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## The Cost of Penicillin Allergy Evaluation

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### Abstract

**Background**—Unverified penicillin allergy leads to adverse downstream clinical and economic sequelae. Penicillin allergy evaluation can be used to identify true, IgE-mediated allergy.

**Objective**—We estimated the cost of penicillin allergy evaluation using time-driven activity-based costing (TDABC).

**Methods**—We implemented TDABC throughout the care pathway for 30 outpatients presenting for penicillin allergy evaluation. The base case evaluation included penicillin skin testing and a one-step amoxicillin drug challenge, performed by an allergist. We varied assumptions about the provider type, clinical setting, procedure type, and personnel timing.

**Results**—The base case penicillin allergy evaluation costs \$220 in 2016 United States dollars: \$98 for personnel, \$119 for consumables, and \$3 for space. In sensitivity analyses, lower cost estimates were achieved when only a drug challenge was performed (i.e., no skin test, \$84) and a nurse practitioner provider was used (\$170). Adjusting for the probability of anaphylaxis did not result in a changed estimate (\$220); while other analyses led to modest changes in the TDABC estimate (\$214–\$246), higher estimates were identified with changing to a low demand practice

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### CONFLICTS OF INTEREST

None

setting (\$268), a 50% increase in personnel times (\$269), and including clinician documentation time (\$288). In a least/most costly scenario analyses, the lowest TDABC estimate was \$40 and the highest was \$537.

**Conclusions**—Using TDABC, penicillin allergy evaluation costs \$220; even with varied assumptions adjusting for operational challenges, clinical setting, and expanded testing, penicillin allergy evaluation still costs only about \$540. This modest investment may be offset for patients treated with costly alternative antibiotics that also may result in adverse consequences.

### Keywords

hypersensitivity; allergy; beta-lactam; resource; skin test; test dose; challenge

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## INTRODUCTION

Ten percent of the United States (US) population reports an allergy to penicillin antibiotics.<sup>1,2</sup> However, most patients with reported penicillin allergy are determined not to be allergic after an allergy evaluation.<sup>2–4</sup> Unverified penicillin allergy results in patients receiving broader-spectrum antibiotics, as well as antibiotics that may be more toxic, less effective, and/or higher cost.<sup>5,6</sup> Further, unnecessary use of  $\beta$ -lactam alternative antibiotics places patients at risk for adverse reactions, treatment failures, and healthcare-associated infections.<sup>6–8</sup>

For patients with self-reported immediate (i.e., immunoglobulin (Ig) E-mediated) penicillin allergy histories, penicillin skin testing and/or drug challenges under medical observation can accurately distinguish true allergy. Currently, most penicillin skin testing in the US is performed using major determinant, or benzylpenicilloyl (Pre-Pen®), and dilutions of penicillin G. The negative predictive value of penicillin skin testing using these reagents is at least 95%.<sup>2</sup> Allergists may additionally skin test with ampicillin, since side-chain-specific allergy to aminopenicillins has been documented.<sup>9,10</sup> Most practices follow a negative penicillin skin test with an observed test dose challenge to amoxicillin, which increases the negative predictive value of the evaluation to almost 100%.<sup>11</sup>

While penicillin allergy evaluation has been hypothesized to be a cost-effective intervention,<sup>6</sup> there have been no costing studies or cost-effectiveness analyses of penicillin allergy evaluation in patients with reported penicillin allergy. Time-driven activity-based costing (TDABC), a method developed by health care economists, estimates cost through calculation of both time spent using a given resource and the per unit cost of such resource.<sup>12,13</sup> Since its development, TDABC has been used effectively in healthcare settings to determine cost and identify value in oncology,<sup>14</sup> urology,<sup>15</sup> interventional radiology,<sup>16</sup> and surgery.<sup>17–22</sup>

To inform efficient clinical operations, encourage cost-conscious care, and enable cost-effectiveness research, we performed TDABC of penicillin allergy evaluation. We additionally compared TDABC estimates to estimates derived from two other common costing models: (1) ratio of costs to charges (RCC) method and (2) relative value unit (RVU) method.<sup>12,13,23</sup>

