

Participatory Medicine: A Home Score for Streptococcal Pharyngitis Enabled by Real-Time Biosurveillance

A Cohort Study

Andrew M. Fine, MD, MPH; Victor Nizet, MD; and Kenneth D. Mandl, MD, MPH

Background: Consensus guidelines recommend against testing or treating adults at low risk for group A streptococcal (GAS) pharyngitis.

Objective: To help patients decide when to visit a clinician for the evaluation of sore throat.

Design: Retrospective cohort study.

Setting: A national chain of retail health clinics.

Patients: 71 776 patients aged 15 years or older with pharyngitis who visited a clinic from September 2006 to December 2008.

Measurements: The authors created a score using information from patient-reported clinical variables plus the incidence of local disease and compared it with the Centor score and other traditional scores that require clinician-elicited signs.

Results: If patients aged 15 years or older with sore throat did not visit a clinician when the new score estimated the likelihood of GAS

pharyngitis to be less than 10% instead of having clinicians manage their symptoms following guidelines that use the Centor score, 230 000 visits would be avoided in the United States each year and 8500 patients with GAS pharyngitis who would have received antibiotics would not be treated with them.

Limitation: Real-time information about the local incidence of GAS pharyngitis, which is necessary to calculate the new score, is not currently available.

Conclusion: A patient-driven approach to pharyngitis diagnosis that uses this new score could save hundreds of thousands of visits annually by identifying patients at home who are unlikely to require testing or treatment.

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For author affiliations, see end of text.

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Globally, group A streptococcal (GAS) pharyngitis affects hundreds of millions of persons each year (1, 2). In the United States, more than 12 million persons make outpatient visits for pharyngitis; however, clinicians cannot differentiate GAS pharyngitis from other causes of acute pharyngitis (for example, viral) on the basis of a physical examination of the oropharynx (3).

The American College of Physicians and Centers for Disease Control and Prevention recommend that health care providers apply clinical scores to classify risk for GAS pharyngitis and direct management of adults with acute pharyngitis (4–6) (Table 1). When the clinical score indicates a low risk, consensus guidelines recommend that adult patients should be neither tested nor treated for GAS pharyngitis. The updated 2012 guidelines from the Infectious Diseases Society of America concur that clinical scoring systems may help identify patients with pharyngitis at sufficiently low risk for GAS pharyngitis that testing may not be necessary (7).

We recently showed that the contemporaneous local incidence of GAS pharyngitis is an important predictor of this condition among patients presenting with a sore throat to CVS MinuteClinics, a large chain of retail health clinics where data are captured uniformly in a single electronic health record (8). Building on this framework, we derived a disease prediction model that we call the “home score” because it was designed for use at home by the patient without input from a clinician and relies on the patient to provide historical features but not physical examination

findings (Table 1). The model also includes a local incidence variable for streptococcus, bringing biosurveillance data into the clinical process. We seek to evaluate whether this participatory medicine approach could reduce unnecessary outpatient and emergency department visits for pharyngitis not requiring antibiotic treatment.

METHODS

Study Design

We retrospectively analyzed a cohort of patients tested for GAS pharyngitis when they presented with a sore throat from 1 September 2006 to 1 December 2008 to CVS MinuteClinics, which has about 600 sites in 25 states and the District of Columbia (9–13). MinuteClinics provide care for patients with a limited number of conditions, including sore throat. This data set included 238 656 patient encounters where physician assistants or nurse practitioners collected standardized information from the history and physical examination based on algorithm-driven care. Clinicians enter codified data in real time, and the records are stored in a common database.

See also:

Print

Editorial comments. 636, 638
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Context

Adults with sore throat who are at low risk for group A streptococcal pharyngitis can forgo testing and treatment.

Contribution

The investigators developed a new method to identify low-risk patients by using information that does not require a visit to a clinician.

Caution

Some of the required information is population-based and not presently available for most persons.

Implication

Widespread implementation of the new method could make many patient visits to clinicians for management of sore throat unnecessary.

—The Editors

MinuteClinic providers have shown more than 99% adherence to a recognized protocol for acute pharyngitis: the Strep Pharyngitis Algorithm from the Institute for Clinical Systems Improvement (14, 15). Guided by the algorithm, clinicians collect structured information about relevant signs and symptoms, acquire rapid testing on all patients with pharyngitis (ordering confirmatory testing when the rapid test results are negative), and treat only patients with positive test results for GAS pharyngitis. All visits in this data set contained complete information about age; all signs and symptoms included in 2 traditional, validated clinical scores (the Centor and McIsaac scores); and test results (4, 16) (Table 1).

