Cost Effectiveness of a Point-of-Care Test for Adenoviral Conjunctivitis

BELINDA L. UDEH, PhD; JOHN E. SCHNEIDER, PhD; ROBERT L. OHSFELDT, PhD

ABSTRACT: *Background:* Conjunctivitis is a relatively common condition of the eye that can be caused by a number of different pathogens including bacteria and viruses. Clinical differentiation between adenoviral and bacterial conjunctivitis is difficult, often resulting in misdiagnosis and the provision of inappropriate treatment. *Methods:* A cost-effectiveness analysis was performed from a societal perspective using primary, secondary, published literature, and expert opinion data sources. The incremental costs and effects (cases of unnecessary antibiotic treatment avoided) for a rapid point-of-care test for adenoviral conjunctivitis (RPS Adeno Detector) were modeled. *Results:* Using base case values, the incremental cost of using no point-of-care test compared with the point-of-care test is $71.30 with 0.1786 cases of unnecessary antibiotic treatment. Extrapolating these costs to the entire U.S. population per annum, society could potentially save nearly $430 million currently spent on unnecessary medical care and avoid over 1 million cases of unnecessary antibiotic treatment. The no-point-of-care test strategy is both more costly and less effective; indicating that the point-of-care test strategy is the most cost-effective option. The results were robust to variation in key model parameters. *Conclusions:* Through the use of a rapid point-of-care test for adenovirus, much of the cost to society caused by acute conjunctivitis can be avoided through more timely and accurate diagnosis. **KEY INDEXING TERMS:** Cost effectiveness; Adenoviral; Conjunctivitis. **[Am J Med Sci 2008;336(3):254–264.]**

Conjunctivitis is a relatively common condition of the eye that occurs worldwide, affects all ages and social strata.[1] Conjunctivitis can be caused by a number of different pathogens, including bacteria and viruses, or may be caused by such things as allergies, irritants, or medications. Most types of conjunctivitis are self limiting, but some may progress and cause serious ocular and extraocular complications.[1] A survey conducted in 1972 reported that conjunctivitis in the United States occurs in 13 of every 1000 people between the ages of 1 and 74.[2] A more recent analysis of Medstat commercial insurance data estimated that conjunctivitis affects close to 3.5 million with private insurance.[3] Approximately 3% of all emergency department visits are ocular related, and of these, conjunctivitis is indicated in 30% of cases.[4] Among patients visiting primary care physicians, 2% of all visits are for eye complaints with 54% of these cases being diagnosed as conjunctivitis or corneal abrasion.[5] Several studies have reported that the majority of these cases—as much as 2% of all general practice consultations—are cases of acute infective conjunctivitis.[6–11] A survey of 8723 children in Taiwan looked at the prevalence of childhood allergic and infectious diseases. Purulent conjunctivitis accounted for 2.5% of the 12-month prevalence of diagnosis of infectious diseases and 0.2% lifetime rate of admission because of infectious diseases.[12] A meta-analysis of 6 U.S. studies demonstrates a prevalence of adenovirus of approximately 36% of all cases of acute conjunctivitis.[7–11,13]

The main thrust of the aforementioned epidemiologic and clinical research suggests that there are potential clinical and economic gains from improvements in diagnosis and management of conjunctivitis. In this article, we address one part of this challenge: diagnosis. Specifically, we examine the cost effectiveness of a point-of-service test for adenoviral conjunctivitis. The early identification of viral conjunctivitis has the potential to reduce unnecessary antibiotic usage, reduce work-loss and school-loss days, and assist in better management of the condition, which in turn has the potential to reduce contagiousness and shorten the duration of illness spells.

From the Health Economics Consulting Group (BU, JES), LLC, Morristown, New Jersey; and Department of Health Policy and Management (RLO), School of Rural Public Health, Texas A&M Health Science Center, Texas.

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Correspondence: John E. Schneider, PhD, Health Economics Consulting Group, LLC, 167 Mills St., Morristown, NJ 07690 (E-mail: jeschneider@hecg-llc.com).

Background

Because of its common occurrence, contagiousness, and potentially debilitating symptoms, conjunctivitis has the potential for substantial societal impact. In addition to the health and productivity burden, conjunctivitis has the potential to cause substantial economic burden. The costs of conjunctivitis include direct costs—such as diagnosis and treatment (self-treatment and treatment by medical professionals), prescription drugs, work-loss days,[14] informal care, and alike. Indirect costs include avoidable medical care utilization ex post (eg, avoidable medical consultations and reconsultations, avoidable hospital admissions), reductions in health-related quality of life, and reductions in school time for school age children.[15–18]

The bulk of the costs incurred to a patient with conjunctivitis include the cost of the physician consults, supportive care, diagnostic tests, and lost productivity associated with time away from work or school. Adding an additional layer of complexity, conjunctivitis is commonly misdiagnosed. Misdiagnosed cases may have substantially higher costs, including repeat physician visits, additional diagnostic testing, referrals to specialists, and other medical costs associated with inappropriate treatment.[3,19,20] A misdiagnosis may also imply that proper precautions were not taken to prevent the spread of infection (especially in the case of viral conjunctivitis), thereby adding additional cases and costs. Moreover, misdiagnosis of the causative agent of conjunctivitis may lead to misdiagnoses of associated morbidities or underlying systemic diseases.