## METHODS

### Time-driven Activity-based Costing (TDABC)

**Base Case**—We considered the base case of an outpatient penicillin allergy visit with an American Board of Allergy and Immunology Certified Allergist/Immunologist who, after taking the allergy history, ordered skin testing with major determinant and dilutions of penicillin G, as well as a 1-step amoxicillin 500 mg oral challenge for all patients whose skin test result was negative. To estimate the cost of the base case, we defined each step along the outpatient penicillin allergy evaluation pathway in a process map (Figure 1). We then identified the personnel, consumables, and space used for 30 unique patients presenting for penicillin allergy evaluation, a convenience sample of prospectively observed patients at Massachusetts General Hospital (MGH) Allergy Associates (Boston, MA). Prior to their visit, the patients were deemed appropriate for a penicillin allergy evaluation appointment. Tested patients had immunologic reactions that were potentially IgE-mediated, but not anaphylactic in the last 5 years. We determined that 30 patients provided sufficiently stable time estimates by assessing personnel and space time descriptive characteristics (e.g., means, standard deviations, etc.) for the first 25 patients compared to the final 5 patients. No significant time differences were observed, and the 30 patients comprised the sample.

We calculated capacity cost rates for each personnel type in 2016 US dollars (USD) per minute using regional and national compensation data that included salary, payroll taxes, and fringe benefits (e.g., health insurance).<sup>24–26</sup> Regional and national averages, rather than actual MGH Allergy Associates compensation, were used to achieve more generalizable results. Allergists/Immunologists and other personnel were estimated to work 8.0 hours per day.<sup>27</sup> Within each work day, we assumed 5% idle or break time for physicians and 10% idle or break time for other personnel.<sup>12,27</sup> Twenty one days of vacation, six days for educational time and sick/personal leave, and 114 days for weekends/holidays were additionally accounted for by assuming 224 of a possible 260 workdays a year.<sup>12</sup>

Medical consumables used at each stage in the penicillin allergy evaluation pathway were costed according to the acquisition cost to MGH, except for drug costs, for which we used the average wholesale price.<sup>28,29</sup> For the base case analysis, we assumed that demand for evaluation was high with clinic operations accommodating four penicillin allergy patients per day. Thus, for example, the clinician time spent preparing penicillin G dilutions and the cost of the penicillin G vial was split among four patients in the base case rather than being a per-patient cost.

Space costs were calculated using the mean time patients occupied the exam room and allergy testing space, a procedure space at MGH Allergy Associates where skin testing and drug challenges are performed under nursing observation, and measuring the square footage of each clinical space. Construction and renovation costs were incorporated by using the price per square foot. We assumed a 20-year, linear depreciation of the building with 15% annual maintenance, operating, and housekeeping costs.<sup>23</sup> Space availability was calculated using a 9-hour Monday through Friday clinical practice (143,100 available minutes annually).

**One-Way Sensitivity Analyses**—We performed one-way sensitivity analyses to assess how assumptions about provider type, clinical setting, procedure type, and personnel timing impact TDABC estimates. Specifically, we: (1) changed the procedure to include only a 2-step challenge (i.e., no skin testing), which may be appropriate for low risk patients;<sup>30–33</sup> (2) changed the clinical provider from an Allergist/Immunologist to a nurse practitioner, and considered both the scenarios of a minimally supervised nurse practitioner and a nurse practitioner supervised at every patient encounter; (3) changed drug compounding from an allergist-performed task to a task performed by a registered nurse; (4) added a resource adjustment to account for the rare but non-zero probability of causing resource-intensive anaphylaxis (3.2/1000), which was not observed in the 30 prospectively-observed patients (E Methods); (5) added ampicillin as an additional skin testing reagent; (6) simulated a 2-step graded challenge after skin testing (an initial 30 minute period of observation followed by a 60 minute period of observation); (7) assumed a 50% increase in all personnel activity times; (8) simulated an inpatient penicillin allergy evaluation, with an allergy registered nurse skin tester and pharmacist-prepared drug, assuming 15 minutes for reagent preparation, safety checking, and labeling; (9) changed clinical volume to a low demand setting (e.g., multi-use drug consumables would not be reused); (10) included 20 minutes of provider time to perform clinical documentation; and (11) considered a two-visit penicillin allergy evaluation (history and physical during the first visit followed by a second visit where testing was performed with limited clinician time).

**Multi-Way Sensitivity and Scenario Analyses**—We performed multi-way sensitivity analyses where we simultaneously varied the most influential one-way sensitivity analyses. We also performed a minimum and maximum scenario analysis intended to reflect the lowest and highest plausible costs of the procedure, using results from the one-way analyses.