Our study included patients with a chief symptom of sore throat or symptoms of pharyngitis with testing performed for GAS pharyngitis. Patients who reported having been treated for GAS pharyngitis within the previous month and those younger than 15 years were excluded. When patients contributed more than 1 visit to the data set, only the first visit was included. MinuteClinic policy is to care only for patients who are generally well-appearing; those with concern for sepsis are referred to emergent care centers.

Test Methods

All clinic locations used the QuickVue In-Line Strep A test (Quidel, San Diego, California), which was waived under the Clinical Laboratory Improvement Amendments. The confirmatory test was a throat culture (43%) or streptococcal DNA probe (57%), which is often considered equal to culture and is widely used in the United States (17, 18). Patients were diagnosed with GAS pharyngitis if the rapid or confirmatory test results were positive.

Statistical Analysis

The analysis was restricted to 9 MinuteClinic markets from 6 states (Georgia, Indiana, Maryland, Minnesota,

North Carolina, and Tennessee) with a minimum of 7000 patient visits each for pharyngitis during the study. Two thirds of the patients were selected randomly for derivation and the rest for validation. We repeated all steps used on the derivation set with the validation set to compare results. To enable integration of contemporaneous, local epidemiologic data on GAS pharyngitis, we used a previously validated biosurveillance variable reflecting disease incidence, the recent local proportion positive (RLPP) (8), expressed using the following equation (Appendix, available at www.annals.org).

$$\frac{\text{(Patients with pharyngitis who tested positive for GAS pharyngitis in market A in the previous 14 d)}}{\text{(Total patients with pharyngitis tested for GAS pharyngitis in market A in the previous 14 d)}}$$

The RLPP was assigned for each patient visit on the basis of location and date.

Variable Selection

Our a priori hypothesis was that the original variables from the Centor and McIsaac scores would dominate the home score. Because the purpose of the home score is to focus on information that can be supplied by the patient combined with biosurveillance-derived knowledge, we excluded physical examination variables (tender anterior cervical lymph nodes and exudates) from the Centor and McIsaac scores and added the RLPP variable. A stepwise selection model with 14 home score predictors (sex, absence of cough, pain when swallowing, history of fever, exposure to GAS pharyngitis, stomachache, difficulty sleeping, ear pain, postnasal discharge, hoarseness, headache, nausea, vomiting, and lack of rhinorrhea confirmed the hypothesis, identifying the same home variables from the original Centor and McIsaac scores (fever, absence of cough, and age) and RLPP.

Table 1. Data Elements Used to Compute the Centor, McIsaac, Clinical Biosurveillance, and Home Scores*

Variable	Centor Score	McIsaac Score	Clinical Biosurveillance Score	Home Score
Historical elements				
Fever	X	X	X	X
Absence of cough	X	X	X	X
Age	–	X	–	X
Physical examination findings				
Swollen, tender anterior cervical lymph nodes	X	X	X	–
Tonsillar exudate	X	X	X	–
Biosurveillance data				
RLPP	–	–	X	X

RLPP = recent local proportion positive.

* For details on how to calculate these scores, see the Methods section.

Home Score Calculation

The home score (actual range, 8–62; possible range 0–100) is based on demographic, historical, and biosurveillance data only, not physical examination data. To calculate the home score for each patient, we used the results of logistic regression based on the final model to calculate the predicted probability (0–100) of GAS pharyngitis. The home score can be calculated from the following equation, where $f = -1$ if fever is present, $f = 1$ if fever is not present, $c = 1$ if cough is present, and $c = -1$ if cough is not present.

$$\frac{100}{1 + \exp[(2.05 + f \times (0.44) + c \times (0.27) - 3.60 (\text{RLPP}) + 0.0002 (\text{age in y})]}$$

For example, for a 41-year-old patient with fever and cough who presented when the RLPP was 0.19, the home score would be 23.