Prescription antibiotic utilization constitutes a large proportion of conjunctivitis costs. For example, in the Netherlands more than 900,000 prescriptions for topical ocular antibiotics were issued in 2001, for a total cost of approximately US $10.9 million dollars.[21] Antibiotic prescriptions for the treatment of conjunctivitis cost the British National Health System (NHS) approximately US $8.7 million per year.[22] Unnecessary or inappropriate prescription of antibiotics is in part attributable to physician difficulties accurately discriminating between viral and bacterial conjunctivitis. Consequently, the standard of care for conjunctivitis, regardless of causative agent, continues to be antibiotics prescribed empirically. Over-utilization of prescription drugs is likely to result in substantial unnecessary costs, contribute to antibiotic resistance, and expose patients to drug-related topical allergies and toxicity.

Nosocomial conjunctivitis infections have also been shown to incur substantial costs. For example, one study found that an outbreak of adenoviral keratoconjunctivitis in a long-term care facility incurred US $29,527 in additional medical, investigative and productivity costs.[23] Nosocomial outbreaks can also lead to extended inpatient stays, additional staffing costs, and reduced productivity. In some cases, nosocomial infections can lead to temporary closure of units or entire facilities, thereby incurring broader costs associated with lost wages and revenue. For example, a study from India examined the economic impact of epidemic hemorrhagic conjunctivitis in a rural community. Of the 7230 families surveyed in 1981, 35% of families reported being affected and 62% of these families reported that at least 3 members of their household had contracted conjunctivitis. The disease burden was found to have led to a loss of 7735 work days and a significant loss of income.[24] Similarly, a U.S. study of the cost-effectiveness of preventing herpes simplex virus eye disease with acyclovir prophylaxis found that US $17.7 million is spent to treat 59,000 new and recurrent cases in 29,000 individuals each year, and acyclovir prophylaxis cost US $8532 per case of ocular herpes simplex virus averted.[25]

Several studies have evaluated the economic and quality of life impact of allergic conjunctivitis. For example, a study conducted in England demonstrated that seasonal allergic conjunctivitis was highly prevalent and associated with significant reductions in ocular performance and quality of life and significant increases costs.[26] Similar findings were reported in a study conducted in Spain.[27]

Studies have also addressed the economic impact of alternate tests and treatments for the various causative pathogens of conjunctivitis. For example, a study from England examined the value and cost-effectiveness of double-culture tests for diagnosis of ocular viral and chlamydial conjunctival infections.[28] From the eye swabs of 4132 patients, laboratory isolation tests showed a positive result for chlamydia, adenovirus or herpes simplex virus in 17% of cases. In those cases of positive isolation, only 49% agreed with the clinical diagnosis whereas 51% had no definitive diagnosis or had been clinically diagnosed incorrectly. This study demonstrated that by routinely testing for all ocular specimens at the initial visit, appropriate treatment can be initiated sooner and patients do not have to return for subsequent visits for further testing therefore saving additional healthcare and private expenses.

The main objective of this article is to examine the cost effectiveness of a point-of-service test for adenoviral conjunctivitis. A meta-analysis of 6 U.S. studies demonstrates a prevalence of adenovirus of approximately 36% of all cases of acute conjunctivitis.[7–11,13]

Methods

Overview. Following basic cost-effectiveness methodology,[17,18,29] a cost-effectiveness analysis was performed using a decision analytic model. The interventions evaluated include the use of a rapid point-of-care test (RPS Adeno Detector, hereafter referred to as AVD) for cases of acute conjunctivitis (viral and bacterial) as compared with no use of a point-of-care test (hereafter referred to

