Evaluation of a Rule-Based Program to Describe Antibiotic Utilization for Otitis Media Among Three Medical Plans

Gregory Reardon, Andreas M. Pleil, and Allan F. Zaenger

OBJECTIVE: The purpose of this study was to develop and test an analytical technique for describing variations in the antibiotic prescribing process for otitis media (OM) in ambulatory medical plans.

DESIGN: Using medical, hospital, and pharmacy claims over an 18-month period, a computerized rule-based system identified which antibiotics were probable therapy for OM. For each patient and OM episode of treatment, the rule-based system recorded the ordinal sequencing of specific antibiotics, including first-line and follow-up choices, to treat the OM condition.

SETTING: Three medical plans in the Midwest were studied: a Medicaid-funded IPA-model HMO; an employer-funded, indemnity-based PPO; and an employer-funded “at-risk” network.

RESULTS: The number of OM antibiotics dispensed per subject was similar among plans. For first-line therapy, inexpensive penicillinase-sensitive penicillins, trimethoprim-sulfamethoxazole, and erythromycin-sulfisoxazole, combined, accounted for 74.6%, 47.2%, and 47.7% of total OM antibiotic prescriptions for the HMO, PPO, and employer-funded network, respectively. For follow-up therapy, all plans increased proportional use of amoxicillin-clavulanate and decreased use of penicillinase-sensitive penicillins; the PPO actually decreased proportional use of cephalosporins. Mean ingredient costs for all OM therapy for the HMO was 53%-61% that of the other two plans. The PPO subjects had the highest rate of OM comorbidity measures.

CONCLUSION: Substantial differences in product selection and sequencing of therapy were found among the three plans. The rule-based system developed here may be useful for dynamically analyzing treatment processes of medical plans.

KEYWORDS: Otitis media, Antibiotic, Quality management, Utilization review, Prescribing patterns, Medical claims, Diagnosis codes, Episode of care

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EXCEPT FOR THE GENERAL CATEGORY “HEALTH SUPERVISION OF INFANT OR CHIL," OTITIS MEDIA (OM) IS THE MOST COMMON DIAGNOSIS RENDERED BY AMERICAN PHYSICIANS FOR CHILDREN UNDER 15 YEARS OF AGE.1 IN 1990, PATIENTS MADE 24.5 MILLION OFFICE VISITS TO PHYSICIANS TO TREAT OM; OFFICE VISITS FOR THE DISEASE ROSE 150% BETWEEN 1975 AND 1990.2

Proper management of OM can prevent complications including subsequent hearing loss, learning delays, reversible motor impairment, mastoiditis, and cholesteatoma. In developed countries, antibiotics generally are used to halt the progression of presumed bacterial causes of most cases of this disease.3 Multidrug-resistant strains of bacterial pathogens may emerge if inappropriate antibiotic treatment is given.4,7 Although no definitive standard exists for selection of antibiotic therapy for OM, some general prescribing consensus is apparent from the medical literature.5,7 General antibiotic treatment guidelines for properly diagnosed OM include:

- the choice of inexpensive amoxicillin as first-line therapy, except when beta-lactamase-producing causative organisms are suspected or are dominant in the local geographic area, or where penicillins are contraindicated;
- for alternative and second-line (follow-up) therapy, the choice of combination antibiotics (trimethoprim-sulfamethoxazole, erythromycin-sulfisoxazole, amoxicillin-clavulanic acid), and indicated cephalosporins;
- 10-day course, though shorter regimens have been proposed to discourage the development of resistant bacterial strains;
▲ possible switching of antibiotics after failure of a course of therapy;
▲ concomitant use of analgesics/antipyretics or, for recurrent cases, corticosteroids;
▲ use of half-dose antibiotic chemoprophylaxis in cases of repeated acute otitis infections or where middle-ear effusion persists for more than three months; and
▲ possible withholding of antibiotics and aggressive follow-up observation in cases where the OM diagnosis is equivocal.