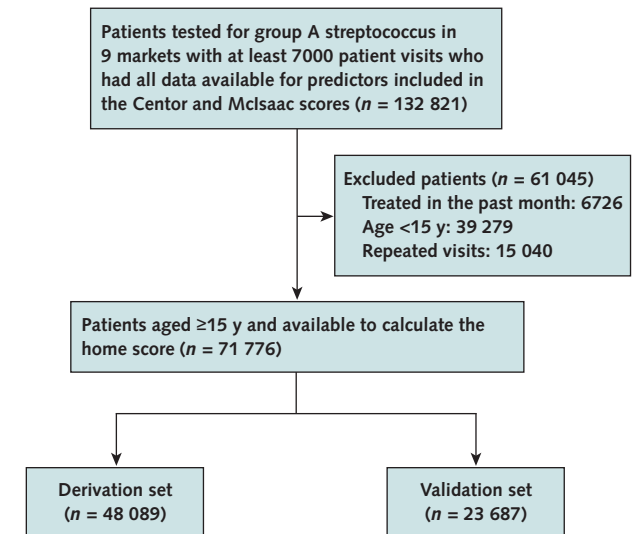
For each home score of 0 to 100, we calculated the percentage of patients who actually tested positive for GAS pharyngitis and examined the relationship between the home score and positivity for GAS pharyngitis. Standard metrics (sensitivity, specificity, and positive and negative predictive values) compared performance of the home score with the Centor and McIsaac scores and the clinical biosurveillance score (8) (Table 1). The Centor and McIsaac scores rely on elements derived from the history and physical examination. To calculate the Centor score, patients receive 1 point for each of the following factors: fever; absence of cough; presence of tonsillar exudates; and swollen, tender anterior cervical lymph nodes. The Centor score is the sum of these points (range, 0–4).

The McIsaac score (range, 0–5) adjusts the Centor score to account for the increased incidence of GAS pharyngitis in children and decreased incidence in older adults by adding 1 point to the Centor score for those younger than 15 years and subtracting 1 point for those aged 45 years or older. The clinical biosurveillance score (range, 4–79) adjusts the Centor score on the basis of real-time biosurveillance data about the recent local incidence of GAS pharyngitis (Appendix). We calculated the clinical biosurveillance score by adjusting a patient's Centor score with the RLPP by using the equations in the Appendix Table (available at www.annals.org).

Hypothetical Outcomes

We computed the number of patients who, according to the home score, were at low risk for GAS pharyngitis and therefore might avoid or delay a trip to a medical provider. The Centers for Disease Control and Prevention advocates the American College of Physicians guideline based on the Centor score for management of acute pharyngitis in adults. This guideline recommends that adult patients who are unlikely to have GAS pharyngitis (Centor score, 0–1) should be neither tested nor treated (5). We calculated the Centor scores for these patients as well as the

Figure. Study flow diagram.



following outcomes: the numbers of visits saved and additional missed cases of GAS pharyngitis compared with the existing American College of Physicians and Centers for Disease Control and Prevention approach.

Analyses ranged across a spectrum of risk thresholds for GAS pharyngitis. We extrapolated results to project the effect on 12 million national visits for pharyngitis annually. We tabulated outcomes across a wide range of home score thresholds from 10 to 30. Metrics include the number of patients who were correctly and incorrectly diagnosed with GAS pharyngitis and the estimated number of patients nationally whose management would be affected by the home score.

The Boston Children's Hospital Committee on Clinical Investigation approved this database analysis. JMP Pro software, version 10.0.0 (SAS Institute, Cary, North Carolina), was used for statistical analyses.

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RESULTS

Of the 132 821 patient visits to 1 of the 9 locations with at least 7000 patient visits, 6726 visits from patients treated in the previous month, 39 279 visits from patients younger than 15 years, and 15 040 repeated visits were excluded, leaving 71 776 visits for calculation of the home score (Figure). Of these, two thirds were used for the der-

Table 2. Clinical Characteristics of Patients in the Derivation and Validation Sets*

Characteristic	Derivation Set		
	Overall (n = 48 089)	GAS Pharyngitis–Positive (n = 11 614)	GAS Pharyngitis–Negative (n = 36 475)
Mean age (median [IQR]), y	34 (33 [24–41])	33 (33 [25–40])	34 (33 [24–42])
Women	32 481 (68)	7565 (65)	24 916 (68)
Fever	14 770 (31)	5340 (46)	9430 (26)
Absence of cough	32 558 (68)	8795 (76)	23 763 (65)
Anterior cervical lymphadenopathy	29 060 (60)	9004 (78)	20 056 (55)
Tonsillar exudate	10 397 (22)	4717 (41)	5680 (16)
Mean RLPP (median [IQR])	0.25 (0.25 [0.20–0.30])	0.27 (0.26 [0.22–0.31])	0.25 (0.24 [0.19–0.29])

GAS = group A streptococcal; IQR = interquartile range; RLPP = recent local proportion positive.
 * Data presented as numbers (percentages) unless otherwise specified.

ivation set (n = 48 089) and one third for the validation set (n = 23 687).