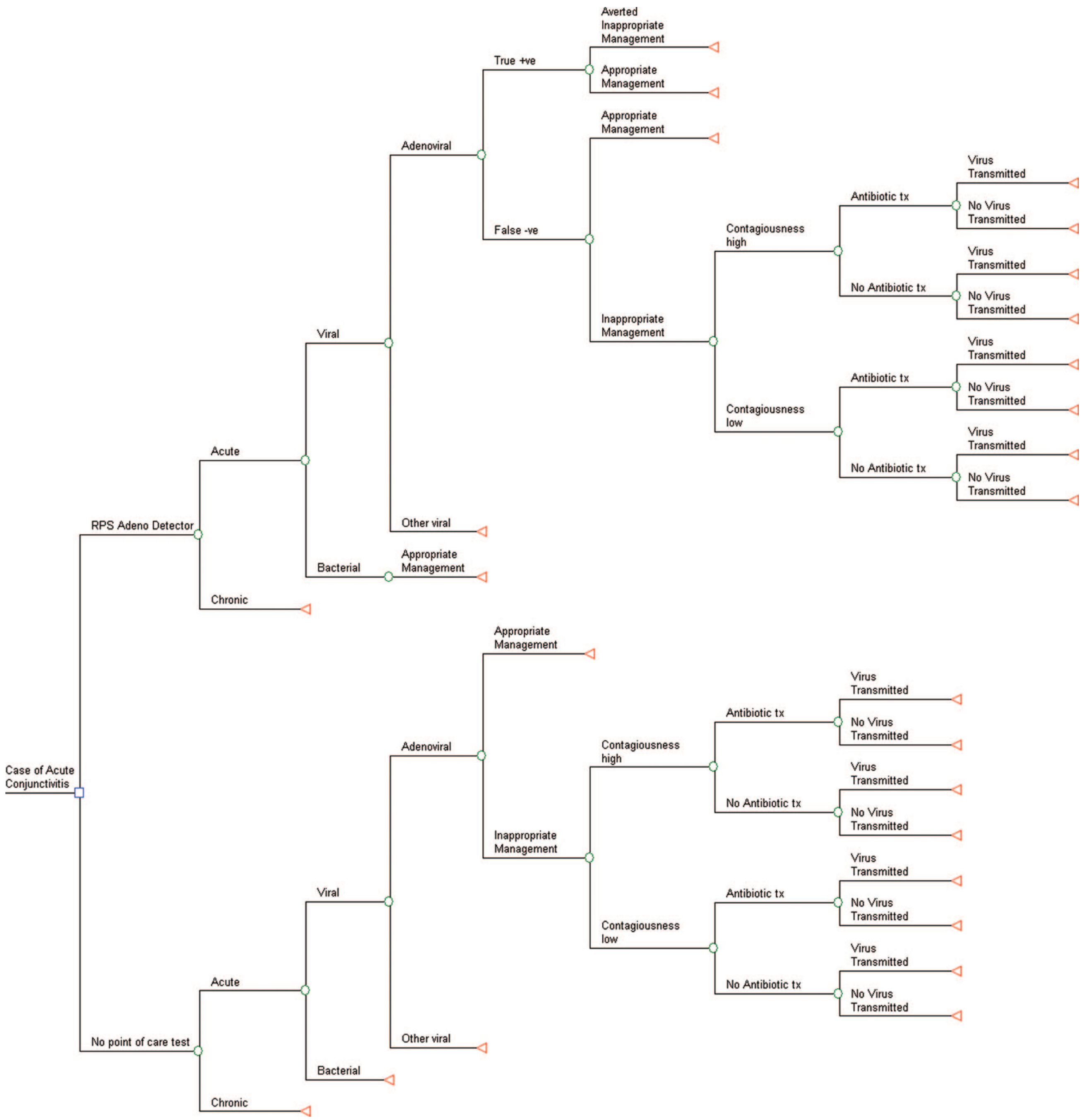

Figure 1. Cost effectiveness model—RPS Adeno Detector.

as NAVD). A complete representation of the decision analytic model is presented in Figure 1. A societal perspective was adopted for this analysis with the impact that conjunctivitis has on productivity being considered. Prevalence data are considered for the entire United States, and all costs are for the year 2006 in US $.

Estimates were derived of the incremental costs of testing, treatment, condition and treatment morbidities, and disease event costs. The savings in avoiding a case of inappropriate antibiotic use are subtracted to derive a net cost of the strategy. The incremental benefit of avoiding cases of inappropriate antibiotic use are weighed against the net costs to produce the cost per case of inappropriate antibiotic use avoided with the results being used to predict the incremental cost-effectiveness ratio (ICER) for each strategy and identify which is cost-effective (less or more costly but more effective) and which are dominated (both more costly and less effective). The ICER was calculated by dividing the difference in effectiveness of the rapid point-of-care test and not using the rapid point-of-care test, against the difference of the expected value of the rapid point-of-care test and no rapid point-of-care test. To further put the results in context, the CE ratios were converted to a societal figure to represent the potential costs and effects for the entire United States.

