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Inappropriate Testing of Streptococcal Pharyngitis in Children Less than Three Years Old

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Abstract

Testing for Group A Strep in children less than 3 years old is not recommended. An appropriate test for strep in this age group is only indicated if the child has been exposed to a positive contact or shows signs of complications, in addition to displaying the appropriate symptoms. This paper analyzes the factors that contribute to appropriate and inappropriate strep testing of children under 3. The results showed no significant effect from the type of ordering provider or age of the child, but revealed that inappropriate testing was more common at emergency departments and at the start of data collection. These results were attributed to parental anxiety in emergency situations and the educational programs that were instituted during the course of the study. Future studies should investigate whether parental anxiety and educational programs do influence appropriate/inappropriate testing and evaluate the efficacy of strategies that intend to reduce inappropriate testing.

1. Introduction

The bacteria *Streptococcus pyogenes* is a common causal pathogen of Streptococcal Pharyngitis, more commonly known as strep throat. Strep throat is most prevalent in children ages 5-15 [1], [13] and results in symptoms such as a sore throat, an exudative and erythematous oropharynx, cervical lymphadenopathy, and fever. Symptoms such as cough and rhinorrhea are not typical of strep throat and usually indicate a viral infection [1], [13-14]. Symptoms usually resolve in 1-2 days with antibiotics such as amoxicillin and penicillin or in 3-5 days without antibiotics [1], [9-10], [15].

A person is tested for strep by swabbing the back of the throat and performing a Rapid Antigen test followed by a culture. The rapid antigen test provides results in about 15 minutes but has a sensitivity as low as 70% for some swabs [5-6], so it is followed by a culture if results are negative. Results from the culture are 90-95% sensitive [4] and typically come back in 24 hours.

While the *streptococcus pyogenes* bacteria is responsible for the illness, about 12% of children ages 3 to 15 are carriers of the bacteria [11], [15], meaning that the bacteria are part of the normal flora of their throat and do not cause symptoms. This poses a problem when one of these children presents to a doctor, often with a viral illness, and the doctor tests for strep throat. The test will produce a positive result but the bacteria are not causing the symptoms. The child will be unnecessarily prescribed antibiotics, posing future problems of antibiotic resistance to the child and society [1], [3] and producing higher costs for the hospital [15-17].

The American Academy of Pediatrics does not recommend testing for strep in children under 3 years old. First, a strep throat infection caused by *Streptococcus pyogenes* is uncommon in children less than 3 (prevalence of 10 – 14% in patients presenting with a sore throat, compared to 37% in school-age children) [8], [11]. Second, in the case that the child *does* have a strep infection, the illness will likely resolve itself in 3-5 days without the use of antibiotics, on average only 16 hours longer than with antibiotics, making the risk associated with an undiagnosed infection relatively low [1], [9-10], [15]. Third, although a strep infection can lead to more serious complications such as rheumatic fever and glomerulonephritis, these illnesses are very rare in young children [1-2], [7].

The American Academy of Pediatrics only recommends strep testing in children under 3 if the child is exposed to a child with strep at home or daycare or if there is a concern for a complication of strep AND shows symptoms associated with strep [1], [12]. For example, a child that presents with a maculopapular rash (indicative of scarlet fever) in addition to a fever and an erythematous oropharynx can be appropriately tested for strep.

Despite these recommendations, some hospitals continue to inappropriately test children under 3. The reasons are unclear. One could be a lack of education

of the health providers on what constitutes an appropriate test. For example, there might be an incongruity of understanding between different health care providers such as attending physicians, residents, physician assistants, and nurses, or differences among testing standards at different locations. Other contributing factors could be the age of the child or tests being ordered under the insistence of parents.

This paper will analyze the factors that contribute to appropriate and inappropriate strep testing. Using data from strep tests collected at Dayton Children's Hospital, I looked at factors that lead to inappropriately-ordered strep tests for children less than 3. Specifically, I hypothesize that 1) health providers with more education are more likely to order strep tests appropriately, 2) the proportion of appropriately-ordered tests will increase over time as providers become more aware of the recommendations, and 3) there will be more inappropriate tests in the emergency setting when parents are distressed.

