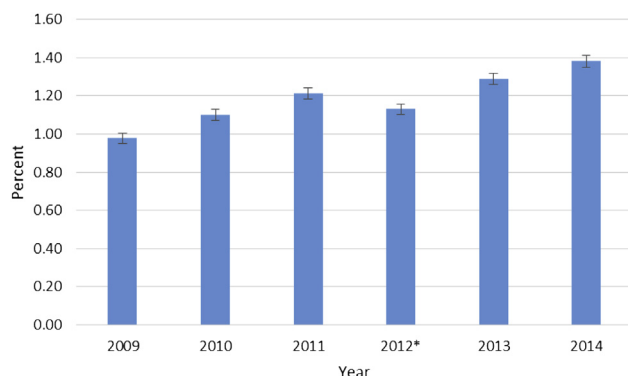


FIG 1. Overall prevalence (%) of students at risk of anaphylaxis from 2009 to 2014 (error bars, 95% CIs). (n = approximately 550,000 students per year, 1500 schools). Trend line generated from the data produced $R^2 = 0.86$. *Lower response rate in reporting the number of students at risk of anaphylaxis in the school census, which was affected by industrial action.

Comparison of prevalence between urban and rural schools

The general trend is similar for both urban and rural schools, where the prevalence decreases with increasing grade of the students within each calendar year surveyed whether or not they are in an urban or rural school with the stepped decrease in prevalence most dramatic at the start of Year 7. However, the prevalence in urban schools is higher than in rural schools in the early primary years of schooling, whereas the reverse is seen in later school years, that is, Years 10 to 12 (Fig 3).

Rate of AAI activation in the school environment

The number of AAIs activated from 2010 to 2014 was calculated and shown to be between 6 and 8 AAIs per year per 1000 students at risk of anaphylaxis (Table II). Although the annual rate of AAI usage appeared higher in rural schools from 2009 to 2012, with an apparent trend reversal in 2013 to 2014, the difference between rural and urban schools was significant only in 2011 and 2012. However, the number of AAIs used per year was considerably higher in secondary schools as compared with primary schools across all years from 2010 to 2014 (Fig 4).

DISCUSSION

The overall prevalence of students at risk of anaphylaxis in Victorian government schools has increased 41% over 6 years from 0.98% in 2009 to 1.38% in 2014. Within each calendar year, the prevalence of students at risk of anaphylaxis decreased with increasing age/sex level but there was a stepped drop with the

commencement of secondary school (ie, transition from Year 6 to Year 7). The prevalence of students at risk of anaphylaxis in urban schools is higher in the earlier school years as compared with rural schools but the reverse was observed in the later secondary school years (Years 11 and 12). We found that the number of AAIs activated per 1000 students at risk of anaphylaxis ranged from 6 to 8 per year, with usage in rural schools higher than in urban schools in the period 2009 to 2012 and a reversal in this trend in the period 2013 to 2014. However, the number of AAIs used per 1000 students at risk of anaphylaxis was significantly higher in secondary schools as compared with primary schools.

The strengths of this study include the very large number of students surveyed (~550,000), with a large cohort of schools (~1,500) covering all Victorian government schools throughout the whole of the state. Our study allows for the comparison of urban versus rural differences because schools in all regions were included. Furthermore, the data were gathered annually over a long period (from inception of the school census in 2009 until 2014) so that temporal changes can be examined. Because the school census questionnaire was compulsory, we expect minimal bias due to nonparticipation.

Some of the potential limitations of this study include the limited number of questions asked on anaphylaxis in the school survey, and the fact that only Victorian government schools were included. However, this includes the bulk of the students in Victoria (at least 60% of all school students). Because there are no surveys that are similar for independent or private schools, we would not be able to comment on nongovernment schools. Furthermore, our prevalence findings are likely to be conservative, because private school students may be from higher socioeconomic backgrounds and be more likely to access medical care. The census questions varied slightly throughout the years but were still sufficiently comparable for the purpose of this study. Another limitation is that there are no data available on the trigger of the AAI activation and the clinical scenario surrounding the usage of the AAIs in the school environment. Although schools in Victoria have unassigned AAIs (also known as AAIs for general use), these were implemented only in April 2014.