Among the 48 089 retail health visits for patients aged 15 years or older in the derivation set, 11 614 (24%) tested positive for GAS pharyngitis. In the validation set, 5728 of 23 687 (24%) tested positive. **Table 2** shows the characteristics of the derivation and validation sets for age, sex, and clinical signs and symptoms of pharyngitis by GAS pharyngitis result for those aged 15 years or older. **Table 2** also contains information about the epidemiologic conditions of GAS pharyngitis (RLPP) when the patient visits took place. In both groups, patients who tested positive for GAS pharyngitis were more likely to present with tonsillar exudates, swollen anterior cervical lymph nodes, absence of cough, and fever in the previous 24 hours. **Table 3** shows the sensitivity, specificity, and positive and negative predictive values of a range of home score thresholds for the derivation and validation sets.

Home Score Performance

Table 4 shows outcomes of patients when strategies based on the low-risk thresholds where neither testing nor treatment would occur were used. Two thresholds for the home score and the low-risk thresholds for the Centor and McIsaac scores of less than 2 are shown. If the home score is less than 10, the negative predictive value is 0.90, which means that 90% of the patients identified as low risk by the home score would have tested negative for GAS pharyngitis.

Table 5 summarizes the outcomes if patients were managed on the basis of a home score determined to be low risk. For example, if the home score were less than 10, for every missed patient with GAS pharyngitis, 27 health care visits could be saved in which patients would have been neither tested nor treated for GAS pharyngitis. On a national scale, it would save 230 000 visits annually. This cutoff also could be expected to miss an additional 8500 cases annually of GAS pharyngitis compared with a conventional Centor score–based approach. However, most patients with GAS pharyngitis have a self-limited course.

Complications from missed cases include acute rheumatic fever, which is rare in adults; acute glomerulonephritis, which would not be prevented even with antibiotics; and abscess formation, highlighting the importance of close follow-up and recognition of patients who seem ill. At a higher home score threshold of 15, a total of 61 000 additional patients would be missed nationally in 1 year but 780 000 visits would be saved.

DISCUSSION

Clinical prediction models tend to rely on elements gleaned from a patient’s history, physical examination, and preliminary laboratory data to calculate the likelihood of disease and then provide physicians with recommendations about whether to test or treat patients for specific conditions (19–22). Recent, local epidemiology is an important

Table 3. Sensitivity, Specificity, and Positive and Negative Predictive Values of the Derivation (n = 48 089) and Validation (n = 23 687) Sets at a Range of Home Score Thresholds

Home Score	Sensitivity, %		Specificity, %		Positive Predictive Value, %		Negative Predictive Value, %	
	Derivation Set	Validation Set	Derivation Set	Validation Set	Derivation Set	Validation Set	Derivation Set	Validation Set
<10	99	99	4	1	25	24	90	87
<15	90	91	22	18	27	26	87	86
<20	70	74	50	44	31	30	84	84
<25	51	50	71	70	36	35	82	82
<30	40	37	81	81	40	38	81	80

Table 2—Continued

Validation Set		
Overall (n = 23 687)	GAS Pharyngitis–Positive (n = 5728)	GAS Pharyngitis–Negative (n = 17 959)
34 (33 [24–41])	33 (33 [25–40])	34 (33 [24–42])
15 940 (67)	3801 (66)	12 139 (68)
7304 (31)	2517 (44)	4787 (27)
15 986 (67)	4314 (75)	11 672 (65)
14 229 (60)	4399 (77)	9830 (55)
5017 (21)	2267 (40)	2750 (15)
0.25 (0.25 [0.20–0.30])	0.27 (0.26 [0.21–0.31])	0.25 (0.24 [0.19–0.29])

predictor of the risk for communicable diseases among symptomatic patients but is rarely if ever integrated quantitatively into prediction models (8, 23–25). We have internally validated a fusion model using population health data and information supplied directly by patients, using both biosurveillance and participatory medicine approaches to make a common diagnostic decision.

