

Epidemiologic and Social Determinants of *Bordetella pertussis* Infection in New Mexico

Pertussis, commonly known as whooping cough, is a highly contagious respiratory disease characterized by a prolonged paroxysmal cough, frequently accompanied by an inspiratory “whoop”, post-tussive vomiting, or apnea (among infants). In recent years, the United States has reported elevated rates of pertussis, and New Mexico has experienced even higher incidence rates than the national rate since 2011, when NM became one of seven sites nationally to participate in population-based surveillance as part of the Emerging Infections Program (EIP). Risk factors for pertussis infection include having limited or no immunity (e.g. vaccination), age, and among infants, Hispanic ethnicity. There have been no comprehensive analyses of neighborhood level risk factors and pertussis incidence, however.

Increased attention is being turned toward analyzing risk factors for infectious diseases at the geographic level¹ and several studies have demonstrated the usefulness of identifying neighborhood-level risk factors for infectious diseases.²⁻⁴ Using area-based socioeconomic measures allows for a more direct understanding of how socioeconomic risk factors affect disease transmission and/or infection.⁵⁻⁶ The purpose of this analysis was to identify socioeconomic and demographic characteristics to describe populations at risk of pertussis infection in New Mexico and inform strategies for prevention.

Methods

All probable and confirmed cases (n=2128), as defined by the Council of State and Territorial Epidemiologist (CSTE) case definition, reported to the New Mexico Department of Health (NMDOH) between 2012-2015 were included in this analysis. Cases were geocoded according to the NMDOH address-geocoding protocol and procedures, aggregated to the census tract level using ArcGIS 10.3.1 software, and linked to census-level demographic data from the American Community Survey (ACS) 2009-2014 and 2010 US Census

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Summary File 1. The majority of cases were geocoded, n=2049 (96.3%), and the 79 cases that were excluded due to inability to geocode were not significantly different by age, race/ethnicity or gender.

Incidence rates with 95% confidence intervals were calculated by age group and year of infection. X² tests were performed on categorical demographic and clinical variables (age, sex, pregnant, urbanicity (assigned as metropolitan, small metropolitan, mixed urban-rural, and rural according to NMDOH classifications), and vaccination status, both overall and stratified by race/ethnicity. White refers to non-Hispanic White. Based upon the methodology described by the Public Health Disparities Geocoding Project,⁵ direct age-adjusted incidence rates with 95% inverse gamma confidence intervals were calculated for social determinants including poverty, female head of household, educational attainment, and household crowdedness. Poverty level was divided into 4 categories: <9.9% of census tract residents below poverty threshold, 10- <19.9%, 20- <29.9%, and 30% or more. This differs from federal definitions for high poverty areas,⁶ but these were chosen because they better represent New Mexico's high poverty environment. Crowding was defined as the percentage of households with more than one occupant per room. Neighborhood crowding and female head of household variables were divided using quartiles for distribution in New Mexico.

Results

The overall incidence of pertussis among cases reported to NMDOH decreased from the recent peak of 42.8 per 100,000 in 2012 to 11.7 per 100,000 in 2015 (Figure 1). Across all years, children (0-17 years) had significantly higher rates than adults (68.7 vs. 10.9 per

100,000), and infants had greater than twice the overall rate (140.2 vs. 68.7 per 100,000).

AIAN pertussis cases had a significantly larger mean household size compared to Hispanics and Whites (5.5 household members vs. 4.8 and 4.1 ($p=0.05$)) and were more likely than Whites to be up-to-date on pertussis vaccination (65% vs. 53%). White cases were more than twice as likely as AIAN and Hispanics to be unvaccinated (13% vs 1.6% and 5%, respectively).