The value of the parameters used in these calculations was sourced from primary data sets, published literature, and expert

Table 1 Baseline Values, Ranges and Sources of Key Parameters

Parameter and Source	Baseline Value	Range
U.S. Population[31]	298.44 mil	
Prevalence Conjunctivitis PCP[2,4,5,7–9,11,32]	0.0171	
Prevalence Conjunctivitis ER[2,4,5,7–9,11,32]	0.0035	
[a]Prevalence Acute Conjunctivitis[33–38]	0.98	(0.9, 1.0)
[b]Prevalence Viral Conjunctivitis[33,39–42]	0.45	(0.4, 0.5)
Prevalence of Bacterial Conjunctivitis[33,39–42]	0.45	(0.4, 0.5)
[c]Prevalence Adenoviral Conjunctivitis[7–11,13,33,43–46]	0.91	(0.8, 1.0)
Percent adenoviral cases high contagiousness[47]	0.75	(0.50, 1.0)
Percent adenoviral cases low contagiousness[47]	0.25	(0.0, 0.50)
Percent transmit virus (high contagiousness)[48–56]	0.46	(0.1, 0.67)
Percent transmit virus (low contagiousness)[56,57]	0.10	(0.05, 0.15)
Percent adenoviral cases misdiagnosed[43,58]	0.50	(0.25, 0.75)
Percent misdiagnosed cases prescribed antibiotics[59–64]	0.80	(0.65, 0.95)
Percent misdiagnosed cases requiring re-consultation[54,55,65–72]	0.50	(0.25, 0.75)
Percent misdiagnosed cases requiring referral[11,63]	0.08	(0.0, 0.16)
Number of days absent from work/school (incorrect diagnosis)[73]	2.00	(1, 3)
Number of days absent from work/school (correct diagnosis)[d,69,73,74–77]	5.00	(2, 10)
Prevalence antibiotic morbidity[78]	0.10	(0.02, 0.18)
Prevalence adenoviral conjunctivitis morbidity[7,47,54,55,65–67,71,79–81]	0.50	(0.1, 0.9)
Sensitivity RPS Test[82]	0.89	(0.74, 0.96)
Cost RPS test[83]	$24.00	($18.00, $30.00)
Cost Physician consult primary consult[84,85]	$154.77	($116.08, $193.46)
Cost Physician consult referral consult[84,85]	$267.80	($200.85, $334.75)
Cost Course antibiotics[85,86]	$44.00	($33.00, $55.00)
Cost Conservative therapy[87]	$17.28	($12.96, $21.60)
Cost day lost productivity[85,88]	$147.68	($110.76, $184.60)
Cost antibiotic morbidity[56,84,86]	$267.80	($200.85, $334.75)
Cost adenoviral conjunctivitis morbidity[56,84,86]	$302.53	($226.90, $378.16)
Cost steroid treatment[85,86]	$34.73	($26.05, $43.41)

[a] *Within cases of conjunctivitis presenting to primary care (PCP) and emergency rooms (ER).*

[b] *Within cases of acute conjunctivitis.*

[c] *Within cases of viral conjunctivitis.*

[d] *Dart J. Personal Communication.*

opinion. The parameters used in the analysis are listed in Table 1. For each parameter, a baseline value is listed along with a favorable and unfavorable value. (High–low ranges were determined by either the lowest and highest value reported in the literature, a confidence interval based on sample variance, or a ±25 percent variance applied for cost parameters. For parameters with a greater uncertainty surrounding its value, a larger range was defined.) The baseline value was chosen based on primary data or the value most commonly referenced. The favorable and unfavorable values define the range around which the robustness of the results was tested. As an additional check on the robustness of some of the key data elements, Medstat supplied MarketScan data on conjunctivitis cases appearing in their large merged data file of commercial health insurance claims. This analysis utilized the 2005 MarketScan Commercial Claims and Encounters Database, which included the enrollment, claims (paid and adjudicated), and encounter records for employees and dependents who received coverage from large, self-insured employers.[30] Patients are selected for this study if they had any claims with a conjunctivitis diagnosis in 2005. Patients who had this diagnosis on a laboratory claim (CPT procedure codes 80000-89999) and no other claims were not included, as these are likely to be rule-out diagnoses. In addition, patients were required to have been enrolled in the database for the entire year (n = 10.9 million).

Incremental Benefits. Incremental benefits were measured in cases of inappropriate antibiotic treatment avoided. A case was defined as a case of adenoviral conjunctivitis that would have otherwise been misdiagnosed and prescribed antibiotics had the rapid point-of-care test not been used. It was determined that a large portion of incorrectly diagnosed cases of adenoviral conjunctivitis would be prescribed antibiotics unnecessarily but with correct diagnosis, it was assumed that conservative therapy would be provided. Other assumptions were made that AVD would be used for all cases of bacterial and viral conjunctivitis, that diagnosis without AVD would be made by clinical findings and that all secondary transmissions will be correctly diagnosed at the time of initial physician consult. The probability of avoiding a case of inappropriate antibiotic treatment is based on the probability of misdiagnosing a case of adenoviral conjunctivitis with diagnosis by clinical findings, the probability that antibiotics would be prescribed and the sensitivity of AVD.