### Ratio of Cost to Charge (RCC) Model

To examine the sensitivity of our results to our methods used, we also examined an alternative costing approach where we identified charges for the office visit and procedure codes used for penicillin allergy evaluation. We calculated the cost to charge ratio (CCR) for MGH Allergy Associates by using the total operating costs divided by the total gross charges from the last fiscal year. As this internal CCR was similar to the published Massachusetts CCR for fiscal year 2016 (0.505),<sup>34</sup> we used the published Massachusetts CCR to enhance generalizability. Using this adjustment, we calculated the base case penicillin allergy evaluation patient. We also calculated different evaluation combinations, varying the evaluation and management (E&M) codes (none, follow up, new, two visits) and procedures performed (skin testing, skin testing with ampicillin, one-step challenge, two-step challenge).

Procedure charges used current procedural terminology (CPT) codes 95018 for skin testing and 95076 for ingestion challenges, the latter only considered for multi-step challenges from 61 to 120 minutes in duration.<sup>35</sup> E&M codes assumed new patients were level 4 (99204) and follow up patients were level 3 (99213). Two visit sensitivity analyses included two E&M codes: one new and one follow up.

## Relative Value Units (RVU) Model

In a final methodologic approach, we identified work and facility-related RVUs for 2016 urban office visit and procedure codes used for penicillin allergy evaluation. We converted the RVUs using the 2016 Medicare conversion factor (35.8043).<sup>36</sup> To increase generalizability of these estimates, facility fees did not assume a hospital-based practice, which would incur an additional facility fee. We again recalculated the cost for the base case penicillin allergy evaluation patient, as well as different combinations of E&M codes (none, follow up, new, two visits) and procedures (skin testing, skin testing with ampicillin, one-step challenge, two-step challenge) using the same assumptions as the RCC model.

## RESULTS

### Time-driven Activity-based Costing (TDABC)

Measured mean personnel times for each process (Figure 1) resulted in an estimated personnel cost of \$98 (Table I), consumables cost of \$119 (Table II), and space cost of \$3 (Table III). The base case penicillin allergy evaluation cost \$220 in 2016 USD.

Assessing variations in one-way sensitivity analyses led to different TDABC estimates (Figure 2). If skin testing were not performed, the cost was \$84: \$82 for personnel, <\$1 for consumables, and \$2 for space. Using a nurse practitioner instead of an Allergist/Immunologist led to a cost of \$170–\$192 depending on Allergist/Immunologist supervision: \$48–\$71 for personnel, \$119 for consumables, and \$3 for space. Many one-way sensitivity analyses did not change, or only modestly changed, the TDABC estimate: drug mixing performed by a registered nurse cost saved \$6 (\$214); adjusting for the probability of anaphylaxis cost \$220; performing skin testing with ampicillin in addition to benzylpenicilloyl and penicillin G cost \$226; a two-step oral challenge after skin testing cost \$227; and inpatient evaluation cost \$220. If the penicillin allergy evaluation were performed in two separate visits, the estimate was \$246, driven by \$26 higher personnel costs. For a clinic with low demand for penicillin allergy evaluation, the TDABC estimate was \$268; increased cost estimates are due to higher personnel (\$122) and consumables (\$143) cost (Table EIII). Assuming a 50% increase in all personnel times led to a cost estimate of \$269, with the cost of personnel \$147, consumables \$119, and space \$3. Including 20 minutes of Allergist/Immunologist documentation time led to the highest estimate among one-way sensitivity analyses (\$288), driven by the \$68 increase in personnel cost.

Varying two or more assumptions simultaneously in multi-way sensitivity analyses led to a more broad range of cost estimates (Figure 3). We identified that the lowest TDABC estimate scenario used a nurse practitioner clinical provider without direct supervision and did not perform the penicillin skin test (\$40). The highest TDABC estimate (\$537) included adjusting the scenario for the possibility of anaphylaxis, testing with ampicillin, increasing personnel time by 50%, having a low demand setting, doing a 2-step oral challenge after skin test, incorporating 20 minutes of Allergist/Immunologist documentation time, and performing the evaluation over assessment and testing in two visits.

### RCC Model

The cost of the base case penicillin allergy evaluation using the RCC model was \$829, which included the cost of a new visit E&M (\$306) as well as the evaluation procedure (\$523, Figure 4). Including ampicillin in the evaluation increased the cost by \$58. Performing a two-step challenge instead of a one-step challenge increased the cost by \$224; forgoing skin testing in favor of a 2-step challenge only saved \$298. The cost of penicillin allergy evaluation using the RCC method ranged from \$225 (no E&M, 2-step challenge only) to \$1,247 (two visits, penicillin skin test with ampicillin, 2-step challenge after skin testing).

