Geographic correlation between nonmedical exemption rates in Arizona kindergarten classes and rates of community pertussis infection

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ABSTRACT

Every state in the US mandates vaccinations for all children prior to school entry. However, many states, such as Arizona, permit nonmedical exemptions (NMEs), and thus, communities with high levels of NMEs may be more vulnerable to outbreaks of vaccine-preventable diseases. The objective of this study was to detect spatial clusters of pertussis cases and kindergarten NMEs of DTaP vaccine in Arizona. Data detailing kindergarten NMEs for each AZ school in the 2012-13 and 2013-14 school years and pertussis cases during those years were obtained from the Arizona Department of Health Services (AZDHS). Using a purely spatial analysis with Poisson probability model, areas with high rates of pertussis or NMEs were identified. The current analysis is insufficient to support an association between NME frequency and pertussis outbreaks within these time periods. Further studies with larger datasets are ongoing.

INTRODUCTION

With the elimination of highly infectious diseases such as smallpox, diphtheria, and polio, vaccines have proven to be one of the greatest public health achievements. Some of the most crucial policies in managing vaccine-preventable diseases have been school immunization requirements. Forty-seven states permit either religious or personal belief exemptions, collectively referred to as non-medical exemptions (NMEs).

Vaccine compliance is of particular importance with regards to the pertussis vaccines, which have been shown to be only 70-90% effective. Because of this lower efficacy, the threshold level of immunization required to achieve herd immunity is higher than for the other vaccines—at least 95% of the population. Retrospective analyses of NMEs in both Michigan and California have demonstrated that geographic clusters of high NME rates overlapped with clusters of pertussis cases. An earlier study in Colorado similarly showed that frequency of measles and pertussis outbreaks in a county was associated with rates of exemption. However, incidences of pertussis have yet to be geographically correlated with NMEs in Arizona, which is among the more lenient states regarding NME procedures, requiring only a form signed by a parent.

METHODS

Data detailing NME rates in Arizona kindergarten classes from the 2012-13 and 2013-14 school years are available through publicly accessible AZDHS databases, as are data concerning probable and confirmed pertussis cases. Reported cases and school addresses were geocoded and aggregated to census tracts prior to analysis.

A Poisson probability model was used to determine significant clusters of NMEs and of pertussis. Candidate spatial clusters of events were identified, and a likelihood ratio statistic was calculated for each. A parameter was set to 50% or more of the population being at risk without restricting the radius. The output files of the clusters were examined to remove extremely large clusters (> 50-kilometer radius) and those extending beyond state borders. The odds ratio was calculated for a census tract being in both a pertussis cluster and a NME cluster versus a tract being in a pertussis cluster but not a NME cluster. Identified clusters and associations were considered significant with reference to $\alpha = 0.05$.

RESULTS AND DISCUSSION

During the 2012-13 and 2013-14 school years, the geographic overlap between clusters of kindergarten NMEs and pertussis cases was not found to be significant in either year (Figure 1). We compared the number of census tracts with high versus low risk of occurring within NME and pertussis clusters (Table 1). In 2012-13, the overall probability for a census tract having a higher pertussis risk was 0.81 and a higher NME risk was 0.57. In 2013-14, the probability was 1 for pertussis and 0.55 for NME. The correlation between NME and pertussis risks was not significant in either year.

We were unable to determine a significant correlation between high-risk clusters of pertussis and high-risk clusters of NMEs. Due to the lower efficacy of pertussis vaccines and their potentially waning effects relative to the other pediatric vaccines, some of these outbreaks may have been unavoidable. Since kindergarten NMEs vary from year to year, it is possible that these NME rates are not reflective of those in the community.

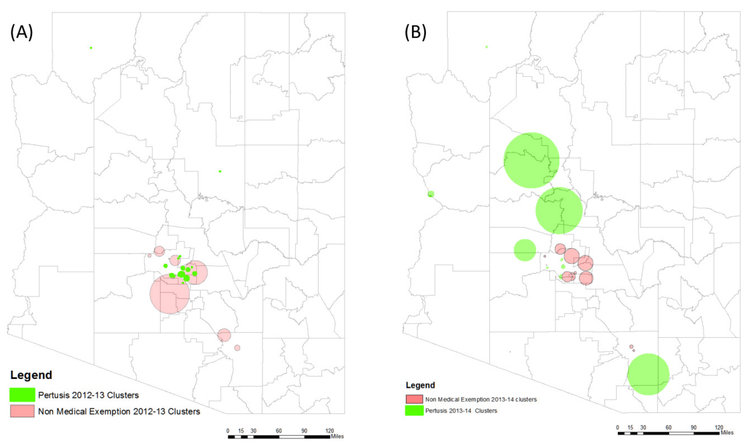

Figure 1. Geographic clusters of increased relative risk of pertussis and of NMEs in Arizona census tracts in (A) 2012-13 and (B) 2013-14 school years

(A)

		Pertussis risk		
		High	Low	
NME risk	High	105	27	132
	Low	83	17	100
		188	44	232

(B)

		Pertussis risk		
		High	Low	
NME risk	High	89	0	89
	Low	73	0	73
		162	0	162

Table 1. Comparison of high versus low relative risk of a census tract occurring within a pertussis or NME cluster in (A) 2012-13 and (B) 2013-14

Several known outbreaks occurred near the northern border, and these were excluded from this analysis because the calculated areas of the clusters were too large or crossed state boundaries. The areas occurring within some of these clusters could have had a significant impact on the final results. In our follow-up study analyzing data from 2012-2016, we will explore different methodologies to include more of the clusters that affect the state of Arizona.

CONCLUSIONS

The current analyses do not support an association between kindergarten NME frequency and pertussis outbreaks within these time periods. Clusters of both NMEs and pertussis cases were located in different regions each year. Since the results of this study have thus far been non-significant, Arizona-specific evidence on the relationship between NMEs and pertussis is still not conclusive. However, the pertussis vaccines have been demonstrated to offer protection against *B. pertussis* in clinical trials, which still suggests that higher vaccination rates would confer greater protection to a population overall.[25] Further studies with larger datasets will be important in elucidating the spatial distribution of pertussis cases and NMEs, and we will also attempt analysis that includes key clusters that were previously excluded.

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