Identification of Incremental Costs. Values for all relevant positive and negative costs were included in this analysis. Positive costs of the analysis include the additional cost of AVD, the additional cost of conservative therapy with correct diagnosis, the additional costs of productivity losses because of the additional time recommended to be absent from work/school because of infectivity, and the additional costs of an incorrect diagnosis using AVD when its sensitivity is considered. Negative costs include the costs of unnecessary antibiotic therapy avoided with correct diagnosis; costs of unnecessary reconsults avoided, costs of unnecessary referrals avoided, costs of secondarily transmitted infection averted, costs of unnecessary antibiotic morbidities and the costs of unnecessary misdiagnosis morbidities. To estimate the value of these costs, we assume several assumptions. First, if a child is infected, the same productivity losses will apply as a caregiver will be needed. Second, we assume that typically the diagnosing physician will have a primary focus on family practice, internal medicine, pediatrics, or emergency medicine. Third,

Table 2 Summary of Average Cost Effect Outcomes per Case of Acute Conjunctivitis per Annum and for the Entire U.S. Population

Strategy	Per Case of Acute Conjunctivitis Per Annum		Entire U.S. Population per Annum	
	Cost ($)	Effect[a]	Cost ($)	Effect[b]
RPS Adeno Detector	40.25	0.1786	242,407,034	1,075,522
No point-of-care Test	111.56	0	671,874,004	0

[a] *Case of inappropriate antibiotic treatment avoided.*

[b] *Number of cases of acute conjunctivitis in the U.S. population per annum equals 6,022,535.*

we assume that all referrals are made to ophthalmologists. Fourth, we assume that all primary and secondarily transmitted infections will comply with the recommended time off work or school.

Uncertainty and Sensitivity Analyses. In addition to the base case analysis discussed, rigorous sensitivity analysis was used to explore the robustness of the results to uncertainty within the model parameters. The variables for which the model results were most sensitive were identified through a series of one-way sensitivity analysis used to produce a tornado diagram. These identified variables were more rigorously tested using a threshold and two-way sensitivity analyses. To further test the robustness of results to uncertainty within the model, a micro-simulation was performed to simulate a variety of parameter changes. The models simulate the costs, outcomes, and net benefits of a representative patient, repeating the process to generate robust estimates.

Results

Using baseline values, if no point-of-care test is used, the average cost per case of acute conjunctivitis to society is $111.56 with no effects (ie, no cases of inappropriate antibiotic treatment avoided). If AVD was used, there would be an average cost of $40.25 per case of acute conjunctivitis and 0.1786 cases of inappropriate antibiotic use would be avoided (for each application of AVD). These results are presented in Table 2. These average costs and effects produce an average cost effectiveness ratio for AVD of $225.40 per case of inappropriate antibiotic treatment avoided (Table 3). An average cost effectiveness ratio could not be calculated for NAVD strategy because it produces no effects.

When considering incremental costs and benefits (the change in costs or benefits of NAVD versus AVD) using the least costly strategy as the baseline (AVD), the incremental cost of NAVD equates to US$71.30 [refers to the difference between the cost per case of acute conjunctivitis to society with NAVD (US$111.56) and AVD (US$40.25)] and −0.1786 cases of inappropriate antibiotic treatment avoided [refers to the difference between the number of cases of inappropriate antibiotic treatment avoided with NAVD (0) and AVD (0.1786)]. An ICER could not be calculated because the NAVD strategy is clearly dominated by the AVD strategy. The NAVD strategy is both more costly and less effective, indicating that the AVD strategy is the most cost-effective option.

The results were expanded to reflect the costs and effects for the entire U.S. population per annum. Previous calculations indicated that there were approximately 6 million cases of acute conjunctivitis in the United States each year.[3] When considering average costs and effects, the NAVD strategy results in a societal cost of US $671.9 million attributable to cases of acute conjunctivitis (with no cases of inappropriate antibiotic use avoided). In contrast, the AVD strategy lowers those costs to US $242.4 million and 1.1 million avoided cases involving antibiotic use. When considering the incremental costs and effects, the AVD strategy could potentially save US $429.4 million and avoid 1.1 million cases of inappropriate antibiotic use.

The series of one-way sensitivity analyses (ie, the "tornado" analysis) determined that 8 variables accounted for 99.9% of the uncertainty within the model (Figure 2): percent of cases of adenoviral conjunctivitis misdiagnosed; clinical sensitivity of

Table 3 Summary of Incremental Cost and Effect Outcomes per Annum per case of Acute Conjunctivitis and for the Entire U.S. Population

Strategy	Per Case of Acute Conjunctivitis Per Annum		Entire U.S. Population per Annum		C/E $/a	ICER
	Incremental Cost ($)	Incremental Effect (a)	Incremental Cost ($)	Incremental Effect (a)		
RPS Adeno detector					225.40	
No point-of-care test	71.30	−0.1786	429,406,746	−1,075,522	Undefined	Dominated