Invasive and expensive surgical procedures, such as myringotomy and tympanostomy with tube placement, may be indicated when antibiotic therapy repeatedly fails.

For many diseases, health plans have developed treatment protocols to improve the quality of drug use by promoting selection of the most appropriate and cost-effective drugs at key decision points in therapy. Yet for drugs such as antibiotics, used to treat several diseases, our experience shows that few plans professionals can describe the drug selection process that physicians currently use to treat these conditions. Existing reporting systems at the plan level fail to show how such drugs are prescribed to treat specific medical diagnoses, because outpatient pharmacy claims do not carry diagnostic codes. Few plans routinely link information from medical service claims, which contain diagnostic information, to pharmacy claims.

Determining how well prescribers adhere to protocol requires analysis that isolates those drugs being used to treat the condition of interest and that captures the dynamics of drug selection as the diagnosis and treatment process unfolds. A principle of quality management holds that understanding the variability inherent in a process is a precondition to gaining knowledge about performance. Changes to a process are more likely to lead to positive outcomes if the variation inherent within the process is understood first.

The purpose of this study was to develop and test an analytical technique for describing variation in antibiotic prescribing for OM in three ambulatory medical plans. This analysis also explored factors that might relate to the prescribing process, including 1) plan and patient characteristics and 2) utilization measures and cost. To make this technique practical for medical plans to adopt, we used readily available pharmacy and medical claims data on electronic media and applied computer technology to efficiently organize and scan the data selected from these sources. The results obtained from this project were later applied to the development of specific physician reports that contrasted the selection of antibiotics by individual to aggregate data of physician peers within his/her practice specialty (these reports are not described here).

**METHODOLOGY**

**Subjects and Claims**

Three medical plans in separate Midwestern communities were studied: an IPA-model HMO serving 25,000 Medicaid-covered lives in an urban area (Medicaid IPA Plan); an employer-funded at-risk network serving 14,000 covered lives in a small community (Network Plan); and an employer-funded, indemnity-based PPO serving 37,000 covered lives in a small community (Indemnity Plan).

Plans provided all pharmacy and medical service claims, including hospitalization, for covered patients who had at least one diagnosis of OM (ICD code beginning with 381 or 382 reported on either a medical service or hospital claim) during the 18-month period from July 1, 1993, to December 31, 1994. As in the Byrns et al. study of OM utilization, no attempt was made to distinguish chronic from acute designations of otitis media from ICD codes on the medical claim record, except as a patient comorbidity covariate as described below. This follows empirical work by Roark et al., who noted the inconsistency with which physicians code OM among its various subtypes.

Eligible subjects were then further restricted to those 10 years or younger at the midpoint of the study period (March 31, 1994), those who were born before the start of the 18-month data collection period (July 1, 1993), and those who had prescription drug coverage under the plan. We excluded 363 subjects from Medicaid IPA Plan due to problems with patient identification codes, yielding 4,318 subjects from this plan. One subject was excluded from Network Plan due to unreadable claims data, yielding 364 subjects. Indemnity Plan contributed 1,169 eligible subjects, for a total count of 5,851 eligible subjects for all three plans, as shown in Table 1.

**LINKING ANTIBIOTIC CLAIMS TO OTITIS MEDIA MEDICAL SERVICES**

For each plan, selected data fields from all pharmacy and medical claims for the 18-month period were merged into a common dataset, with each record representing one claim. Claim records in this merged dataset were flagged as ATB for antibiotic prescription claims dispensed by a pharmacy or administered in the physician's office; OM for medical/hospital claims coded for OM (primary or secondary ICD=381.XX or 382.XX); and null for all other claims. For the remainder of this report, "dispensed" refers to drugs both dispensed by pharmacies and administered in physician offices.

The resulting dataset was sorted by ascending recipient number, ascending service date, ascending service type (Hospital, Medical, or Rx), then ascending flag (null, ATB, or OM). Also included in each record of this merged dataset were the primary and secondary ICD codes for medical/hospital services and the National Drug Code (NDC) for drugs and for all claims—a key reference field that could link each record back to the original claim from which it was abstracted.