Despite increasing rates of food allergies and anaphylaxis, prevalence data are limited and are often complicated by different methodologies, with much heterogeneity seen in self-reported food allergy including a range of 0.1% to 6.0% of allergy to common foods in systematic analyses of European studies.^{8,9} A meta-analysis of 34 studies has found that the incidence of hospital admissions related to food anaphylaxis was the highest in young children aged 0 to 4 years.¹⁰ The Australian HealthNuts study has shown that infants at 12 months of age have more than 10% prevalence rate of challenge-proven IgE-mediated food allergy. However, follow-up studies in progress at age 4 and

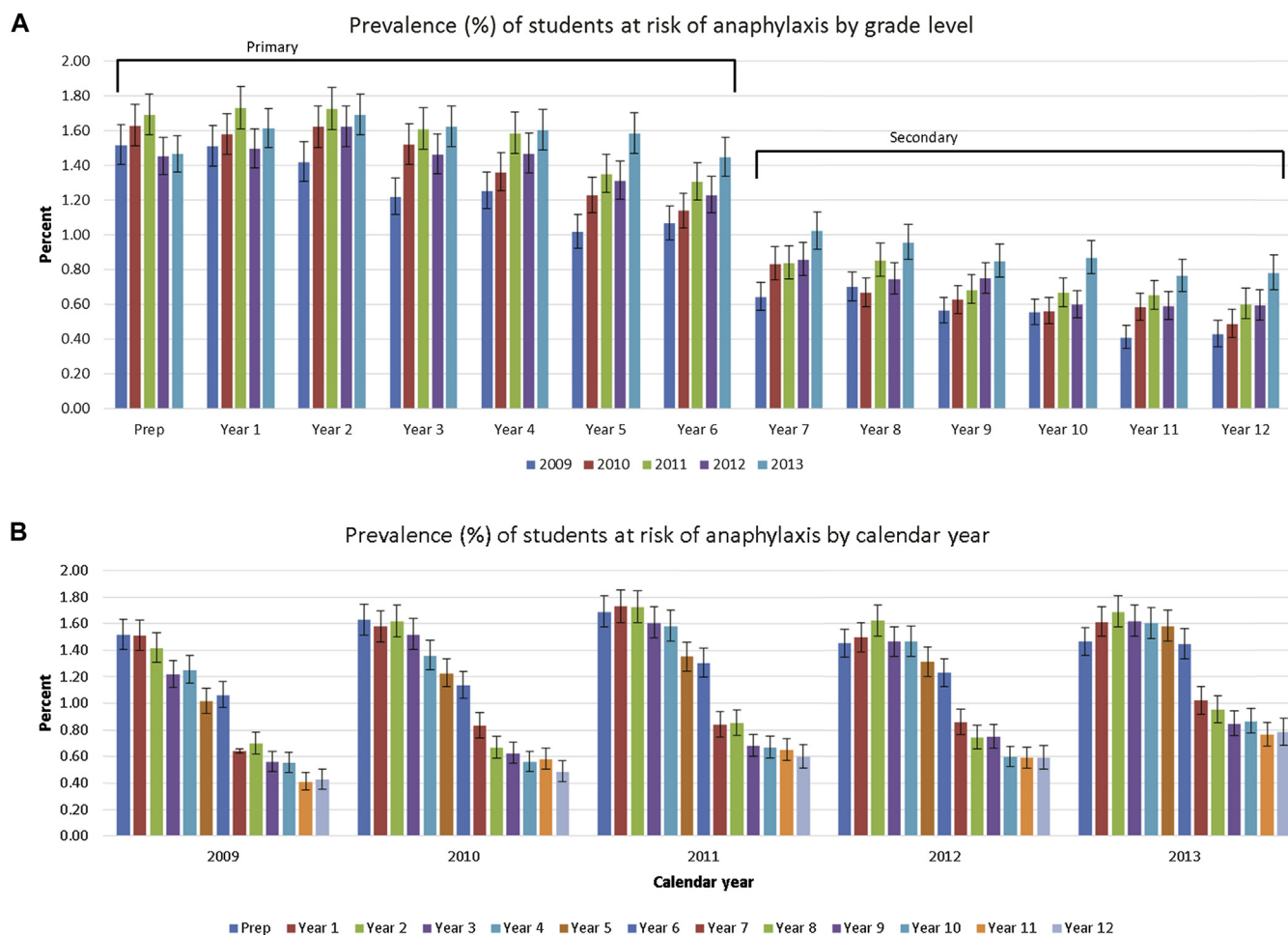


FIG 2. Prevalence (%) of students at risk of anaphylaxis. **A**, By individual school year level (grade) from 2009 to 2013 (error bars, 95% CIs). **B**, Grouped by school grades within each calendar year (2009-2013) (error bars, 95% CIs).

