

State Surveillance Data Improves a Clinical Prediction Model for Pertussis

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OBJECTIVE

To explore the integration of epidemiological context – current population-level disease incidence data – into a clinical prediction model for pertussis.

BACKGROUND

Bordetella Pertussis outbreaks cause morbidity in all age groups, but the infection is most dangerous for young infants. Pertussis is difficult to diagnose, especially in its early stages, and definitive test results are not available for several days. Because of temporal and geographic variability of pertussis outbreaks, delay in diagnostic test results and ramifications of incorrect management decisions at the point of care, pertussis represents a prototypical disease where real-time public health surveillance data might inform, guide and improve medical decision making. Previously, we showed that diagnostic accuracy for meningitis can be improved when information about recent, local disease incidence is accounted for. [1] Here, we quantify the contribution of epidemiologic context to a clinical prediction model for pertussis using a state public health data stream.

METHODS

A retrospective chart review was conducted of 443 infants who presented to a large pediatric emergency department and were tested for pertussis from 2003-07. Clinical variables collected included demographics, signs and symptoms commonly associated with infant pertussis, and outcomes. Based on 19,907 pertussis cultures from Massachusetts Department of Public Health over the same time period, we created epidemiological context variables including total cultures sent, total positive and proportion positive 1,2,3 and 4 weeks prior to each study date. Using logistic regression, three prediction models were derived: 1) clinical only; 2) surveillance only; and 3) “contextualized model” which included all clinical and surveillance variables. Bootstrap validation was performed for each model. The best clinical, surveillance, and contextualized models were then compared across standard metrics (sensitivity, specificity, positive and negative predictive value (PPV, NPV), and area under the ROC curve (AOC)).

RESULTS

Cyanosis, cough for at least one week and absence of fever contributed to the best “clinical only” prediction model (89% sensitive, 27% specific, PPV 12%,

NPV 96%, area under the ROC curve 0.80). The best “surveillance only” model was generated when the proportion positive of pertussis tests two weeks prior to a study date exceeded 0.09 (13% sensitive, 53% specific, PPV 26%, NPV 94%, AROC 0.65). Cyanosis, cough for at least one week and proportion positive of pertussis tests two weeks prior to a study date above 0.10 contributed to the best “contextualized” model (100% sensitive, 38% specific, 15% PPV, 100% NPV, AROC 0.82). The contextualized model outperformed all other models across all metrics and was statistically significant for sensitivity ($p<0.04$), specificity ($p<0.001$) and NPV ($p<0.02$). (Figure).

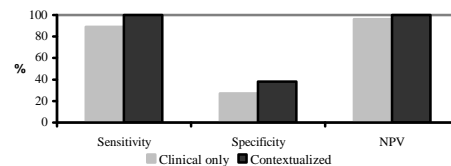


Figure – The contextualized model outperforms the clinical only model across all testing metrics.

CONCLUSIONS

Incorporation of state public health surveillance data improved the ability of a clinical prediction model to correctly identify cases of pertussis. Our findings support the importance of fostering two way-data exchange between public health and clinical practice, and provide a framework for encouraging integration of large-scale public health datasets with rich clinical data to improve clinical decision-making, and individual patient and public health.

REFERENCES

[1] Fine AM, Nigrovic LE, Reis BY, Cook EF, Mandl KD. Linking Surveillance to Action: Incorporation of Real-time Regional Data into a Medical Decision Rule. *J Am Med Inform Assoc.* March 1 2007;14(2):206-211.

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