[a] *Case of inappropriate antibiotic treatment avoided.*

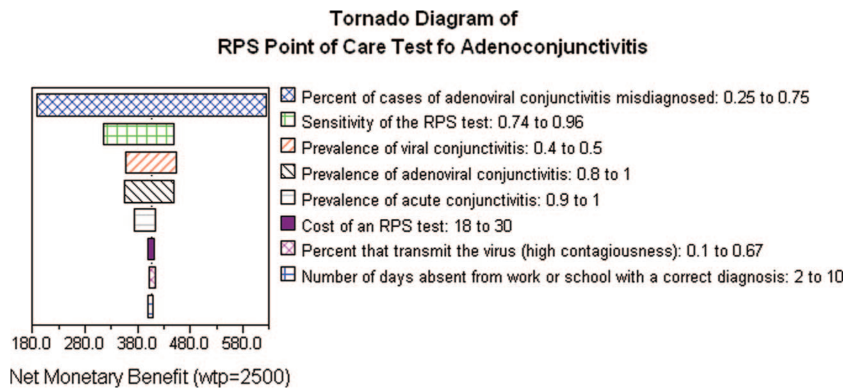

Figure 2. Tornado diagram for the 8 most influential variables.

the AVD; prevalence of viral conjunctivitis; prevalence of adenoviral conjunctivitis; prevalence of acute conjunctivitis; cost of the AVD; percent of patients who transmit the virus (ie, high contagiousness); and the number of days absent from work or school with correct diagnosis.

These 8 variables have the greatest influence on the uncertainty and are therefore considered the "drivers" of the results of this model. However, it is interesting to note that of the 8 variables considered to be model drivers, the percent of cases of adenoviral conjunctivitis misdiagnosed accounts for nearly 80% of the uncertainty within the model. Further sensitivity analysis was performed on the 8 variables to determine threshold points; that is, the points at which the choice of optimal strategy would change with a change in parameter value. The analysis did not determine a threshold point for any of the 8 variables. This suggests that the superiority of the AVD strategy is robust to any reasonable changes in these key parameters. Figures 3 and 4 present the sensitivity analysis of the 2 variables accounting for the greatest level of uncertainty (Table 4).

Further sensitivity analysis was performed on the unit price of AVD and the prevalence of adenovirus to determine the point at which the test would be considered cost neutral when compared with NAVD and to determine in more detail how the point-of-cost neutrality and cost savings is affected by this change. These results are presented in Table 5. In the base case analysis (which assumes 0.91 adenovirus prevalence of viral conjunctivitis), the NAVD societal cost per case of acute conjunctivitis is about US $112. Thus, the unit price of AVD would need to be $96.80 to equate the costs to society of NAVD and AVD. If the adenovirus prevalence of viral conjunctivitis is assumed to be 0.80 (as opposed to 0.91), the cost to society per case of acute conjunctivitis with NAVD is close to US $100. The unit price of AVD would need to be US $74.80 to reach the same cost to society. Finally, if the prevalence of adenovirus of viral conjunctivitis was only 0.70, the cost to society when no test is used would be about $86, and the unit price of AVD would need to be US $85.10 to reach the same cost to society.

Additional sensitivity analyses were performed to determine the impact of the perspective of the analysis (societal versus payer) on the results. The main difference between the 2 perspectives is that the payer perspective does not include indirect costs such as productivity attenuation at school or work. From the payer perspective, the NAVD strategy produces an average cost per case of acute conjunctivitis of US $56.73, with no cases of inappropriate

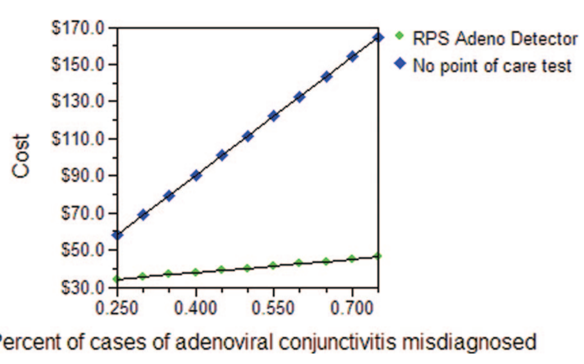

Figure 3. Sensitivity analysis on percent of cases of adenoviral conjunctivitis misdiagnosed.

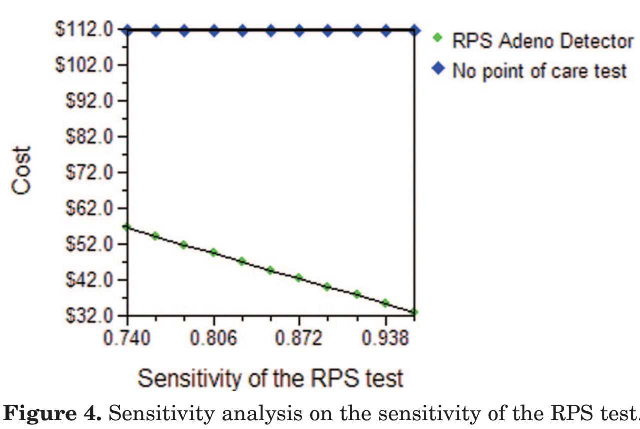

Figure 4. Sensitivity analysis on the sensitivity of the RPS test.