### RVU Model

The cost of the base case penicillin allergy evaluation using the RVU model was \$328, \$218 from the E&M code and \$110 from the CPT code (Figure 5). Including ampicillin in the evaluation increased the cost by \$12. Performing a two-step instead of a one-step challenge increased cost by \$128; forgoing skin testing with a 2-step challenge resulted in a \$19 higher cost. The cost of penicillin allergy evaluation using the RVU method ranged from \$110 (no E&M, skin test, 1-step challenge) to \$555 (two visits, skin test with ampicillin, 2-step challenge after skin testing).

## DISCUSSION

Using a TDABC approach, we found that the base case penicillin allergy evaluation, penicillin skin testing and a one-step amoxicillin drug challenge performed by an allergy-boarded physician, cost \$220 in 2016 USD, with over half of the cost attributed to consumables and about 45% attributed to personnel. Under alternative assumptions, we identified a cost range from \$40 to \$537 per penicillin allergy evaluation. Finally, we identified that the TDABC estimates were lower than estimates using the RCC model or RVU model, the two most commonly used accounting-based costing methods; the maximum cost of the evaluation, considering all approaches and assumptions, was \$1,247.

Although we observed variation in TDABC estimates with different conditions related to provider type, clinical setting, procedure type, and personnel timing, the total cost of penicillin allergy evaluation never exceeded \$540 in multi-way sensitivity analyses. The only prior reported cost for penicillin allergy evaluation was estimated in the Kaiser Permanente health maintenance organization and was restricted to an assessment of cost for one penicillin skin test (\$131).<sup>6</sup> This study's TDABC estimates of comprehensive penicillin allergy evaluation demonstrate that this intervention is neither resource intensive nor costly. Indeed, the evaluation cost may well be offset by ultimate medication cost savings – not captured here – since the average wholesale price for  $\beta$ -lactam antibiotics is generally less than that of  $\beta$ -lactam alternative antibiotics.<sup>29</sup> Prior studies comparing drug costs in patients labeled as penicillin allergic, compared to those without the penicillin allergy label, found the total inpatient cost of antibiotics for patients labeled as penicillin-allergic from \$11 to \$582 higher.<sup>37–41</sup> Further, through removal of an erroneous penicillin allergy label, some patients may avert unnecessary costly clinical outcomes such as adverse reactions, treatment failures, and healthcare-associated infections, outcomes that cost from \$3,023–\$14,629 2016

USD per event.<sup>6-8,42-46</sup> Considering the reasonable cost identified, and all of the potential benefits, penicillin allergy evaluation should not be seen as a barrier for patients with an indication for a  $\beta$ -lactam antibiotic; ultimately, it is likely to be both clinically beneficial and cost-saving.

The lowest TDABC estimate of \$40 was achieved through use of an independent nurse practitioner provider and performing a two-step graded challenge only (no skin testing). With over 25 million Americans reporting a penicillin allergy history and only about 5,000 Allergist/Immunologists in the US, any widespread evaluation program would require involvement of non-allergist providers, such as nurse practitioners and physician assistants.<sup>2,47</sup> Our findings therefore emphasize the potential role of nurse practitioners, and other advanced providers, in expanding care delivery and lowering healthcare costs. Even when accounting for the supervision of a physician who understands how to appropriately prescribe, perform, and interpret the testing, the cost increase was not large (\$22). A medical doctor provider performing a two-step graded challenge only (no skin testing) cost \$84, \$136 (62%) less than the base case. The identified cost savings with forgoing the skin test was greater in this study than reported in one prior study that identified a reduction by \$69 (35% lower) if no skin test was performed.<sup>48</sup> While complete evaluation with skin testing is preferred, especially for patients with higher risk allergy histories, oral challenge only can be considered for patients with mild allergy histories or when there are no personnel trained to perform and interpret skin tests. Indeed, through use of challenge-only evaluations, 818 Canadian children with histories of amoxicillin allergy were safely challenged to amoxicillin without skin testing, and in that study saved their health system \$182,393 compared to full skin testing with oral challenge.<sup>31</sup>

Accurately measuring the cost of healthcare is important to guide efficient clinical operations and the practice of cost-conscious medical care.<sup>13</sup> Identifying and using valid costs in health care provides a common currency for clinicians and administrators to identify cost reduction and process improvement opportunities. Through assessing true costs, redundancies may be identified, equipment may be more efficiently used, and benchmarking across clinicians, facilities, and institutions becomes possible.<sup>13</sup> To our knowledge, TDABC methods have not been applied previously to allergy practices to guide cost-reduction or value-improvement opportunities. By considering the variation in TDABC estimates of penicillin allergy evaluation, allergy clinics may identify their optimal testing practice, such as one that maintains clinical outcomes with lower costs (e.g., uses nurses for drug compounding, employs challenge-only procedures, batches penicillin allergy evaluations into a single day in the week, deploys nurse practitioner providers, and/or hires a scribe to perform clinical documentation). Accurate cost estimates additionally enables cost-effectiveness research. To date, cost-effectiveness analyses in drug hypersensitivity have been limited to genetic testing in severe cutaneous adverse reactions and desensitization in aspirin hypersensitivity.<sup>49-54</sup>