Drugs administered in a physician's office presented a special problem when they were dispensed by pharmacies and administered in physician offices. The former were coded by physicians with a Health Care Financing Administration Common Procedure...
Table 1. Subject Characteristics and Comorbidity Measures

<table>
<thead>
<tr>
<th>Age Category</th>
<th>Medicaid IPA Plan</th>
<th>Network Plan</th>
<th>Indemnity Plan</th>
<th>All Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–3 Years</td>
<td>2,819</td>
<td>155</td>
<td>583</td>
<td>3,557</td>
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<tr>
<td>4–7 Years</td>
<td>1,181</td>
<td>149</td>
<td>402</td>
<td>1,732</td>
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<tr>
<td>8–10 Years</td>
<td>318</td>
<td>60</td>
<td>184</td>
<td>562</td>
</tr>
<tr>
<td>Total</td>
<td>4,318</td>
<td>364</td>
<td>1,169</td>
<td>5,851</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Sex</th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
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<td>Female</td>
<td>2,072</td>
<td>175</td>
<td>552</td>
<td>2,799</td>
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<td>Male</td>
<td>2,246</td>
<td>189</td>
<td>617</td>
<td>3,052</td>
</tr>
<tr>
<td>Total</td>
<td>4,318</td>
<td>364</td>
<td>1,169</td>
<td>5,851</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Chronic Otitis Media</th>
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<tbody>
<tr>
<td>No</td>
<td>3,960</td>
<td>338</td>
<td>969</td>
<td>5,267</td>
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<tr>
<td>Yes</td>
<td>358</td>
<td>26</td>
<td>200</td>
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<td>Total</td>
<td>4,318</td>
<td>364</td>
<td>1,169</td>
<td>5,851</td>
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</tbody>
</table>

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<th>Concurrent Diseases of Ear</th>
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<tbody>
<tr>
<td>No</td>
<td>3,752</td>
<td>328</td>
<td>983</td>
<td>5,063</td>
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<tr>
<td>Yes</td>
<td>566</td>
<td>36</td>
<td>186</td>
<td>788</td>
</tr>
<tr>
<td>Total</td>
<td>4,318</td>
<td>364</td>
<td>1,169</td>
<td>5,851</td>
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</tbody>
</table>

<table>
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<tr>
<th>Middle Ear Incision Surgery</th>
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<tr>
<td>No</td>
<td>4,135</td>
<td>348</td>
<td>1,081</td>
<td>5,564</td>
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<tr>
<td>Yes</td>
<td>183</td>
<td>16</td>
<td>88</td>
<td>287</td>
</tr>
<tr>
<td>Total</td>
<td>4,318</td>
<td>364</td>
<td>1,169</td>
<td>5,851</td>
</tr>
</tbody>
</table>

Coding System Level II J-Code, while pharmacy claims were coded with the NDC. All physician-administered drug claims were converted to pseudopharmacy claims by converting the J-Code to a representative NDC number. These claims were then coded as being physician-administered and appended to the pharmacy claims database prior to creation of the common dataset. Injectable antibiotics, which were the only physician-administered drugs noted on the medical claim, accounted for a trivial proportion of total utilization. For Medicaid IPA, Indemnity, and Network plans, the proportion of injectables to total antibiotics dispensed equaled 1.0%, 0.5%, and 0.6%, respectively.

Using this sorted, merged dataset and the BASIC programming language provided with the Microsoft Access 2.0 database manager, a rule-based program was written to track those antibiotics that were probable therapy for medical/hospital service claims coded for OM. The goal of this rule system was to identify medical interventions for OM—defined here as episodes of treatment even when care was limited to a single diagnostic exam—and then to identify the sequence of any antibiotics administered or dispensed to treat OM. Various methodological approaches to defining such episodes of care have been described and tested.