2. Methods

2.1. Data Collection and Organization

The data was collected from visits to Dayton Children's Hospital between May 2018 and May 2019. All visits were for children less than 36 months old in which a strep test was ordered. The data consists of visits to two emergency departments (South and Main locations) and three urgent cares (Huber Heights, Springboro, and Kids Express).

The data set consists of 1163 visits and was compiled in Excel by examining the electronic records of each visit. The results of the rapid strep test and culture were found under the test results. The SOAP notes revealed the symptoms, the kind of health provider that ordered the test (attending, resident, physician assistant/advanced practice registered nurse (PA/APN), or registered nurse), and whether there were any positive strep throat contacts. Finally, the child's age in months and any prescribed antibiotics were documented. All the information was entered into an excel spreadsheet with each data point representing one visit.

We used the recommended guidelines set by the American Academy of Pediatrics to determine if tests were ordered appropriately. Therefore, any child that had 1) a positive strep contact at home or daycare, 2) a classic maculopapular rash and also displayed appropriate symptoms (including an erythematous or exudative oropharynx, cervical lymphadenopathy, and/or fever), or 3) concerns for a complication of strep such as rheumatic fever or glomerulonephritis. Anything not covered by these guidelines was considered inappropriate.

2.2. Statistical Analysis

Data was analyzed in JMP. I used feature selection and created a logistic model to determine which factors contributed to inappropriate/appropriate testing.

The proportion of appropriate and inappropriate tests over time was calculated with a chi-square test. First, the data was grouped into 2-month intervals using "binning." Then the proportion of appropriate and inappropriate tests was compared between the different groups using a chi-square test. It was displayed with a histogram (rather than a mosaic plot) to show that actual number of tests, rather than just the proportions.

The locations were grouped by type (emergency department or urgent care). A Chi-square test compared the proportions of appropriate and inappropriate tests by location. Some of the data points did not include location, and these data points were excluded from the calculation (45 out of 1163).

To compare the proportions of providers that were ordering appropriate strep tests versus inappropriate strep tests, a chi square test was performed. The four categories of providers were attending physician, resident, PA/APN, and registered nurse. The proportions were also graphed using Pareto charts—one showing the proportions of appropriately ordered-tests and the other one showing the provider proportions of inappropriately-ordered tests.

3. Results

The logistic model using feature selection showed that date, age, and who ordered the test were significant variables in the model (Figure 1). The accuracy of the model was 0.67. The model had a sensitivity of 0.05 and specificity of 0.99 (Figure 2).

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Date	1	1	55.1765242	<.0001*
Age (mos)	1	1	15.1197081	0.0001*
Who Ordered	3	3	13.767251	0.0032*

Figure 1. Results of logistic model showing the factors contributing to appropriate and inappropriate testing

Confusion Matrix

Training

Actual	Predicted Count	
Appropriate?	appropriate	inappropriate
appropriate	14	245
inappropriate	6	898

Figure 2. Confusion Matrix for logistic model

The chi-square test comparing the proportions of appropriate/inappropriate tests between dates showed significant results (Figure 3). The histogram of appropriate and inappropriate tests overlaying the date and using binning shows that over time, the proportion of tests that were appropriate increased (Figure 4).

Tests

N	DF	-LogLike	RSquare (U)
1163	6	29.481132	0.0478

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	58.962	<.0001*
Pearson	62.808	<.0001*

Figure 3. Results of a chi-square showing a significant difference between the proportion of appropriate/inappropriate testing over time