We found that the RCC method valued the cost of penicillin allergy evaluation \$609 (>250%) more than TDABC. This higher cost estimate was expected given that the RCC methodology relies on aggregate data for assessing costs, and assumes that indirect resource costs are the same for each E&M or CPT code.<sup>23</sup> The RVU method, which achieved similar

estimates to the TDABC estimate, still over-valued the cost for the base case by \$108 (49%). While the RVU method often provides a more accurate assessment of work than the RCC method, the RVU method presupposes that indirect resource costs are proportional to patient volume; some economists and costing experts disagree with the subjective method of RVU value assignment (i.e., physician specialty panels/surveys rather than by an objective measurement of resource use).<sup>12</sup>

Although TDABC provides a good estimate of cost from measurable resources, it does not include all costs related to healthcare delivery. For example, our analysis did not include the cost of services such as access to information technology support and other ancillary services, such as billing and human resources. We also did not include supervision costs for all personnel (e.g., nursing supervisor, clinic administrator, teaching of housestaff, etc). While the former was excluded because it was too technically challenging to accurately estimate, the later exclusion was intentional, since there is tremendous variability in clinical personnel across practice types and sites. We justified this exclusion after determining that, in our practice, supervision costs by a nursing supervisor and clinic administrator resulted in \$5 more per patient visit. While we used averages for salaries and drug prices in the TDABC analysis, many costs are variable by region in the US. The base case accounted for skin testing with benzylpenicilloyl (Pre-Pen ®) and dilutions of penicillin G, and ampicillin skin testing was considered in sensitivity analyses. Skin testing with minor determinant mix was excluded from the analysis, given that minor determinant mix is not commercially available and is laborious to compound. While we were able to use observed data for many of the sensitivity analyses, simulated estimates were necessary for scenarios not observable in our practice environment (e.g., registered nurse and pharmacist drug compounding time). TDABC estimates cost from the perspective of the healthcare system; we did not consider costs from the societal perspective that would need to account for the patient's time spent at the penicillin allergy evaluation appointment. Finally, TDABC methodology assumes that the resources and infrastructure exists to provide the evaluation. While this is true for general allergist-offered penicillin allergy evaluation, in the case of large-scale penicillin allergy evaluations, additional infrastructure would be required.

Through a comprehensive time-driven activity-based costing analysis, we estimated that the cost of penicillin allergy evaluation is \$220, and identified a range from \$40 to \$537 under different assumptions. Using other common costing methods, the ratio of cost to charge and the relative value unit model, penicillin allergy evaluation cost more, but never exceeded \$1,247. Given the modest cost of evaluation, and the potential downstream clinical and economic benefits, penicillin allergy evaluation should be encouraged by medical providers and covered, indeed, encouraged, by US insurance plans. However, given the number of patients in the US with an unverified penicillin allergy, testing demand could easily overcome the supply of Allergists/Immunologists to perform these evaluations. Given these impending challenges, it may be necessary to educate an expanded workforce to achieve large-scale testing.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.