Each antibiotic administered or dispensed on the same day or after the start of an OM episode of treatment was evaluated through the rule-based program to determine 1) whether it was probable therapy for the OM episode and 2) if part of a multiple-antibiotic regimen, at what ordinal point it was administered in the regimen.

The rule-based program performed the analysis separately for each subject by iteratively organizing the sorted merged dataset into individual subsets of records (i.e., patient profiles) for each subject prior to analysis. Specific rules applied to these subsets or patient profiles are summarized in Figure 1. A more detailed description of program rules can be obtained by writing to the authors.

Two recent studies tracked antibiotic use for otitis media for Medicaid patients in Tennessee26 and Colorado. Both studies classified antibiotics as probable OM therapy if they were given within two days of an OM-coded medical visit. This is in accordance with the Health Plan Employer Data and Information Set 3.0 specification for antibiotic utilization in OM, which also specifies a two-day rule. The longitudinal rule-based approach used in the present study was a more complex approach developed by necessity to track the sequencing of antibiotics within episodes of treatment.

Efforts were made in designing this rule system to address validity issues, such as a reasonable expiration time to link an antibiotic to an earlier OM-coded medical visit, identification of routine follow-up medical visits to treat the same OM.
Episode rather than a new problem, and alternative diseases and conditions that might be rival uses for an antibiotic.

A very conservative approach was taken to rule out rival uses. All medical visits that occurred after the date of the initial OM diagnosis but that did not also carry OM ICD codes were considered rival uses for antibiotics. This halted the hunt for more antibiotics to link to the initial OM visit. A search was made then for new, later, OM episodes for that subject.

Results were recorded and written by the rule-based program to an output dataset for each plan and analyzed in Access 2.0, Excel 7.0, and SPSS 6.1. Because 18 months of data were examined for each subject, OM episodes of treatment that began during the first and final three months, and their linked antibiotics, were removed from the output dataset to yield 12 months of medical experience for each subject. By including only those episodes that began during the 12-month window and their linked antibiotics, including those dispensed in the three months subsequent to the window, we hoped to achieve steady-state conditions for episodes of treatment.

**Profiling Physicians**

An attempt was made to directly cross-link pharmacy claim records for OM antibiotics to physicians identified in the medical claims data, but in each plan, only a third or fewer of these OM antibiotic pharmacy claims could be directly linked to physicians identified from the medical claims data. An alternative, indirect approach linked all antibiotics dispensed over an episode of treatment to the physician shown on the medical claim who coded the initial OM visit for that particular episode of treatment.

**RESULTS**

**Patient Characteristics and Medical Claims**

Cross-tabulation of subjects by age (see Table 1) showed a statistically significant difference in distribution between plans (where α = .05 for all significance tests conducted in this study). Medicaid IPA had a much higher proportion of subjects in the 0–3 years age range. The proportional breakdown by sex did not significantly vary between plans, though males slightly outnumbered females in each.

Table 1 also shows the rate of three OM comorbidity measures during the 12-month window for subjects in each of the three medical plans. Distributions were significantly different between plans for each of the three measures. The Indemnity plan had more than twice the proportion of chronic OM-coded subjects as the other plans. Indemnity Plan subjects had a 60% higher rate of non-OM concurrent ear diseases than the Network plan, with the Medicaid IPA plan nearly midway between both. The Indemnity plan also had the highest rate of middle-ear incision surgery, with equivalent surgery rates between the Network and Medicaid IPA plans.