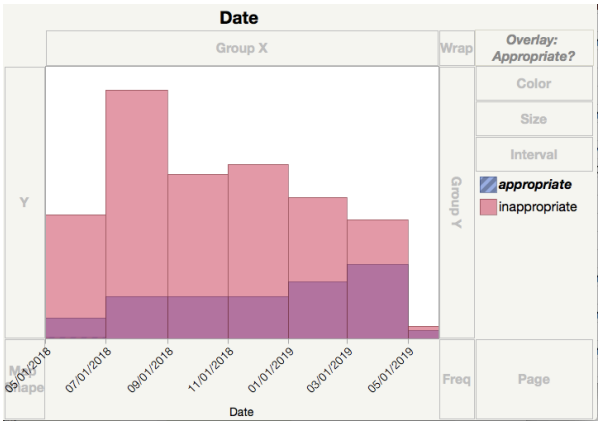

Figure 4. Histogram displaying the proportion of appropriate and inappropriate tests over time

The chi-square test comparing the proportions of appropriate and inappropriate tests by location revealed a significant difference between urgent cares and emergency departments (p = 0.004). The percentage of appropriate tests ordered at urgent cares was 30% and at the emergency department was 21% (Figures 5 and 6). See Figure 9 in the appendix for the contingency table.

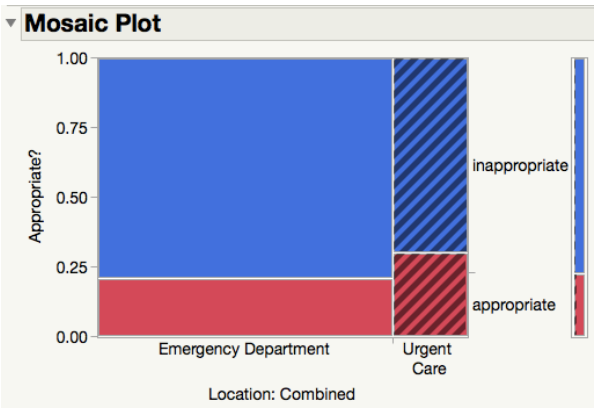

Figure 5. Mosaic Plot displaying the proportion of appropriate and inappropriately tests by location

Tests

N	DF	-LogLike	RSquare (U)
1118	1	4.0641778	0.0068

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	8.128	0.0044*
Pearson	8.526	0.0035*

Figure 6. Chi square test shows a significant difference in the proportion of appropriate/inappropriate tests by location

Most strep tests were ordered by advanced practice registered nurses and physician assistants (APN/PAs), followed by attending physicians, registered nurses, and finally residents. Both appropriate and inappropriately-ordered tests showed this order of providers, as seen in Figure 7.

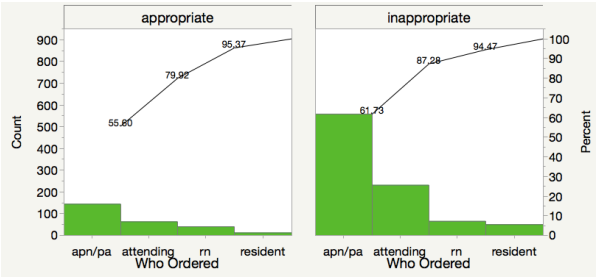

Figure 7. Pareto Chart displaying providers that order appropriate and inappropriate strep tests

As determined by the chi square test, the proportion of providers ordering appropriate tests was significantly different from the proportion ordering inappropriate tests (Figures 8 and 9). The Chi Square value likelihood ratio was 15.067 and the p value was 0.0018. Specifically, registered nurses were more represented in the tests that were appropriately ordered

and PA/APNs were more represented in the tests that were inappropriately ordered. (See Figure 10 in the appendix for the contingency table).

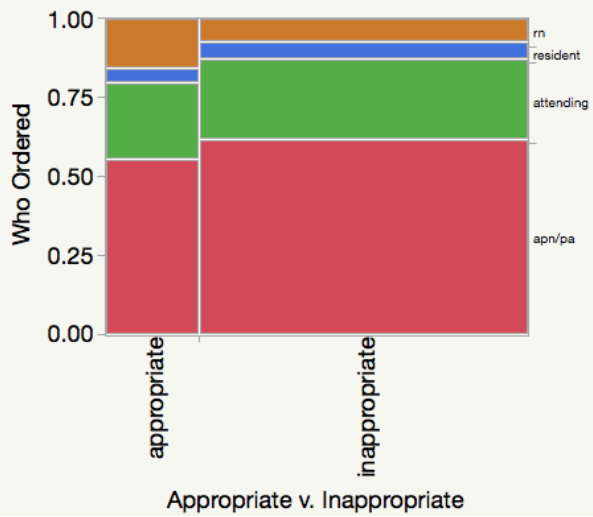

Figure 8. Chi Square Mosaic Plot displaying the proportions of providers ordering appropriate and inappropriate strep tests

