A Cough Analysis Smartphone Application for Diagnosis of Acute Respiratory Illnesses in Children

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I. Background

Acute respiratory illnesses, including upper respiratory tract infections, asthma, croup, bronchiolitis, and pneumonia, are the most common reason for emergency department (ED) visits among children in the United States and the leading cause of under 5 mortality worldwide. A point of care test for distinguishing between the major causes of acute respiratory illness could reduce time to appropriate treatment, reduce ED visits, and improve outcomes.

II. Methods

We performed a prospective study of ResAppDx, a cough analysis algorithm that automatically detects coughs and uses mathematical features of the cough and parent-reported symptoms (fever, wheeze, rhinorrhea, duration of symptoms, and age) to predict the presence of various common childhood respiratory illnesses. We enrolled children age 1 month to 12 years presenting with a respiratory complaint to primary care clinics, urgent care, emergency department, or inpatient wards (within 24 hours of admission) at Massachusetts General Hospital, Cleveland Clinic, and Texas Children's Hospital. A minimum of 5 spontaneous or voluntary coughs were recorded using an iPhone 6S. All cases were reviewed by an adjudication committee blinded to the ResAppDx diagnosis. The sensitivity and specificity of the ResAppDx diagnosis was calculated using clinical and radiologic adjudication as reference standards.

III. Results

We enrolled 1468 children, of which 1251 children had analyzable coughs. The average age of enrolled children was 5.8 ($\pm$3.2) years, and 55% of children were male. Children were enrolled in outpatient clinics (30%), urgent care (19%), ED (45%), and inpatient (6%) settings. The ResAppDx algorithm predicted presence of isolated upper respiratory tract disease with 76.5% sensitivity and 70.9% specificity, lower respiratory tract disease with 73% sensitivity and 77% specificity, asthma/reactive airways disease with 71% sensitivity and 86% specificity, bronchiolitis with 76% sensitivity and 60% specificity, and pneumonia with 63% sensitivity and 62% specificity (see Table I).

TABLE I

Disease	**Sensitivity (%) [95% CI]**	**Specificity (%) [95% CI]**	**AUC [95% CI]**	**Positive likelihood ratio [95% CI]**	**Negative likelihood ratio [95% CI]**
Upper respiratory tract disease (isolated)	76.5 [73.2, 79.5]	70.9 [66.4, 75.0]	0.74 [0.71, 0.76]	2.62 [2.26, 3.05]	0.33 [0.29, 0.38]
Lower respiratory tract disease	72.8 [68.2, 77.1]	77.2 [74.0, 80.1]	0.75 [0.72, 0.78]	3.19 [2.77, 3.68]	0.35 [0.30, 0.42]
Asthma	71.0 [63.7, 77.6]	85.9 [83.4, 88.1]	0.79 [0.75, 0.82]	5.03 [4.17, 6.07]	0.34 [0.27, 0.43]
Bronchiolitis	76.2 [60.5, 87.9]	59.6 [48.6, 69.8]	0.68 [0.60, 0.76]	1.88 [1.39, 2.55]	0.40 [0.23, 0.71]
Pneumonia	63.0 [52.8, 72.4]	61.9 [59.0, 64.7]	0.63 [0.58, 0.67]	1.65 [1.40, 1.96]	0.60 [0.46, 0.78]

IV. Discussion

A smartphone-based algorithm using cough analysis and parent-reported symptoms provides moderate sensitivity and specificity for common childhood respiratory illnesses, within the reported range of chest radiography and rapid viral respiratory tests. This diagnostic tool has potential applications in the care of children with acute respiratory illness in both high and low-resource healthcare settings.

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