**Figure 1. Program Rules for Tracking OM Antibiotics**

- Antibiotics, if prescribed, are filled on the same day ("baseline date") or subsequent to an initial medical visit that was coded for OM (ICD=381 or ICD=382).
- An antibiotic prescription filled within five days of the OM-coded visit is considered the first antibiotic in the episode of therapy.
- If no antibiotic is filled within five days of the OM-coded visit but an antibiotic is filled within six to 30 days of the visit, this antibiotic is considered to be the second antibiotic in the therapeutic sequence. The "first" or pseudo-antibiotic is coded as "antibiotic-free holiday or unknown antibiotic." This is done because there is no way of knowing if the antibiotic sample was dispensed by the physician, whether the parent delayed in having the prescription filled, or whether no antibiotic was prescribed.
- If more than 30 days pass from the OM coded-visit and the fill date of an antibiotic and no other antibiotic was filled in the interim, the antibiotic is not linked to the OM-coded visit.
- If an antibiotic is filled within 30 days of the visit, the baseline date is reset to this fill date. A search is then made for a subsequent antibiotic dispensed within 30 days of this fill date. As subsequent antibiotics are found, the baseline date is reset and the search continues for more antibiotics. After 30 days without a subsequent antibiotic, the search ends.
- If another medical visit occurs on a day following that of the initial OM-coded visit, and the later medical visit does not carry a code for OM (in which case it becomes a rival explanation for antibiotic therapy), then the search for antibiotics to be linked to the initial OM-visit is halted.
- Once the search for antibiotics to be linked to an OM-coded visit exceeds the 30-day limit, or once a non-OM coded medical visit appears in the dataset, the search for the next OM-coded visit resumes.

**Otitis Media Antibiotics**

The rule-based system program ran successfully for each of the 5,851 eligible subjects, identifying 10,199 episodes of treatment. We analyzed 9,289 systemic antibiotic prescriptions identified as probable OM therapy for the three plans. To examine sequencing of therapy, antibiotics linked to OM were further classified according to when they were given relative to the start of the OM episodes of treatment. Those antibiotics that were used as initial therapy to treat an OM episode were classified as first-line therapy. Any OM antibiotics that followed first-line therapy to treat the same OM episode were classified as follow-up therapy. This information was readily obtained from the output dataset created by the rule system because it recorded the ordinal sequence of each antibiotic attributed as probable therapy for each identified OM episode of treatment. Figure 2 shows the relative usage rates of OM antibiotics among plans by pharmacologic class.
The proportional breakdown of antibiotics used to treat OM, when organized by drug class, differed considerably among plans, particularly between the Medicaid IPA plan and the other two plans. For first-line therapy, the Medicaid IPA plan had approximately half the proportional use of amoxicillin-clavulanate and cephalosporins/loracarbef of the other two plans. Penicillinase-sensitive penicillins, principally inexpensive amoxicillin, were used proportionately nearly twice as often in the Medicaid IPA plan compared to the other two plans. Sulfamethoxazole-trimethoprim was used at double the relative rate for the Indemnity plan when compared to the Network plan.

Key Utilization Measures
Seven key utilization measures were examined to explore differences between plans. The first five measures were derived from the rule-system output dataset. The last two were derived from the original medical and hospital claims datasets. Descriptions of these measures are shown in Figure 3. For each subject, each of the seven utilization measures reflects activity over the 12-month window.

Descriptive statistics for the seven utilization measures for each plan are shown in Table 2. Multivariate Analysis of Variance (MANOVA) was performed to compare plans on the complete set of utilization measures. The null hypothesis of no difference between plans on the entire set of utilization measures was rejected ($S=2, M=2, N=2920$; Wilks Lambda; $p<.001$). To permit pair-wise comparisons between plans on specific measures, joint multivariate Bonferroni confidence intervals were calculated at 95% confidence for the differences between plan means on each utilization measure. These results are also shown in Table 2.

Bonferroni comparisons between plan means on Total Count OM Antibiotic Rxs show no significant differences between plans. The Medicaid IPA plan was significantly higher than the other two plans on Total Count First-Line PCN-asensitive OM Rxs but not on Total Count Second-Line PCN-
asensitive OM Rxs. The number of OM Medical Encounter Days was significantly higher for the Indemnity plan than the other two plans, which were not significantly different from each other. Plan means for Non-OM Medical Encounter Days were significantly higher only for the Medicaid IPA plan when compared to the Network plan.