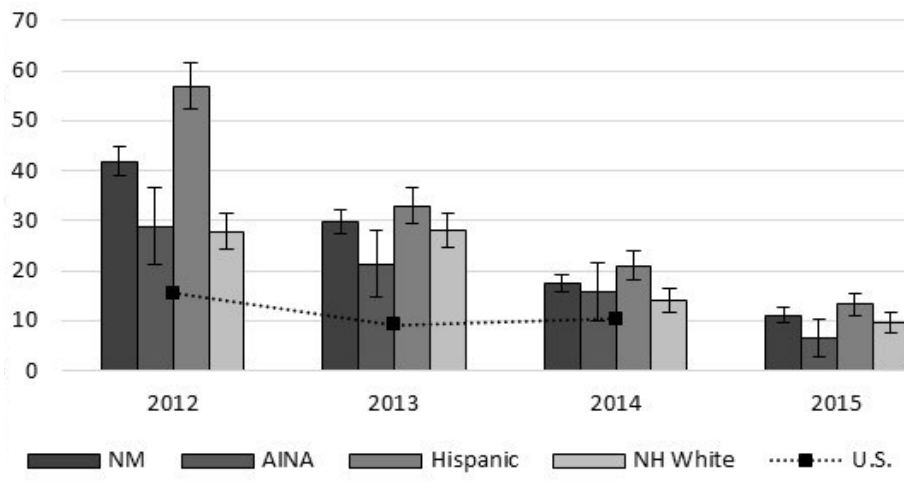
Overall incidence decreased with higher poverty levels (Figure 2). Those in the lowest poverty category had a higher incidence of disease (29.6 per 100,000 person-years), although the next three poverty categories had similar overall rates and overlapping confidence intervals (19.1, 18.6, and 17.2 per 100,000 person-years for medium low, medium high, and high poverty categories) (Figure 2). In crowdedness categories, the highest overall incidence (29.4 per 100,000 person-years) is in the lowest crowding categories (Figure 3). Trends among female head of household show a mixed picture by race/ethnicity (Figure 4). Urban residents had higher rates than rural residents, except among American Indians/Alaska Natives.

Discussion

This was an exploratory analysis to determine if there were neighborhood level risk factors associated with pertussis cases in New Mexico. Overall, incidence decreased among groups with lower poverty and crowding, particularly for White and Hispanic populations. There was higher incidence among urban residents than rural, although American Indians/Alaska Natives did not conform to this trend. These results contrast with many previous studies suggesting a positive relationship between increased percentages of the population living below poverty and incidence of infectious disease,²⁻⁴ and a similar relationship between poverty and death in New Mexico.⁷

The lack of association between poverty and pertussis incidence may be a result of a variety of causes. One such factor may be differential usage of medical systems. If those in lower socioeconomic strata are less

Figure 1. Pertussis Incidence by Year, Stratified by Race/Ethnicity, NM, 2012-2015



likely to seek care, it may artificially underestimate the rates of pertussis incidence. Lower rates may also be due to differential provider practices. If providers who serve low SES communities are less likely to perform lab-confirmation or inquire about epi-linkage, there may be under-ascertainment of cases compared to doctors who serve higher SES neighborhoods. Although no information is available on pertussis testing specifically, previous studies have shown that patient socioeconomic status affects providers' ordering practices for other types of laboratory testing.⁸ Previous studies on infectious diseases have also shown that rural residence is a risk factor for delaying care.⁹ A final explanation may also be that there are differences in vaccination practices by socioeconomic status – those in lower socioeconomic strata may be less likely to be vaccine exemptors, for example.

This study has several limitations. Neighborhood characteristics may not apply to individuals represented in this study; it is important not to infer individual characteristics. These variables do, however, provide valuable insight into the types of neighborhoods which are disproportionately affected by pertussis. 2010 Census data was used instead of IBIS denominators in order to allow this methodology to be replicated across Emerging Infection Program sites. The decennial census is recommended by both the Harvard Public Health Geocoding Protocol and the CSTE geocoding guidelines,⁵ however experience in NM shows that IBIS denominators are a more accurate reflection of New Mexico's population. In addition, census tracts were classified as

