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Who Is the "Herd" in Herd Immunity?: How Herd Definition Affects Vaccination Coverage Rates and Herd Immunity Status

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Objective: Explain how variations in the definition of herds affect vaccine coverage calculations and the identification of communities at risk of vaccine-preventable disease outbreaks based on herd immunity status.
Background: Herd immunity occurs when a critical proportion of a population have immunity from an infectious disease, thereby protecting unvaccinated members of that population from disease transmission. The herd immunity threshold (HIT) is the minimum percentage of a population having immunity to prevent epidemics from occurring. Although the herd immunity concept is straightforward, evaluating a population's herd immunity status is difficult in practice. Importantly, there is no generally accepted approach to define the herd or delineate a larger population into herds. We examine how variations in herd definition affect vaccine coverage calculations and the identification of at-risk communities based on herd immunity status.
Methods: Pertussis vaccination data from California schools were used to calculate coverage rates for kindergarteners in each US Census block (n=403,398). Multiple realizations of communities or "herds" were generated from these foundational data, ranging from small to large herds and including common community designations such as census tracts, counties, and school districts. Additional herd realizations were generated by grouping spatially contiguous regions with similar sociodemographic characteristics, including age distribution, race/ethnicity, and education. We calculated the pertussis vaccination coverage for each community and designated each as above or below the HIT, which falls between 91.7% and 94.4% for pertussis.[1] We mapped and summarized the statewide proportion of kindergarteners in communities above and below the HIT and evaluated the sensitivity of individual communities to herd designation.
Results and Conclusion: The potentially at-risk population in California fluctuates substantially due to variation in herd definition. The percentage of kindergarteners residing in communities falling below the pertussis HIT ranged from 26-69% for the low HIT (91.7%) and from 72-89% for the high HIT (94.4%). Maps of California communities by HIT status exhibit considerable spatial variation across the different herd realizations. For many communities, HIT status is noticeably sensitive to which herd the community was assigned. Herd immunity status and the HIT are often used as benchmarks for childhood vaccine programs and public health interventions.[2] This research indicates that the use of vaccination coverage rates and herd immunity status may not be a sufficient approach given the uncertainty in what constitutes a herd. Developing a more robust definition of the "herd" is crucial to identify at-risk communities and to implement more effective vaccine-related policies.

References:

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Measles Immunity and Illness in Tianjin, China

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Objective: Describe the population characteristics of those individuals who are and those who are not susceptible to measles infection.
Background: Successful interruption of measles transmission requires high herd immunity of approximately 95%. Studies typically report vaccination coverage rather than population-level susceptibility when characterizing herd immunity although the latter is more informative in assessing control efforts. We examine multi-year incidence of measles and prevalence of measles antibodies in persons from Tianjin, China.
Methods: From 2011-15, we collected blood spots for measles testing from a population-based sample in Tianjin, China of 2,818 persons, including 1,200 aged 1-49 and 809 mother-infant pairs. We compare results from the measles serological testing to measles cases included in the disease surveillance system during that time.

Results and Conclusion: Overall, 72.7% of the sample tested positive for measles IgG antibodies. Most children 1-9 years (97.5%) tested IgG positive; the lowest levels of IgG positivity occurred in infants (37%) and individuals 30-39 years (81%). Vaccination-ineligible infants under age 8 months had 16.9% IgG positive and represented the age group with the greatest burden of disease (15.1% of cases). Testing results among the participants who were ≥9 months of age showed that seropositivity was comparable in males and females, and by rural, urban and, and suburban districts; by mother's education level, and by participant education level for those > 18 years. In the multivariable logistic regression, age and vaccination status were significantly associated with measles IgG antibody status. The odds of positive IgG antibody status were 0.337 times as high for the unvaccinated compared to those vaccinated (95% CI: 0.217, 0.524). Children over age 1 year in Tianjin have a high level of herd immunity against measles. Infants and adults 30-39 years accounted for the majority of measles cases and have a level of herd immunity below the threshold required to interrupt measles transmission. Overall, the measles control program in Tianjin has been successful in reaching its target age group. China needs to increase measles herd immunity in adults while also preventing vaccine-ineligible infants from acquiring disease to realize national measles elimination goals.

Reference:

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Developing Canadian Human Health Vaccine Priorities

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Objective: Explain the process undertaken in Canada to Identify priorities for human vaccines.Discuss Canada's identified human health vaccine priorities.

Background: The Public Health Agency of Canada (PHAC) is mandated to protect the health of Canadians from infectious diseases. Immunization programs play an integral role in preventing infection, morbidity and mortality nationwide, and are a shared responsibility as Canada is a federated State. Canada is interested in targeting investments toward developing priority human health vaccines. In order to support priority vaccine development PHAC undertook a broad consultation with industry and public health professionals.[1] We describe the consultation and results subsequently.[2]

Methods: In 2012, a series of ten consultation workshops were initiated, with an aim to identify and prioritize vaccine-candidate pathogens against defined criteria, including: incidence; mortality; case fatality; communicability; treatability; clinical impact; public & political profile; ten-year projection of incidence; economic impact; and preventability. The results of these consultations were used as context for a structured survey distributed to the Canadian Council of Chief Medical Officers of Health (CCMOH), a federal, provincial, territorial expert body, in late 2014. Results were ranked and compared against the Global Vaccine Action Plan (GVAP).[3]

Results and Conclusion: Through systematic consultations, we identified 16 candidate vaccines likely to emerge over the next six years, with six (38%) identified as having impacts on anti-microbial resistance (AMR). Nine candidate vaccines were identified as being medium term (7-12 years to production time), with three (33%) having AMR impacts. A final five candidate vaccines, including HIV, were identified as emerging over the longer-term (e.g., 13+ years), with all five having AMR impacts. These results informed a candidate-vaccine prioritization process, as was assessed by members of the CCMOH. The top five candidate vaccines from each category are presented. Short term: Influenza; RSV; *Clostridium difficile*; Streptococcus, Group A; *Streptococcus pneumoniae*. Medium term: Hepatitis C; Pertussis; Chlamydia trachomatis; *S. aureus*; Herpes simplex type 2. Long-term: HIV; universal influenza; Tuberculosis; *Neisseria gonorrhea*; VRE. Nine (30%) of the candidate vaccines identified in this study are included in the GVAP, including seven (47%) from the five higher priority vaccines identified in each production timeline category. Conclusions With the development of vaccine priorities, the Federal Government is demonstrating leadership in promoting targeted vaccine development in the interests of Canadians. This data will support Canadian provinces, territories and industry alike in developing key vaccines for identified public health concerns.