6 years^{11,12} are already showing significant food allergy resolution by school age. For example, the prevalence of peanut allergy was 3% at age 1 year but had resolved in 22% of cases by age 4 years.¹³

The treatment of anaphylaxis is the timely administration of intramuscular adrenaline, which is usually in the form of an AAI in the community setting.¹⁴ In anaphylaxis and AAI usage studies, a survey of 14 pediatric allergy clinics in the United Kingdom revealed that an AAI was used by only 16.7% of the participants (41 of 245, mean age 8 years) who had experienced an anaphylaxis event in the community in the previous year.¹⁵ The EpiPen4Schools pilot survey involving 6019 schools in the United States also revealed that an AAI was used in 74.7% of 851 anaphylaxis episodes that occurred in 607 schools over one school year from 2013 to 2014.¹⁶ This study did not have details on the total number of students and it is difficult to compare the AAI usage rate, except to note that it is possible that in the school environment, anaphylaxis might be better recognized and an AAI used more appropriately than in the community (as compared with the UK study). However, none of these surveys has details on the number of students already at risk of anaphylaxis. Using the UK study's rate of AAI utilization during episodes of anaphylaxis, and extrapolating this to the number of AAIs used

per 1,000 students at risk of anaphylaxis (6-8 per year) in our study, the actual events of anaphylaxis could be up to 4 to 5 times higher than anticipated. As such, the rate of AAI utilization is likely to underestimate the rate of severe reactions in schools and the true rate of anaphylaxis could be up to 40 cases per 1,000 students at risk of anaphylaxis per year. In a study of 798,762 school students in Massachusetts, there were 115 administrations of adrenaline over a 2-year period from 2001 to 2003.¹⁷ This survey did not report on the number of students who were diagnosed with or identified to be at risk of anaphylaxis. Given that their total number of students was about a third more than the number of Victorian government school students and assuming that their prevalence of students at risk of anaphylaxis is 1%, the number of AAIs used per year equates to 7.2 AAIs per 1,000 students at risk of anaphylaxis and this would be comparable to our study.

As described earlier, having an AAI does not necessarily mean that it will be used in the appropriate situation. The low rates of AAI usage in Victorian government schools per student at risk may reflect the failure to use such devices when required or that strict risk minimization strategies in school have limited accidental exposure and reactions to allergens, or both. It is well known that AAI prescription rates have risen faster than the

