Original Research

Density of day cares in relation to reported pertussis incidence in Philadelphia

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ABSTRACT

Objectives: Reported pertussis incidence has increased markedly in recent years. In addition to the documented increase in under-immunization and waning immunity, the increase may be related to the more frequent use of child care services by parents over the last few decades. Additionally, clustering of outbreaks may be related to neighborhood characteristics not previously identified.

Study Design: We conducted a citywide case–control study of children in Philadelphia aged birth through six years, between 2001 and 2013. Cases were reported as probable pertussis diagnoses to the Health Department. Controls were sampled from the city's immunization information system and matched to the cases by date of birth.

Methods: Multilevel logistic regression was used to isolate the independent contributions of individual and neighborhood risk factors and the corresponding relative odds of pertussis. The density of day cares in each neighborhood served as the main exposure and reported incident cases of confirmed and probable pertussis was the main outcome.

Results: Between 2001 and 2013, 410 cases of confirmed and probable pertussis were included with four controls matched per case yielding a final sample of 2050 children from 45 Philadelphia neighborhoods. There was a 30% increase in the risk of pertussis based solely on the neighborhood where the children resided (median odds ratio 1.3, 95% credible interval 1.1, 1.6). The density of day cares in each neighborhood was unrelated to the distribution of pertussis cases.

Conclusions: Pertussis clustering was observed at the neighborhood level in Philadelphia, but was unrelated to the neighborhood's day care density. From a Health Department perspective, the highest risk neighborhoods should be targeted for vaccine campaigns and further research to identify the etiologic risk factors.

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Introduction

With parental shifts in employment over the last few decades, day care enrollment as well as the number of facility options in a community have both increased.[1] Within these day care facilities, children, teachers, and parents congregate, providing an opportunity for transmission of highly contagious diseases. In a study undertaken by the National Institute of Child Health and Human Development investigators observed a direct link between the rates of communicable disease and use of out-of-home child care,[2] and a follow-up study demonstrated the risk is magnified based on the number of children in the day care.[3] The recent increase in respiratory infectious diseases, such as pertussis, may be partially attributable to this occurrence, especially if the children are unimmunized or underimmunized.[4,5] Vaccination against pertussis, a multi-dose series started around two months of age and completed by age six years, means that children enrolled in day cares at younger ages have potentially vulnerable immune systems, as the full series may not be completed. Although some immunologic benefit occurs from receiving fewer doses, optimal protection is conferred from completion of the primary series.[6]

A review of vaccine-preventable infectious diseases in day cares noted that the average age of children enrolled in day care was decreasing, while immunization coverage was increasing.[7] Yet two recent studies found evidence that pertussis outbreaks can occur in these congregant settings despite high vaccination coverage, and further that vaccinated children can be asymptomatic carries of the pathogen.[8,9] While literature is scant on the relationship between day care attendance and pertussis, these two studies from Israel underscore the importance of not only proper vaccination for children and adults within the day care environment, but also protection for the community at large as these children interact within their neighborhoods.

Few studies have been conducted that consider day care attendance as the primary exposure and pertussis as the outcome, and to our knowledge no study has examined the relationship between prevalence of day care facilities and community risk of disease. This disease is of particular interest as there has been a sharp increase in cases over recent years. To demonstrate a correlation between day care use and community infection, the key assumption is that the community uses local day care. A 2013 review of child care decision making processes noted both 'accessibility of providers is [...] a strong correlate of child care choices' and travel beyond the local community for day care was often 'unmanageable,' particularly for low income families.[10] One potential measure of accessibility is through a day care density metric, which allows for neighborhoods with more day cares per area to have a higher level of exposure. This implies potential for increased use by the local residents and more sources for pathogen transmission. In this study, we sought to examine the interplay between Philadelphia neighborhood and pertussis risk, with specific focus on day cares as the risk factor of interest. Our hypothesis was that neighborhoods with a greater density of day cares would report a greater number of incident pertussis cases to the local Health Department.

Methods

Source population and study sample

Two data sources served as the source population for this study: the clinical disease management system (CDMS) and the Philadelphia immunization information system (IIS) dubbed KIDS Plus. CDMS logs and tracks all notifiable diseases reported to the Philadelphia Department of Public Health (PDPH) as mandated by the Philadelphia Health Code.[11] KIDS Plus provides a lifetime snapshot of immunization history, is linked to a variety of other systems including vital records to provide other health related data, and serves the entire Philadelphia area for residents of all ages. All cases in CDMS were linked to their vaccination records, if available, in KIDS Plus either through a unique identifier or permutations of last name, address, and date of birth when an identifier was unavailable.

Potential pertussis cases were retrieved from CDMS and controls were selected from non-case children in KIDS Plus at a 4:1 control to case ratio. At each point in time a case was reported to PDPH, a corresponding control was frequency matched by date of birth to within two weeks, akin to performing incidence density sampling. When a potential case occurred in an infant less than two weeks of age, the control had to be born before the case diagnosis date to ensure the control was eligible to become a case at the time of diagnosis. The study sample was restricted to children born between 1 January, 2001 and 31 December, 2013, and only included children aged birth through six years to capture the full five-dose series of pertussis vaccine in childhood. Based on the experience of the PDPH, children with fewer than two vaccines (any type) were excluded as these children were considered born in Philadelphia but moved or resided elsewhere. Only cases and controls that had geocodable addresses were included due to the multilevel modeling requirements. Geocoding was performed using Google Map's Application Program Interface using freely available R code.[12] This study was approved by the Institutional Review Boards for the City of Philadelphia and Drexel University (Philadelphia, PA).

Exposure, outcome, and covariates

The primary exposure for this study was the number of day cares in a neighborhood, obtained from the Pennsylvania Department of Human Services (DHS). DHS tracks day cares statewide[13] and during the study period, there were approximately 2000 registered day cares in Philadelphia. Neighborhoods were well-defined aggregates of census tracts denoted by the City of Philadelphia,[14] and were chosen as the spatial unit of analysis.

The day care variable was conceptualized into several competing measures that represent different neighborhood features and the most parsimonious predictor assessed by comparing the Akaike Information Criterion (AIC) was ultimately modeled in the statistical analysis. First, we examined a raw count of the number of day cares in each neighborhood. Next, we adjusted this count by dividing by the area of the neighborhood (in square miles) creating a day care density measure representing the ease of accessing the resource.