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### HIGHLIGHTS BOX

#### 1. What is already known about this topic?

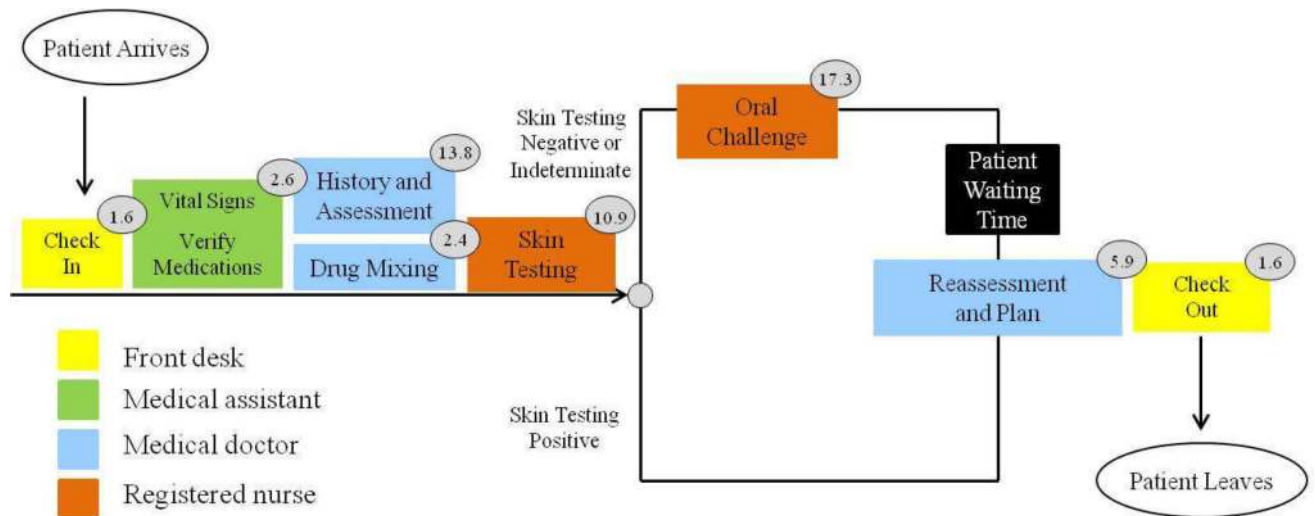
Unverified penicillin allergy leads to adverse clinical and economic consequences. Penicillin allergy evaluation is a simple procedure, typically performed by allergy specialists. Time-driven activity-based costing (TDABC) is an accurate method to estimate cost.

#### 2. What does this article add to our knowledge?

Using TDABC, we identified that penicillin allergy evaluation costs \$220 in the base case. In a variety of univariable and multivariable sensitivity analyses, we identified a cost range of penicillin allergy evaluation from \$40 to \$537.

#### 3. How does this study impact current management guidelines?

Penicillin allergy evaluation is inexpensive, even when considering operational challenges, such as infrequent or expanded testing. TDABC estimates of penicillin allergy evaluation can inform efficient clinical operations, the practice of cost-conscious care, and cost-effectiveness assessments.



**Figure 1. Outpatient Penicillin Allergy Evaluation Process Map**

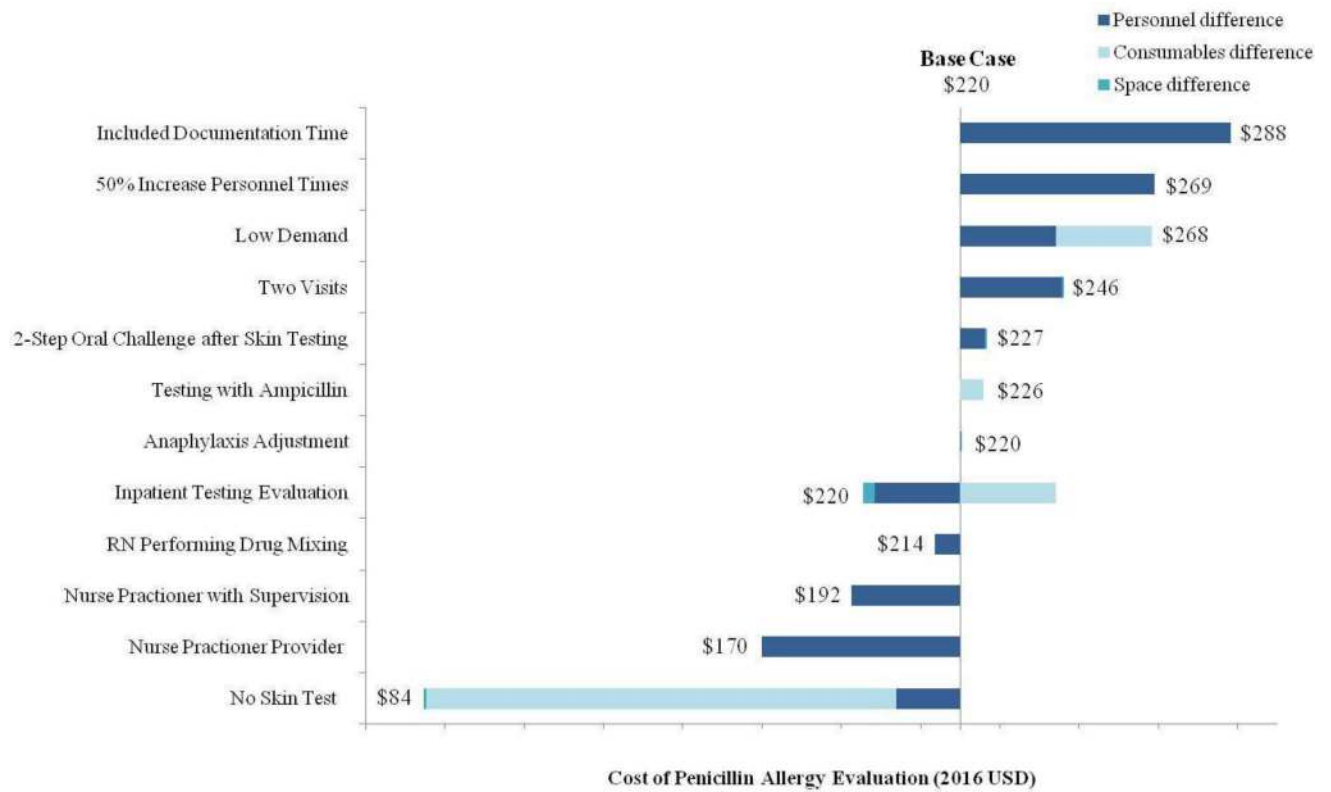
The process map identifies all components of outpatient penicillin allergy evaluation including personnel type (indicated by color). The numbers in the gray circles indicate the mean measured time (in minutes) for each process for the 30 prospectively observed outpatients at Massachusetts General Hospital's Allergy Associates. Note that patient time is excluded from process map, given that costing is performed from the healthcare system perspective. Patient time spent in the clinical exam room and test room is included in space cost (Table III).