The model, based on history and recent, local disease patterns without physical examination information, could help clinicians and patients estimate the likelihood of disease before a clinical encounter and help steer these patients to timely, appropriate care when needed. In some instances, patients unlikely to have GAS pharyngitis might avoid, or at least delay, an emergency or outpatient visit.

Anhang Price and colleagues (26) and Kellermann and colleagues (27) have shown the feasibility of Web-based triaging by patients and parents of children with influenza-like illness. Although these studies showed great sensitivity in detecting children at risk for complications of influenza, it had low specificity. Our analysis of GAS pharyngitis offers an opportunity for improving specificity via home triage that incorporates clinical symptoms with relevant, real-time biosurveillance. One other advantage of a home triage system for well-appearing adults with pharyngitis is that acute decompensation is much less probable in this population than in children with influenza.

Even without information from physical examination findings, the home score approaches the accuracies and overall performances of the existing validated scores. Clinicians could use the home score to interact with patients online or over the telephone. There may also be circum-

stances in which it would be safe for patients themselves to be guided by a home score application.

For example, a home score less than 10 (low risk) might yield the recommendation of supportive measures, such as fever control, rest, and hydration. A tailored message could recommend that these patients recheck their home score in 24 to 48 hours. Because the home score is dynamic, a change in symptoms or local epidemiology could result in a different recommendation.

Patients with higher scores might be advised to seek care for further evaluation and possibly testing. Presenting the absolute risk for GAS pharyngitis and the corresponding recommendation could decrease ambulatory visits that would have been unlikely to result in diagnostic testing for this condition but would have contributed to increased cost, reduced efficiency of the health system, and opportunity cost for the patient. An additional public health benefit could be reduced antibiotic exposure, lessening selection for drug-resistant strains and perturbation of the normal microflora.

Patient-generated data for care and research are becoming increasingly common with further penetration of consumer technology and use of patient portals, personally controlled health records, and mobile health applications (28–30). Although the GAS pharyngitis home score shows the potential value of these data, safe and effective implementation requires key logistic and workflow decisions.

First, the strategy requires national, regional, or local approaches to making the biosurveillance data available at the point of care. Because so many patients are tested for GAS pharyngitis, most hospitals and many large group

Table 4. Overall Performance of Models at Thresholds for Identifying Patients at Risk for GAS Pharyngitis in the Derivation Set

Model and Threshold	True Positive, n	False Positive, n	False Negative, n	True Negative, n	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
Home score								
<10	11 453	35 101	161	1374	0.99	0.04	0.25	0.90
<15	10 424	28 608	1190	7867	0.90	0.22	0.27	0.87
Centor score <2	9310	18 849	2304	17 626	0.80	0.48	0.33	0.88
Mclsaac score <2	8739	16 671	2875	19 804	0.75	0.54	0.34	0.87

GAS = group A streptococcal.

Table 5. Patient Outcomes When the Home Score Classifies Adult Patients as Low Risk*

Home Score	Outcomes of Patients in Derivation Set		National Estimates of Outcomes		
	Visits Saved, <i>n</i> [†]	Additional Cases Missed Compared With the Centor Approach, <i>n</i>	Visits Saved, <i>n</i> (million) [†]	Additional Cases Missed Compared With the Centor Approach, <i>n</i>	Visits Saved per Missed Case, <i>n</i>
≤10 (<i>n</i> = 1535)	1374	53	0.23	8500	27
≤15 (<i>n</i> = 9061)	4947	374	0.78	61 000	13
≤20 (<i>n</i> = 21 630)	18 157	1963	2.9	320 000	9
≤25 (<i>n</i> = 31 563)	25 927	3641	4.2	590 000	7
≤30 (<i>n</i> = 36 429)	29 447	4775	4.8	780 000	6

* Derivation set, *n* = 48 089.

† Patients correctly classified as negative for group A streptococcal pharyngitis.

practices would have sufficient data to generate their own RLPPs. Second, implementers can decide whether a computerized decision-support system based on patient-entered data advises patients directly or is used to guide their providers' decisions through a shared portal or application.

The home score could help clinicians estimate the risk for GAS pharyngitis in children. However, because the American Academy of Pediatrics recommends that all children with pharyngitis be tested for GAS pharyngitis, we did not include patients younger than 15 years in the analyses about visits saved.