Prescription Ingredient Costs
Actual ingredient costs paid by the plan and average wholesale price (AWP) estimates for OM antibiotics and for all prescriptions used during the 12-month window are shown in Table 3. This set of four ingredient cost means was compared by plan using MANOVA. The null hypothesis for no difference between plans on ingredient costs was rejected ($S=2, M=5, N=2921.5$; Wilks Lambda; $p<.001$). The Medicaid IPA plan had significantly lower mean ingredient costs for OM antibiotics than did the other two plans, which were not significantly
**Figure 3. Description of Key Utilization Measures**

<table>
<thead>
<tr>
<th>Utilization Measure</th>
<th>Medicaid IPA Plan (n=4,318) Original Data</th>
<th>Network Plan (n=364) Original Data</th>
<th>Indemnity Plan (n=1169) Original Data</th>
<th>Bonferroni Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Otis media treatment episodes</td>
<td>Sum 7,377 1.71 1.23</td>
<td>Sum 563 1.55 0.96</td>
<td>Sum 2,259 1.93 1.40</td>
<td>M&gt;l, N=l, N=M</td>
</tr>
<tr>
<td>OM treatment episodes with antibiotics</td>
<td>Sum 5,453 1.26 1.05</td>
<td>Sum 384 1.06 0.83</td>
<td>Sum 1,201 1.03 1.17</td>
<td>M&gt;l, N=l, N=M</td>
</tr>
<tr>
<td>Total count OM antibiotics Rx's</td>
<td>Sum 6,788 1.57 1.63</td>
<td>Sum 566 1.56 1.74</td>
<td>Sum 1,935 1.66 2.49</td>
<td>M&gt;l, N=l, N=M</td>
</tr>
<tr>
<td>Total count first-line PCN-ase-sensitive OM Rx's</td>
<td>Sum 3,135 0.73 0.76</td>
<td>Sum 122 0.34 0.55</td>
<td>Sum 317 0.27 0.52</td>
<td>M&gt;l, N=l, N=M</td>
</tr>
<tr>
<td>Total count 2nd-line PCN-ase-sensitive OM Rx's</td>
<td>Sum 451 0.10 0.42</td>
<td>Sum 35 0.10 0.43</td>
<td>Sum 121 0.10 0.46</td>
<td>M=l, N=l, N=M</td>
</tr>
<tr>
<td>OM medical encounter days</td>
<td>Sum 9,787 2.27 2.09</td>
<td>Sum 764 2.10 1.83</td>
<td>Sum 3,160 2.70 2.56</td>
<td>M&lt;l, N&lt;l, N=M</td>
</tr>
<tr>
<td>Non-OM medical encounter days</td>
<td>Sum 25,836 5.98 6.62</td>
<td>Sum 1,662 4.57 3.93</td>
<td>Sum 6,262 5.36 8.24</td>
<td>M=I, N=l, N&lt;M</td>
</tr>
</tbody>
</table>

*Based on 95% joint multivariate confidence intervals. M=Medicaid IPA plan, N=Network plan, I=Indemnity plan.

**Discussion**

Antibiotic usage in each plan, in terms of number of prescriptions dispensed, did not appear excessive. Antibiotics were used in only 53%–74% of treatment episodes (see Table 2). When used, the average number of antibiotic prescriptions ranged across plans from 1.24 to 1.61 per treatment episode. Clearly, if the assumptions used in tracking follow-up

different from each other. Actual and AWP mean ingredient costs for OM antibiotics in the Medicaid IPA plan were 53%–61% those of the other two plans. Comparisons of actual and AWP ingredient costs for all prescriptions showed significantly lower ingredient costs for the Medicaid IPA plan. Actual ingredient costs were significantly lower for Indemnity compared to the Network plan, though estimated AWP ingredient costs were not significantly different between these two plans.
antibiotics in this study hold, most OM episodes resolve after one antibiotic treatment. The literature supports this. Most OM cases resolve spontaneously, even in the absence of antibiotic therapy, though Rosenfelds\textsuperscript{28} meta-analysis of 5,400 children shows a definable benefit from antibiotic therapy for some patients.