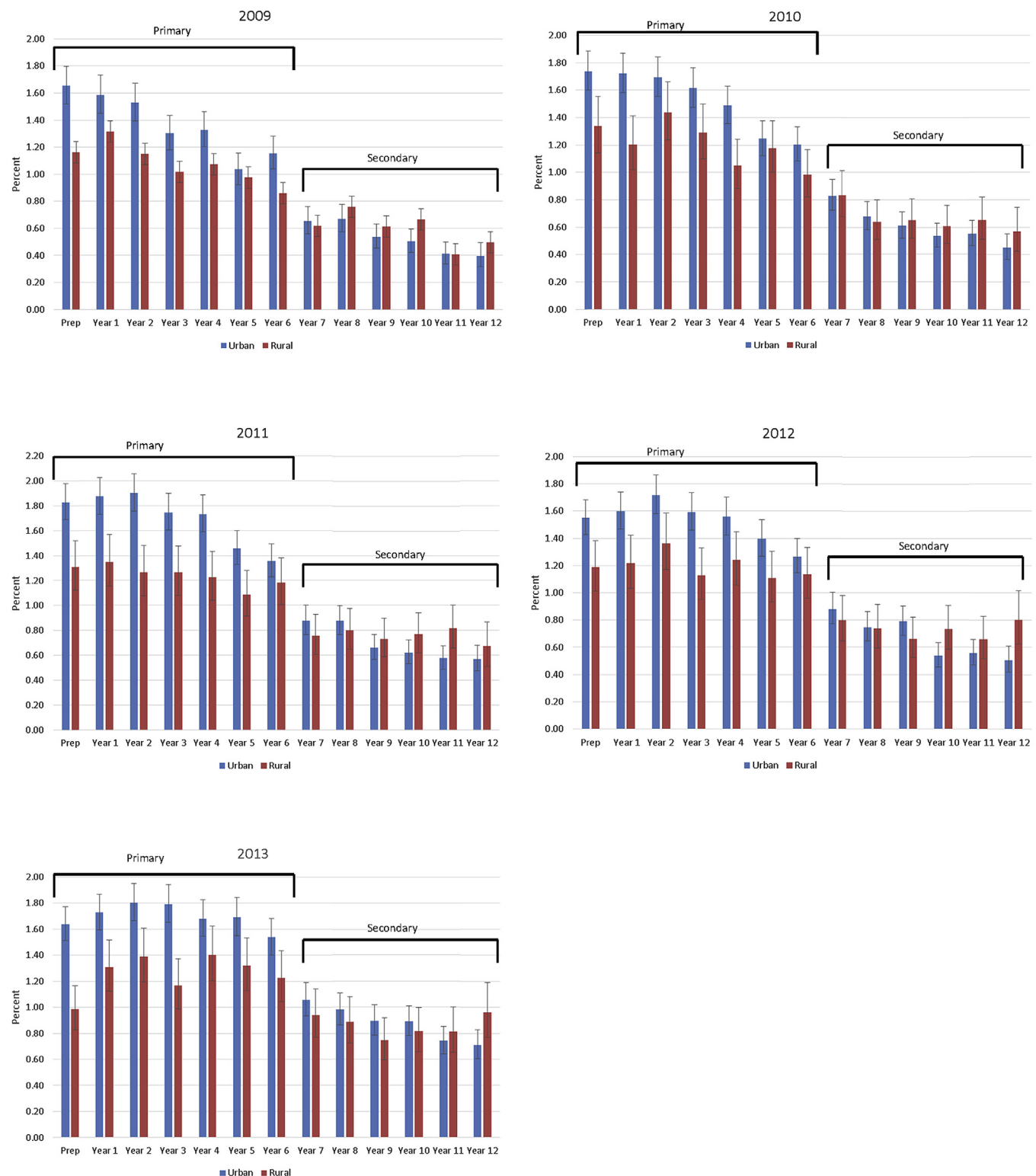


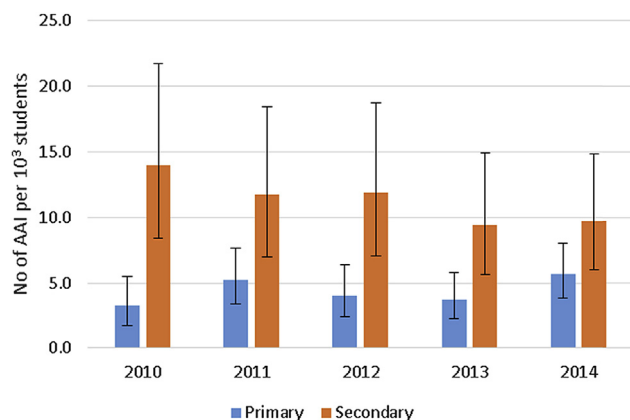
FIG 3. Prevalence (%) of students at risk of anaphylaxis compared by urban versus rural schools by grade level for each year from 2009 to 2013 (error bars, 95% CIs).

food allergy rates in Australia and this has been referred to as an “AAI epidemic” that is costing the health system millions of dollars.^{4,18} The number of prescriptions for the predominant AAI in Australia (EpiPen and EpiPen Jr) was 73,689 in 2011 as

compared to 35,657 in 2006, representing more than a 100% increase in the use of these devices.^{18,19} Furthermore, carrying an AAI can generate anxiety and reduced quality of life²⁰ and recommending an AAI is insufficient because both education

TABLE II. Number of AAI's activated (used) per student at risk of anaphylaxis

Comparison variable	Year				
	2010	2011	2012	2013	2014
No. of students at risk of anaphylaxis	5935	6565	6175	7141	7805
No. of students at risk of anaphylaxis in urban schools	4361	4923	4589	5428	5931
No. of students at risk of anaphylaxis in rural schools	1574	1642	1586	1713	1874
Total AAI's used per year	36.5	46	40	41	66
No. of AAI's used in urban schools	22.5	27.5	23	33	55
No. of AAI's used in rural schools	14	18.5	17	8	11
No. of AAI's used per 1000 students at risk of anaphylaxis (95% CI)	6.1 (4.4-8.6)	7.0 (5.1-9.3)	6.5 (4.6-8.8)	5.7 (4.2-7.8)	8.5 (6.5-10.7)
No. of AAI's used per 1000 students at risk of anaphylaxis in urban schools (95% CI)	5.2 (3.3-7.9)	5.6 (3.8-8.2)	5.0 (3.2-7.5)	6.1 (4.2-8.5)	9.3 (7.0-12.1)
No. of AAI's used per 1000 students at risk of anaphylaxis in rural schools (95% CI)	8.9 (4.9-14.9)	11.3 (7.0-18.0)	10.7 (6.3-17.1)	4.7 (2.0-9.2)	5.9 (2.9-10.5)
<i>P</i> value for comparison of urban vs rural schools	.12	.014	.015	.50	.16
No. of AAI's used in primary schools	14.5	25.5	18.5	19	31
No. of AAI's used in secondary schools	19.5	18.5	18	18	21
No. of students at risk of anaphylaxis in primary schools	4432	4889	4552	5119	5475
No. of students at risk of anaphylaxis in secondary schools	1393	1576	1511	1906	2160
No. of AAI's used per 1000 students at risk of anaphylaxis in primary schools (95% CI)	3.3 (1.9-5.6)	5.2 (3.5-7.8)	4.1 (2.5-6.5)	3.7 (2.2-5.8)	5.7 (3.9-8.0)
No. of AAI's used per 1000 students at risk of anaphylaxis in secondary schools (95% CI)	14.0 (8.8-22.1)	11.7 (7.3-18.8)	11.9 (7.1-18.8)	9.4 (5.6-14.9)	9.7 (6.0-14.8)
<i>P</i> value for comparison of primary vs secondary schools	<.001	.005	.001	.003	.052