Table 4 Results of the Tornado Diagram for the 8 Most Influential Variables

Variable	Low EV	High EV	Low Input	High Input	Spread	Spread Sqr	Risk Pct	Cum Pct
Percent of cases of adenoviral conjunctivitis misdiagnosed	188.8	623.6	0.25	0.75	434.7377	188996.8	83.25769	83.25769
Sensitivity of the RPS test	315	448.8	0.74	0.96	133.7996	17902.34	7.886416	91.1441
Prevalence of viral conjunctivitis	358.5	454	0.4	0.5	95.49451	9119.202	4.017229	95.16133
Prevalence of adenoviral conjunctivitis	354.3	448.7	0.8	1	94.44512	8919.882	3.929424	99.09075
Prevalence of acute conjunctivitis	373	414.5	0.9	1	41.44952	1718.063	0.756848	99.8476
Cost of an RPS test	400.3	412.1	18	30	11.76	138.2976	0.060923	99.90853
Percent that transmit the virus (high contagiousness)	402.3	413	0.1	0.67	10.70312	114.5569	0.050465	99.95899
Number of days absent from work or school with a correct diagnosis	400.2	409.8	2	10	9.648417	93.09195	0.041009	100

indicates EV, expected value; Spread Sqr, Spread Square; Risk Pct, risk percent; Cum Pct, cumulative percent.

antibiotic treatment avoided. In contrast, the AVD strategy results in a cost per case of US $34.22 for acute conjunctivitis, with 0.1786 cases of inappropriate antibiotic use avoided. The incremental cost of the NAVD strategy is $22.51, which aggregates to a potential cost saving to society of US $135.6 million associated with the AVD strategy. Hence, the results differ by perspective but again demonstrate robustness as AVD remains the dominant strategy.

The final microsimulation was based on 10,000 simulations. The results of this analysis are presented similarly to the base case analysis, and are shown in Tables 6 and 7. Considering average costs and effects (Table 6), the NAVD strategy would cost US $107.82 per case of acute conjunctivitis, with no effect. The AVD strategy is associated with costs of US $38.89 per case of acute conjunctivitis, and prevents 0.1807 cases of inappropriate antibiotic use. The resulting average cost effectiveness for the AVD is −US $215.19. When considering incremental costs and benefits using the least costly strategy as the baseline (AVD), the NAVD strategy had an incremental cost of US $68.94 and −0.1807 cases of inappropriate antibiotic use avoided.

The microsimulation results for the average costs and effect were also extrapolated to the entire U.S. population assuming approximately 6 million cases of acute conjunctivitis each year. By using NAVD, acute conjunctivitis would cost society approximately US $649.3 million and have zero effect. In contrast, using AVD would only cost US $234.2 million. When considering incremental costs and effects, by using AVD, society could potentially save US $415.2 million and avoid 1.1 million cases of inappropriate antibiotic use.

Discussion

Conjunctivitis is a costly condition to society because of its commonality, its potential to be transmitted, its potential to be misdiagnosed, the potential for morbidities associated with both the condition and the treatment, and the potential loss of productivity because of absenteeism and presenteeism. This study demonstrated that much of the cost to society can be avoided with the correct diagnosis at the initial consultation. Under the NAVD strategy, over US $670 million is spent in the United States each year managing acute conjunctivitis, largely because of incorrect diagnoses and treatments. A direct implication of this study is that there is a clear business and clinical case for improv-

Table 5 Cost per case of Acute Conjunctivitis, Neutrality Price Points, and Cost Savings with the Change in Adenovirus Prevalence

	No Point-of-Care Test	RPS Adeno Detector		
Prevalence Adenovirus[a]	Cost ($)/Case of Acute Conjunctivitis	Cost ($)/Case of Acute Conjunctivitis	RPS test Neutrality Price Point ($)	Cost Savings[b,c]
0.91	111.56	40.25	96.80	$429.4 million
0.8	98.07	38.23	85.10	$360.4 million
0.7	85.81	36.91	74.80	$294.5 million

[a] *Within cases of viral conjunctivitis.*

[b] *Number of cases of acute conjunctivitis in the U.S. population per annum equals 6,022,535.*

[c] *RPS Adeno Detector cost per case of acute conjunctivitis multiplied by the number of cases of acute conjunctivitis in the U.S. population per annum.*

Table 6 Summary of Average Cost Effect Outcomes per Case of Acute Conjunctivitis per Annum and for the Entire U.S. Population from the Microsimulation

Strategy	Per Case of Acute Conjunctivitis Per Annum		Entire U.S. Population per Annum	
	Cost ($)	Effect[a]	Cost ($)	Effect[b]
RPS Adeno Detector	38.89	0.1807	234,216,386	1,088,272
No Point of Care Test	107.82	0	649,349,724	0

[a] *Case of inappropriate antibiotic treatment avoided.*

[b] *Number of cases of acute conjunctivitis in the U.S. population per annum equals 6,022,535.*

ing conjunctivitis diagnosis. Correct diagnoses are likely to positively impact care for conjunctivitis patients in several ways, including reducing unnecessary medical care; encouraging the provision of appropriate treatment; reducing the rate of unnecessary treatment morbidities; reducing the likelihood of transmitted; and allowing for more effective and efficient treatment of morbidities attributable to the infection. The business case is clear from both a societal and payer perspective: the AVD strategy is robustly associated with a savings of US $430 million. Furthermore, with the use of AVD, over 1 million cases of inappropriate antibiotic treatment could be avoided.