Tests

N	DF	-LogLike	RSquare (U)
1163	3	7.5334276	0.0122

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	15.067	0.0018*
Pearson	16.868	0.0008*

Figure 9. Results of Chi Square test comparing the proportion of providers ordering appropriate/inappropriate tests

Finally, a logistic regression was performed for appropriate/inappropriate testing by the age of the child because "Age" was a significant variable in the original logistic model with feature selection. The logistic regression for age showed no pattern between the two variables, (R^2 = 0.002 and p = 0.1135), indicating no relationship between age and testing (Figure 11 in Appendix).

4. Discussion

The results show that the ordering health provider, location, and date all had a significant relationship with whether a test was appropriate or inappropriate, while the age of the child did not. These results can be explained within the context of the study.

There was a significantly higher proportion of tests that were inappropriately ordered at emergency departments than at urgent cares. My thought is that in the emergency setting, parents are more concerned about their child's wellbeing and are more likely to insist on them being tested. Often, a parent's judgement can be clouded by anxiety [18], even when presented with reasons why being tested would not be in the child's best interest. Additionally, health providers can be pressured by parents into ordering tests simply to ease their anxiety [19-21].

Interestingly, registered nurses had the highest proportion of appropriate tests and APN/PAs had the lowest. This does not align with my hypothesis that higher education is a factor involved in appropriate testing, given that registered nurses have the least education out of the group. Therefore, the differences between testing among different providers might be due to different demands or the roles of each position.

Finally, the proportion of appropriately-ordered tests increased with time. This is likely due to the educational initiatives that were introduced throughout the year to make providers aware of the guidelines for strep testing. In October, an educational meeting was held at Dayton Children's Hospital for health providers regarding the appropriate guidelines. The providers then received regular education sessions in November and feedback on their performance in February. As these initiatives were added, the percentage of appropriate tests increased (Figure 12 in the appendix). This suggests that teaching providers and holding follow-up reminders will have a positive effect on them ordering fewer inappropriate tests.

This study had a number of weaknesses. First, there are a number of factors that influence differences in strep testing throughout the year. For example, more tests are ordered in the winter because of the higher prevalence of illness at that time of the year [1], [12], [14]. Because the data in this study spanned a full year, differences in ordering strep tests may have influenced the data.

Additionally, some of the statistical tests suggested underlying reasons for inappropriate testing, but did not directly test them. For example, the difference in appropriate/inappropriate testing between emergency and urgent care settings might suggest that parents have an influence on whether a test will be ordered, but this was not directly tested. A better study would see if strep tests were more likely ordered under the insistence of a parent, compared to no parental request. Likewise, the increase in appropriate tests over time would lead one to think that the educational initiatives played a role, but this was not directly tested either. A better way to test this would be to see if there was a

significant difference before and after specific educational initiatives were introduced.

While the results did not directly test certain factors, they did bring patterns to light that can be studied in the future. In particular, it appears that education both for the health provider and parent may lead to more appropriate testing. Future tests should investigate whether educational programs for providers, such as provider feedback and reminders, yield improvements. Additionally, a study that addresses how to best teach parents about the reasons for testing a child under 3 for strep would be useful. The study might assess whether conversations or flyers are effective modes of educating parents. Finally, it might be helpful to investigate the best way to approach parents in the emergency department versus urgent care setting to ease any anxiety about strep.