Our study has limitations. Analyses were performed retrospectively, although all data were collected prospectively. Data are not available to calculate interobserver agreement or reliability. Patients entering their symptoms at home could answer differently during a MinuteClinic encounter. These data do not reflect the incidence of other pathogens that can cause pharyngitis, such as *Fusobacterium necrophorum*, which may be particularly severe in young adults and adolescents and is one pathogen that may cause the Lemierre syndrome (31).

Our data do not allow evaluation of streptococcal carriage, although all patients in this data set were symptomatic with a sore throat; thus, those testing positive would be treated clinically. Performance of the score in a home setting would be best if the patients resembled the MinuteClinic clientele who were included in this study. We recommend that any application using the home score limit it to patients without signs or symptoms of serious illness.

We cannot account for baseline immunity to GAS pharyngitis within the population nor the local emergence of hypervirulent GAS pharyngitis strains or infectious causes of community-acquired pharyngitis, which may vary across regions. Data more recent than 2008 were not available for analysis, but the approach to patients with pharyngitis by MinuteClinics has not changed. The same electronic medical record, algorithm-driven approach, and testing methods are still used, with consistently high provider adherence to protocol. One possible limitation is that the prevalence of GAS pharyngitis among MinuteClinic patients could have changed over time, although one gen-

eralizable strength of our model is that it considers a range of prevalence of GAS pharyngitis.

Logistically, integration of a home score might result in lower testing rates by providers, which could weaken the RLPP as a reliable surveillance indicator; therefore, it would be necessary to maintain testing on an intentional sample of patients each week to account for this. The RLPP, as a surveillance variable, is a trailing indicator, so the accuracy of the home score could decrease if GAS pharyngitis rates rapidly changed. To mitigate this effect, we used a 14-day RLPP rather than a 3- or 7-day RLPP, all of which had similar accuracy in the study population.

From Boston Children's Hospital, Harvard Medical School, Harvard-MIT Health Sciences and Technology, and the Center for Biomedical Informatics, Boston, Massachusetts, and the Skaggs School of Pharmacy and Pharmaceutical Sciences, University of California, San Diego, La Jolla, California.

Note: Dr. Fine had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Requests for Single Reprints: Andrew M. Fine, MD, MPH, Division of Emergency Medicine-Main 1, Boston Children's Hospital, 300 Longwood Avenue, Boston, MA 02115; e-mail, andrew.fine@childrens.harvard.edu.

Current author addresses and author contributions are available at www.annals.org.