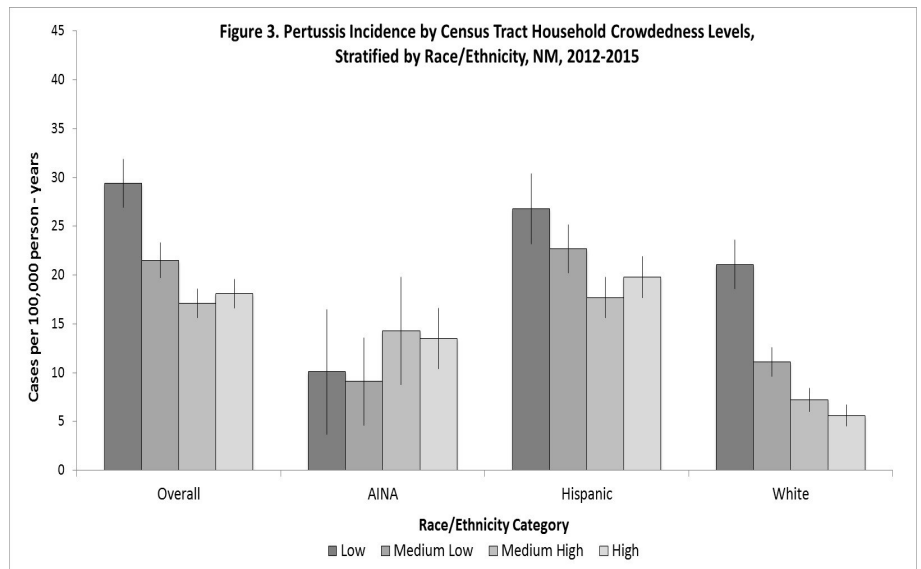
metro, small metro, mixed urban/rural, and rural according to NMDOH classifications of the counties they fell within, not according to the census tract level. Therefore, this data may not be as granular as other measures.

Future studies should examine the diagnosing and testing practices of practitioners in New Mexico, in order to determine whether rates differ by socioeconomic status of the patient. If those in high poverty census tracts are either not seeking care as frequently, or are being underdiagnosed by providers, this represents an opportunity for intervention. Education about symptoms and potential consequences of pertussis may help people understand when to seek care. Targeted education of providers may help patients get the care they need or promote lab-confirmation of cases for improved surveillance.

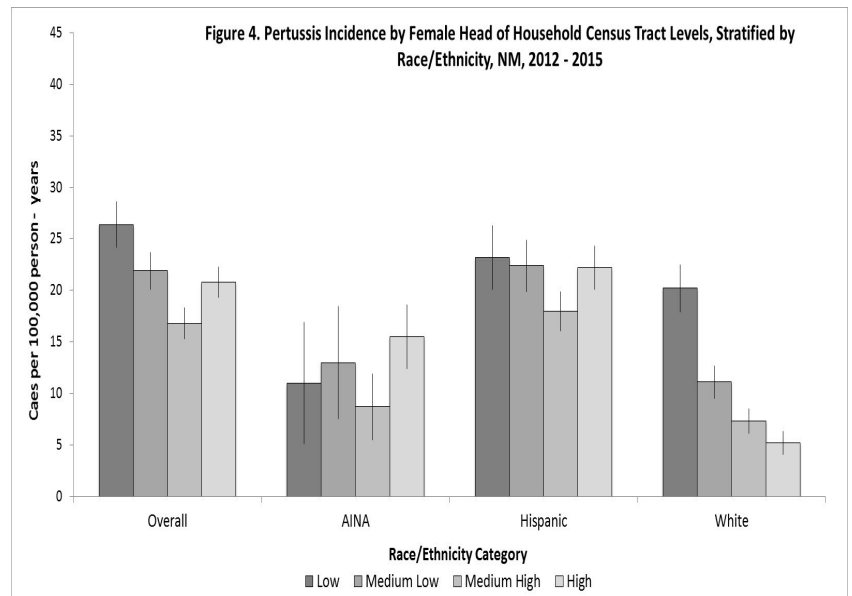
This study suggests new and interesting information about the burden of pertussis in New Mexico: mainly, that the burden of pertussis may not be related to neighborhood level poverty and crowdedness status. Further monitoring and analysis is necessary to determine whether these trends are accurate or are an artifact of differential practices or data gathering. Further study is needed to determine key areas for planning and prevention.

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Figure 2. Pertussis Incidence by Census Tract Poverty Levels, Stratified by Race/Ethnicity, NM, 2012-2015