5. References

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6. Appendix

Contingency Table

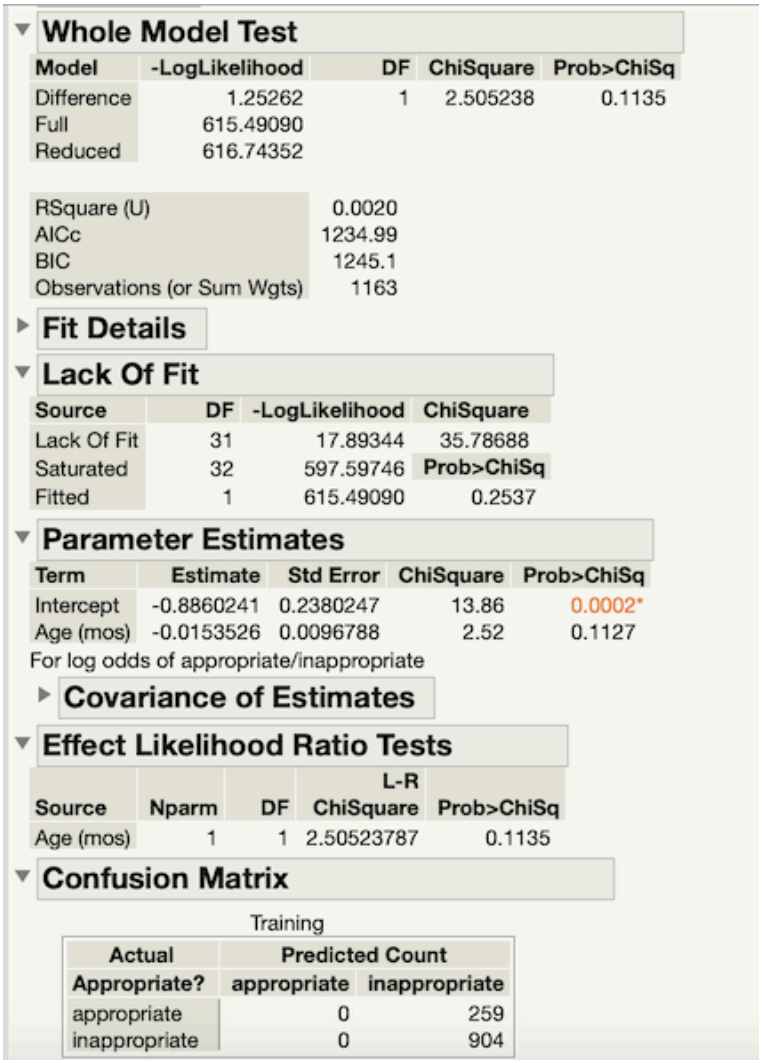
Location: Combined		Appropriate?		
	Count Total % Col % Row %	appropriate	inappropriate	Total
Emergency Department		187 16.73 73.33 20.96	705 63.06 81.69 79.04	892 79.79
Urgent Care		68 6.08 26.67 30.09	158 14.13 18.31 69.91	226 20.21
Total		255 22.81	863 77.19	1118

Figure 9. Contingency table for appropriate/inappropriate testing by location

Contingency Table

Who Ordered		Appropriate?		
	Count Total % Col % Row %	appropriate	inappropriate	Total
		20.51	79.49	
attending		63 5.42 24.32 21.43	231 19.86 25.55 78.57	294 25.28
resident		12 1.03 4.63 19.35	50 4.30 5.53 80.65	62 5.33
rn		40 3.44 15.44 38.10	65 5.59 7.19 61.90	105 9.03
Total		259 22.27	904 77.73	1163

Figure 10. Contingency table for appropriate/inappropriate testing by ordering provider



Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	1.25262	1	2.505238	0.1135
Full	615.49090			
Reduced	616.74352			

RSquare (U)	0.0020
AICc	1234.99
BIC	1245.1
Observations (or Sum Wgts)	1163

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	31	17.89344	35.78688
Saturated	32	597.59746	Prob>ChiSq
Fitted	1	615.49090	0.2537

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-0.8860241	0.2380247	13.86	0.0002*
Age (mos)	-0.0153526	0.0096788	2.52	0.1127

For log odds of appropriate/inappropriate

Covariance of Estimates

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Age (mos)	1	1	2.50523787	0.1135