References

1. Carapetis JR, Steer AC, Mulholland EK, Weber M. The global burden of group A streptococcal diseases. *Lancet Infect Dis*. 2005;5:685-94. [PMID: 16253886]
2. Klepser DG, Bisanz SE, Klepser ME. Cost-effectiveness of pharmacist-provided treatment of adult pharyngitis. *Am J Manag Care*. 2012;18:e145-54. [PMID: 22554040]
3. Wessels MR. Clinical practice. Streptococcal pharyngitis. *N Engl J Med*. 2011;364:648-55. [PMID: 21323542]
4. Centor RM, Witherspoon JM, Dalton HP, Brody CE, Link K. The diagnosis of strep throat in adults in the emergency room. *Med Decis Making*. 1981;1:239-46. [PMID: 6763125]
5. Snow V, Mottur-Pilson C, Cooper RJ, Hoffman JR; American Academy of Family Physicians. Principles of appropriate antibiotic use for acute pharyngitis in adults. *Ann Intern Med*. 2001;134:506-8. [PMID: 11255529]
6. McIsaac WJ, White D, Tannenbaum D, Low DE. A clinical score to reduce unnecessary antibiotic use in patients with sore throat. *CMAJ*. 1998;158:75-83. [PMID: 9475915]
7. Shulman ST, Bisno AL, Clegg HW, Gerber MA, Kaplan EL, Lee G, et al. Clinical practice guideline for the diagnosis and management of group A streptococcal pharyngitis: 2012 update by the Infectious Diseases Society of America. *Clin Infect Dis*. 2012;55:1279-82. [PMID: 23091044]
8. Fine AM, Nizet V, Mandl KD. Improved diagnostic accuracy of group A streptococcal pharyngitis with use of real-time biosurveillance. *Ann Intern Med*. 2011;155:345-52. [PMID: 21930851]
9. Rudavsky R, Pollack CE, Mehrotra A. The geographic distribution, ownership, prices, and scope of practice at retail clinics. *Ann Intern Med*. 2009;151:315-20. [PMID: 19721019]
10. Pollack CE, Armstrong K. The geographic accessibility of retail clinics for underserved populations. *Arch Intern Med*. 2009;169:945-9. [PMID: 19468086]
11. Mehrotra A, Liu H, Adams JL, Wang MC, Lave JR, Thygeson NM, et al. Comparing costs and quality of care at retail clinics with that of other medical settings for 3 common illnesses. *Ann Intern Med*. 2009;151:321-8. [PMID: 19721020]
12. Fine AM, Nizet V, Mandl KD. Large-scale validation of the Centor and McIsaac scores to predict group A streptococcal pharyngitis. *Arch Intern Med*. 2012;172:847-52. [PMID: 22566485]
13. Costello D. A checkup for retail medicine. *Health Aff (Millwood)*. 2008;27:1299-303. [PMID: 18780914]
14. Woodburn JD, Smith KL, Nelson GD. Quality of care in the retail health care setting using national clinical guidelines for acute pharyngitis. *Am J Med Qual*. 2007;22:457-62. [PMID: 18006426]
15. Snellman L, Adams W, Anderson G, Godfrey A, Gravley A, Johnson K, et al; Institute for Clinical Systems Improvement. Health Care Guideline: Diagnosis and Treatment of Respiratory Illness in Children and Adults. Bloomington, MN: Institute for Clinical Systems Improvement; 2013. Accessed at https://www.icsi.org/_asset/1wp8x2/RespIllness.pdf on 5 January 2013.
16. McIsaac WJ, Kellner JD, Aufricht P, Vanjaka A, Low DE. Empirical validation of guidelines for the management of pharyngitis in children and adults. *JAMA*. 2004;291:1587-95. [PMID: 15069046]
17. Nakhoul GN, Hickner J. Management of adults with acute streptococcal pharyngitis: minimal value for backup strep testing and overuse of antibiotics. *J Gen Intern Med*. 2013;28:830-4. [PMID: 23054930]
18. Chapin KC, Blake P, Wilson CD. Performance characteristics and utilization of rapid antigen test, DNA probe, and culture for detection of group A streptococci in an acute care clinic. *J Clin Microbiol*. 2002;40:4207-10. [PMID: 12409399]
19. Laupacis A, Sekar N, Stiell IG. Clinical prediction rules. A review and suggested modifications of methodological standards. *JAMA*. 1997;277:488-94. [PMID: 9020274]
20. Wasson JH, Sox HC. Clinical prediction rules. Have they come of age? [Editorial]. *JAMA*. 1996;275:641-2. [PMID: 8594248]
21. Wasson JH, Sox HC, Neff RK, Goldman L. Clinical prediction rules. Applications and methodological standards. *N Engl J Med*. 1985;313:793-9. [PMID: 3897864]
22. Reilly BM, Evans AT. Translating clinical research into clinical practice: impact of using prediction rules to make decisions. *Ann Intern Med*. 2006;144:201-9. [PMID: 16461965]
23. Fine AM, Reis BY, Nigrovic LE, Goldmann DA, Laporte TN, Olson KL, et al. Use of population health data to refine diagnostic decision-making for pertussis. *J Am Med Inform Assoc*. 2010;17:85-90. [PMID: 20064807]
24. Fine AM, Brownstein JS, Nigrovic LE, Kimia AA, Olson KL, Thompson AD, et al. Integrating spatial epidemiology into a decision model for evaluation of facial palsy in children. *Arch Pediatr Adolesc Med*. 2011;165:61-7. [PMID: 21199982]
25. 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*. 2007;14:206-11. [PMID: 17213492]
26. Anhang Price R, Fagbuyi D, Harris R, Hanfling D, Place F, Taylor TB, et al. Feasibility of web-based self-triage by parents of children with influenza-like illness: a cautionary tale. *JAMA Pediatr*. 2013;167:112-8. [PMID: 23254373]
27. Kellermann AL, Isakov AP, Parker R, Handrigan MT, Foldy S. Web-based self-triage of influenza-like illness during the 2009 H1N1 influenza pandemic. *Ann Emerg Med*. 2010;56:288-294. [PMID: 20605260]
28. Weitzman ER, Kelemen S, Quinn M, Eggleston EM, Mandl KD. Participatory surveillance of hypoglycemia and harms in an online social network. *JAMA Intern Med*. 2013;173:345-51. [PMID: 23400234]
29. Kaye J, Curren L, Anderson N, Edwards K, Fullerton SM, Kanellopoulou N, et al. From patients to partners: participant-centric initiatives in biomedical research. *Nat Rev Genet*. 2012;13:371-6. [PMID: 22473380]
30. Basch E. The missing voice of patients in drug-safety reporting. *N Engl J Med*. 2010;362:865-9. [PMID: 20220181]
31. Centor RM. Adolescent and adult pharyngitis: more than "strep throat": comment on "Large-scale validation of the Centor and McIsaac Scores to predict group A streptococcal pharyngitis." *Arch Intern Med*. 2012;172:852-3. [PMID: 22566487]