Our results also indicate that the price point of AVD is well below the price point at which it would be considered cost neutral, even at only an adenovirus prevalence of 0.70, when compared with NAVD. In addition, we show that the point-of-cost neutrality remains above the suggested retail price for an AVD even under the more restrictive payer perspective.

The results of this study were rigorously tested using sensitivity analysis to determine robustness of results to uncertainty in baseline parameter estimates used in the model. It was determined that the leading driver of the model was the percent of cases of adenoviral conjunctivitis misdiagnosed (ie, the NAVD strategy). As expected, as the percentage of cases misdiagnosed decreases, the benefit of using AVD also decreases. However, even if the misdiagnosed percentage was only 25%, the use of AVD would still be the optimal choice as it would still cost less to society than NAVD. All remaining variables were also tested, and in each case AVD remained the most cost effective choice. The results of the microsimulations confirmed the degree of robustness.

There are some important limitations to this study. First, the only available published data on the contagiousness of adenoviral cases was from a single Asian country, different in its population health status, geography, demographics, and socioeconomic characteristics. Moreover, for the variable measuring the percent of misdiagnosed cases of adenoviral conjunctivitis (i.e., cases of adenoviral conjunctivitis diagnosed initially as bacterial conjunctivitis or an alternative nonviral presentation of conjunctivitis) the data are from 1982 and 1983. The age of these studies suggests that they may not reflect changes and improvements in physician training and the ability to differentially diagnose. Additionally, there may be limitations to the generalizability of the data from the Medstat analysis, as it is from a commercially insured population. Second, this analysis does not address whether treatment failures are referred to a specialist or treated by a primary care physician. Third, the potential secondary effects of unnecessary use of antibiotics and antibiotic resistance were not explicitly modeled. Fourth, in spite of the model robustness, the results are sensitive to baseline assumptions. One important assumption is that the AVD would be used for every case of bacterial and viral conjunctivitis presenting to a physicians office. This assumption mitigates any clear and accurate clinical decisions that may be made by a physician without the assistance of AVD. If AVD was used only for differ-

Table 7 Summary of Incremental Cost and Effect Outcomes per Annum from the Microsimulation per case of Acute Conjunctivitis and for the Entire U.S. Population

Strategy	Per Case of Acute Conjunctivitis Per Annum		Entire U.S. Population per Annum			
	Incremental Cost ($)	Incremental Effect (a)	Incremental Cost ($)	Incremental Effect (a)	C/E $/a	ICER
RPS Adeno Detector					215.19	
No Point of Care Test	68.94	−0.1807	415,193,563	−1,088,272	Undefined	Dominated

[a] *Case of inappropriate antibiotic treatment avoided.*

ential diagnoses that were ambiguous, the cost savings would increase. Another important assumption concerns the productivity effects in the societal perspective models. It is assumed that if a person is correctly diagnosed with an adenoviral infection, they would take more time off work or school than if they were diagnosed with a bacterial infection. It is further assumed that all persons will comply with the absenteeism time recommended by their physician. Changes in compliance would affect cost savings. In addition, although absenteeism is considered, presenteeism is not. If a person is misdiagnosed as having a bacterial infection and returns to work earlier than would have been recommended had they been correctly diagnosed with a viral infection, while they may be present at work, their productivity may be impaired by the conjunctivitis condition. Furthermore, returning to work while still infective could cause other workers to become infected resulting in further presenteeism losses. If presenteeism and infectivity had been included as a positive cost in this study, the cost savings to society would have been considerably greater.

Conclusions

The use of AVD, such as the Adeno Detector manufactured by Rapid Pathogen Screening, can avoid much of the cost to society caused by acute conjunctivitis through the accurate diagnosis and appropriate treatment at the time of initial physician consult. With the use of AVD for every case of viral and bacterial conjunctivitis that presents to a physicians office, over one million cases of inappropriate antibiotic treatment could be avoided and nearly US $430 million dollars of unnecessary medical care and productivity losses could be avoided by society. Additionally, the AVD has a price neutrality point of $96.80 when compared with no point-of-care test, well above its current price point of around US $25 (in the case of the RPS Adeno Detector). The results of this study are robust to all assumptions and variability in population characteristics, confirming that the use of AVD to diagnose adenoviral conjunctivitis is a cost-effective decision.

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