Confusion Matrix

Training

Actual	Predicted Count	
Appropriate?	appropriate	inappropriate
appropriate	0	259
inappropriate	0	904

Figure 11. Results from logistic regression of age by appropriate/inappropriate testing

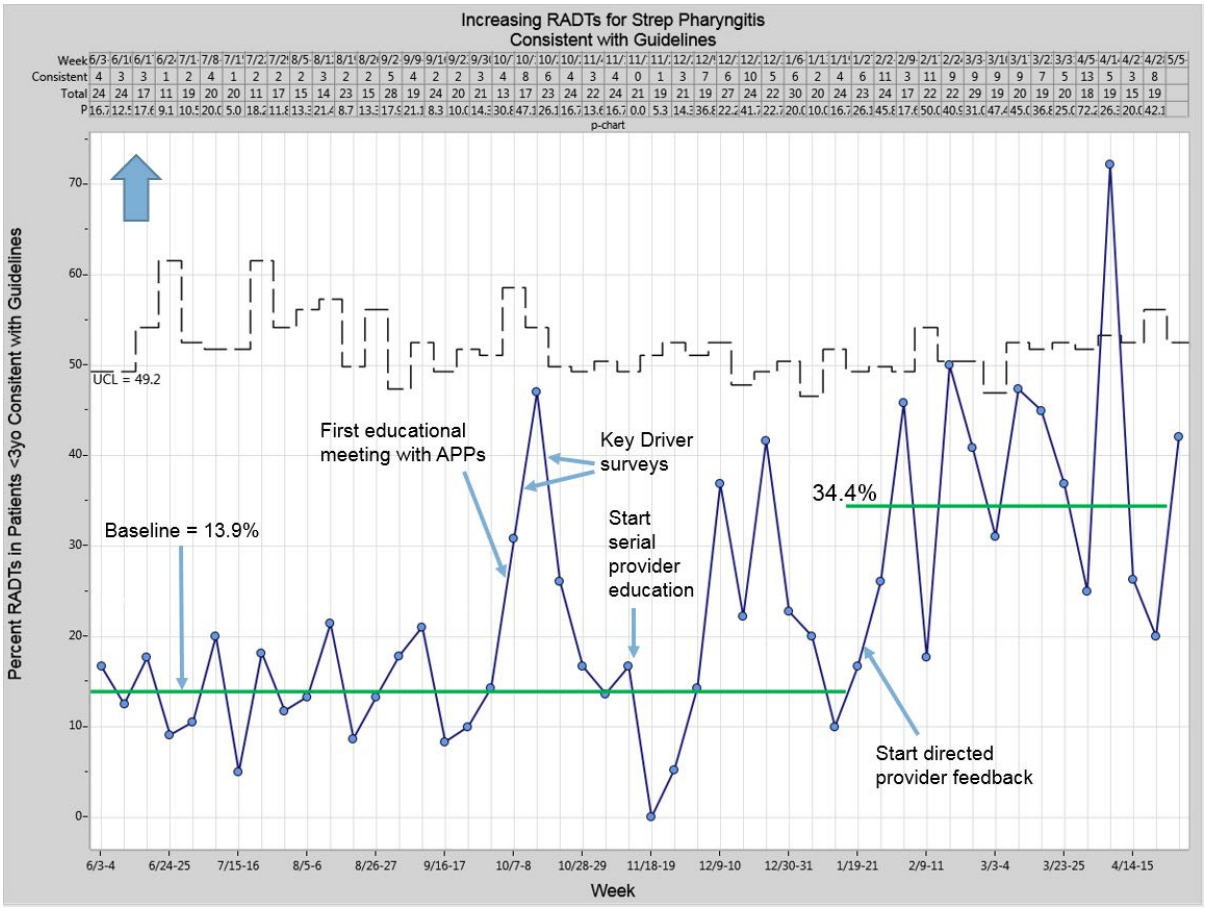


Figure 12. Shows a timeline of educational initiatives for appropriate step testing at Dayton Children's Hospital and the percentage of strep tests that were consistent with guidelines