Current Author Addresses: Dr. Fine: Division of Emergency Medicine—Main 1, Boston Children’s Hospital, 300 Longwood Avenue, Boston, MA 02115.

Dr. Nizet: Division of Pediatric Pharmacology and Drug Discovery, University of California, San Diego, School of Medicine, Cellular & Molecular Medicine East, Room 1066, 9500 Gilman Drive, Mail Code 0687, La Jolla, CA 92093-5611.

Dr. Mandl: Boston Children’s Hospital, 300 Longwood Avenue, Boston, MA 02115.

Author Contributions: Conception and design: A.M. Fine, K.D. Mandl. Analysis and interpretation of the data: A.M. Fine, V. Nizet, K.D. Mandl.

Drafting of the article: A.M. Fine, K.D. Mandl.

Critical revision of the article for important intellectual content: A.M. Fine, V. Nizet, K.D. Mandl.

Final approval of the article: A.M. Fine, V. Nizet, K.D. Mandl.

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Collection and assembly of data: A.M. Fine, K.D. Mandl.

APPENDIX: CALCULATION OF THE RLPP AND THE CLINICAL BIOSURVEILLANCE SCORE

Calculation of the RLPP

The RLPP is a biosurveillance variable that we created previously to reflect the real-time epidemiology of GAS pharyngitis. To calculate the RLPP, we included test results from the study population as well as from younger patients. We included data from patients younger than 15 years when calculating the overall local incidence data because they contribute to the epidemiologic context of the clinically analyzed population. The RLPP is a moving window.

To calculate the 14-day RLPP for a patient seen on 15 January 2007, for example, we divided the number of positive GAS pharyngitis test results by the number of tests sent in that market from 1 to 14 January 2007. We calculated 3-, 7-, and 14-day RLPPs and compared them using the Pearson correlation coefficients. The 3-, 7-, and 14-day RLPPs were strongly correlated (14 vs. 7: $r^2 = 0.79$ [$P < 0.001$]; 7 vs. 3: $r^2 = 0.63$ [$P < 0.001$]; and 14 vs. 3: $r^2 = 0.48$ [$P < 0.001$]), so we used the 14-day RLPP for subsequent analyses because it provides a realistic time frame to generate reliable, contemporaneous local data on GAS pharyngitis.

In the derivation set, an individual patient’s 14-day RLPP was calculated on the basis of a mean of 227 patients (SD, 115; 95% CI, 226 to 228; median, 198 patients [interquartile range, 132 to 334]) tested in that area in the previous 14 days. The median RLPP was 0.25 (interquartile range, 0.20 to 0.30; overall range, 0.08 to 0.51). The RLPP substantially fluctuated across time and location (8).

Calculation of the Clinical Biosurveillance Score

The clinical biosurveillance score can be calculated by adjusting a patient’s Centor score on the basis of the RLPP, as defined by the equations in the **Appendix Table** (8). For example, for a patient with a Centor score of 2 who presents when the RLPP is 0.33, the clinical biosurveillance score would be $8.8 + 64 \times (0.33)$, which equals 30.

Appendix Table. Equations for Calculating the Clinical Biosurveillance Score by Adjusting a Patient’s Centor Score on the Basis of the RLPP

Centor Score	Clinical Biosurveillance Score Adjustment
0	$1.5 + 29 \times \text{RLPP}$
1	$4.2 + 37 \times \text{RLPP}$
2	$8.8 + 64 \times \text{RLPP}$
3	$20 + 88 \times \text{RLPP}$
4	$28 + 121 \times \text{RLPP}$

RLPP = recent local proportion positive.