**Figure 2. The Cost of Penicillin Allergy Evaluation Using Time-Driven Activity-Based Costing: Base Case and One-Way Sensitivity Analyses**

This tornado diagram displays the TDABC estimates identified in different one-way sensitivity analyses, compared to the base case, represented by the vertical line (\$220). Bars to the left are analyses that demonstrate situations where the evaluation is less costly than the base case while bars to the right are analyses that demonstrate situations where the evaluation is more costly than the base case.

*Abbreviations:* RN, registered nurse; USD, United States Dollars



**Figure 3. The Cost of Penicillin Allergy Evaluation Using Time-Driven Activity-Based Costing: Base Case, 2-way, and Multi-Way Sensitivity Analyses**

This bar graph displays the TDABC estimates identified in two-way and multi-way sensitivity analyses. Assumptions varied are shown brightly beneath the horizontal axis.

*Abbreviations:* USD, United States Dollars; NP, nurse practitioner; RN, registered nurse

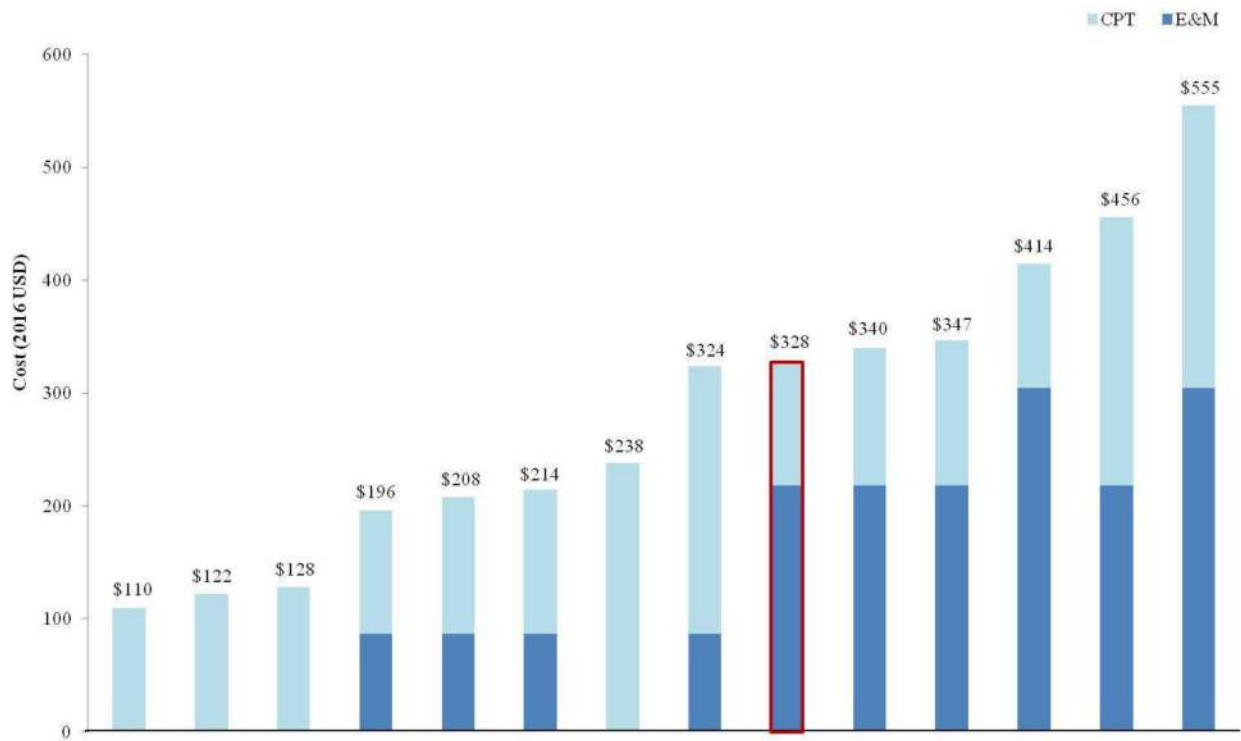




**Figure 4. The Cost of Penicillin Allergy Evaluation: Ratio of Cost to Charge (RCC) Model**

This bar graph demonstrates the different costs for various combinations of visits (E&M, dark blue) and procedures (CPT, light blue) in penicillin allergy evaluation using the RCC model. The base case, outlined in red, costs \$829. Two visit analyses include both a new and follow up E&M.

*Abbreviations:* RCC, ratio of cost to charges; USD, United States Dollars; Amp, ampicillin



E&M	None	None	None	Follow Up	Follow Up	Follow Up	None	Follow Up	New	New	New	Two Visits	New	Two Visits
Skin Testing	Yes	Yes+Amp	None	Yes	Yes+Amp	None	Yes	Yes	Yes	Yes+Amp	None	Yes	Yes	Yes+Amp
Challenge Steps	1	1	2	1	1	2	2	2	1	1	2	1	2	2

**Figure 5. The Cost of Penicillin Allergy Evaluation: Relative Value Unit (RVU) Model**

This bar graph demonstrates the different costs for various combinations of visits (E&M, dark blue) and procedures (CPT, light blue) using the RVU model. The base case, outlined in red, costs \$328. Two visit analyses include both a new and follow up E&M.