**FIG 4.** Number of AAI's activated per student at risk of anaphylaxis compared by primary versus secondary schools (2010-2014) (error bars, 95% CIs).

and allergen avoidance are essential. As such, using the low rates of AAI usage in the school environment as a surrogate marker of anaphylaxis rates, it can be argued that prescribing guidelines may need to be further tightened rather than proper allocation of health resources because overprescription is fueling an AAI epidemic.

The drop in prevalence when students reach the secondary school environment may reflect a change in parental reporting of anaphylaxis risk, rather than a biological phenomenon. This is strengthened by our subgroup analysis that showed that this drop is not seen in combined primary-secondary schools, assuming that students in these schools are less likely to change schools. Although it could also be the shift of students from government schools in the primary years to private or independent schools in

the secondary years, the subgroup analysis that showed no drop in combined schools would suggest otherwise. Thus, when students transit from primary to secondary schools, it may lead to underreporting of anaphylaxis risk in their new school and if this is true, it is a matter of concern and may have both public health and clinical implications because adolescence is a period of increased risk-taking behavior.²¹ This is also supported by the finding that AAI usage is higher per student at risk in secondary schools versus primary schools, and it suggests less vigilance in allergen avoidance, decreased parental supervision, and increased risk-taking activities. Furthermore, it is possible that attitudes by other students may lead to underreporting of anaphylaxis risk. Previous studies have found that bullying is common in children with food allergy, with most of these episodes occurring in the school setting.^{22,23} Another possibility is that the risk of anaphylaxis is overreported in primary school students and more accurately reported in secondary school students although this is less likely.

The reversal in prevalence between urban and rural schools from early to later school years may be associated with reduced access to health care for rural patients, with the result that regular reviews with a specialist to address their allergies may not have taken place in later years, leading to failure to diagnose tolerance in previously allergic children. In contrast, it is also possible that there is an overdiagnosis of risk of anaphylaxis in urban students due to their ease of access to medical services. Although there is no study directly examining differences in access to food allergy specialists between urban and rural settings in Australia, Mullins et al²⁴ found that the sale of infant hypoallergenic formula and EpiPens (per 100,000 population) was higher in major cities than in remote regions in Australia.²⁴ However, there was no relationship found in that study between access to medical practitioners, allergists or number of retail pharmacies, and

EpiPen prescription rates, suggesting that there seems to be no regional differences in health care access for allergy in Australia.²⁴

It is also conceivable that our study will help improve future data collection from the annual school census by streamlining more targeted questions regarding anaphylaxis, including standardization of key questions. Additional questions such as the type of allergen that the student may be at risk of anaphylaxis to and the setting or scenario in which the AAI was used can be included and, together, this may contribute toward improved health policy management in the longer term. In conclusion, statewide prevalence of all Victorian government school children at risk of anaphylaxis increased. This study also demonstrated the utility of using the annual school census to obtain useful epidemiological data in examining a large number of students and raises the possibility that this should be extended nationwide.

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Key messages

- Statewide prevalence of children at risk of anaphylaxis has increased 41% over a 6-year period in government schools across Victoria.
- There was a significant drop in declaration of anaphylaxis risk when school students transit from primary to secondary schools. This is a matter of concern because it possibly reflects underreporting of risk and may result in increased risk-taking behavior during the adolescent period.
- Stable rates of AAI activation occurred despite increased prescription rates, suggesting either overprescription or underutilization of these devices.

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