*Abbreviations:* RVU, relative value unit; USD, United States Dollars; Amp, ampicillin

**Table I**

Analysis of personnel cost in base case penicillin allergy evaluation

<b>Staff Member</b>	<b>Mean Activity Time (minutes)</b>	<b>Cost Per Minute (\$)</b>	<b>Total Cost (\$)</b>
Front Desk	3.2	0.40	1.28
Medical Assistant	2.6	0.33	0.87
Allergist/Immunologist	22.0	3.41	75.17
Registered Nurse	28.2	0.73	20.63
<i>Total Personnel Cost</i>			<i>97.96*</i>

\* Number in text was rounded to nearest \$1

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**Table II**

Analysis of consumables in base case penicillin allergy evaluation

Supplies	Acquisition cost per pack (\$)	Number in pack	Number Used	Total Cost (\$)
Greer <i>Pick</i> <sup>TM</sup>	347.60	1000	4	1.39
BD SafetyGlide <sup>TM</sup>	6.78	25	5	1.36
Albumin saline with phenol	112.20	50	4 <sup>*</sup>	2.24
Drugs	Average Wholesale Price (\$)	Number in pack	Number Used	Total Cost (\$)
Penicillin G Potassium 5 million units	14.47	One vial <sup>*</sup>	0.25	3.62
PRE-PEN®	110.00	One vial	0.50	110.00
Amoxicillin 250 mg/5mL	7.11	30 challenges <sup>†</sup>	0.03	0.47
<i>Total Consumables Cost</i>				<i>119.08<sup>‡</sup></i>

\* Distributed evenly over four patients under high volume assumption in base case

<sup>†</sup> 500 mg of amoxicillin

<sup>‡</sup> Number in text was rounded to nearest \$1

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**Table III**

Analysis of space costs in penicillin allergy evaluation

	Clinical Exam Room	Testing Room Space
Square feet	92.25	34.10
Construction cost, \$/ft <sup>2</sup>	248.00	248.00
Useful life-years	20	20
Maintenance, operating, housekeeping cost	15%	15%
Annual space cost, \$/ft <sup>2</sup>	49.60	49.60
Availability, minutes	143,100	143,100
Capacity cost rate, \$/min/ft <sup>2</sup>	0.00035	0.00035
Mean Time (minutes)	32.16	149.63
Space Cost, \$/patient	1.03	1.79
<i>Total Space Cost</i>		<i>2.82*</i>

\* Number in text was rounded to nearest \$1

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