Most clinicians suggest that antibiotics be considered when a confident diagnosis for otitis media is made.\textsuperscript{4,11} Concern about possible overtreatment of antibiotics for OM may be a consequence either of choosing the wrong drug at a point in therapy—especially an expensive wide-spectrum or beta-lactamase-stable antibiotic given as initial therapy—or, of more recent interest, of physicians over-diagnosing this condition. Several authors have described the inappropriate diagnostic criteria that lead some physicians to misjudge the OM diagnosis.\textsuperscript{11,17,28}

How did results vary by plan? The total count of antibiotics used per patient was similar among plans, despite the substantially younger ages of Medicaid IPA patients. There may have been a lesser propensity to use antibiotics in the Indemnity plan when an OM diagnosis was made, as evidenced by the high number of OM treatment episodes per patient, despite similar antibiotic prescription counts. But this might be explained by a greater likelihood to code a medical visit for OM in the Indemnity plan, especially since OM Medical Encounter Days for the Indemnity plan largely exceeded those of the other plans.

Why did the Indemnity plan have rates that were much higher for chronic OM, concurrent diseases of the ear/mastoid process, and OM incision surgery? From limitations in design of this retrospective study, the question cannot be answered—though hypotheses can be raised. Perhaps the reward structure with indemnity-based reimbursement may promote more aggressive use of services and more liberal upcoding of more complex services by physicians. But other explanations are viable. Patients in the Indemnity plan may have been exposed to more risk factors for OM, such as daycare, parental smoking, and epidemic viral infections, which are linked to higher incidences of OM.\textsuperscript{29,31} Geographic variations in resistance to beta-lactam antibiotics, particularly by Moraxella catarrhalis and Haemophilus influenzae—and, increasingly, Streptococcus pneumoniae—might conceivably lead to more obstinate cases in a community. Perhaps physicians in this community are more predisposed to aggressive medical services because a critical mass of leaders or experts in the community promotes the use of these procedures. Chassin\textsuperscript{32} has documented such “contagious enthusiasm” in a study of variation in use of carotid endarterectomy among communities. Here, a few dominant opinion leaders establish enthusiasm for a set of procedures or techniques. Other physicians in the community follow the lead of these enthusiasts in treating their own patients.

The Medicaid IPA plan had far lower drug ingredient costs than the other two plans, both for OM antibiotics and for all drugs for all conditions. The fact that for both OM antibiotics and all prescriptions average drug costs were lower suggests that these cost differences may be a consequence of plan design and of incentives to prescribers and pharmacists to use fewer or less-expensive drugs in this plan.

The results found for Medicaid IPA patients may be typical of other Medicaid-funded populations. Though methodologies for tracking antibiotic use differed, key utilization measures for Medicaid IPA in this study were similar to those of the Colorado OM Medicaid patients studied by Byrns et al.\textsuperscript{19} On average, each child in Medicaid IPA had 1.57 antibiotics over the 12-month window compared to 1.55 antibiotic courses in Byrns\textsuperscript{19} and 2.27 OM Medical Encounter Days compared to 2.4 ambulatory visits in Byrns\textsuperscript{14}. 4.2% of the children had middle ear incision surgery during the year compared to a slightly higher 54.3 surgical procedures per 1000 children with OM in Byrns.

Except for heavier use of SMX-TMP, similar prescribing patterns were seen between Medicaid IPA and the Tennessee Medicaid children in the White et al.\textsuperscript{19} study. For Medicaid IPA, proportional first-line use for amoxicillin, trimethoprim-sulfamethoxazole, and erythromycin-sulfamethoxazole was

\begin{table}
\centering
\caption{OM Antibiotic Costs by Plan}
\begin{tabular}{|l|cc|cc|cc|}
\hline
\multicolumn{1}{|c|}{Costs} & \multicolumn{2}{c|}{Medicaid IPA Plan} & \multicolumn{2}{c|}{Network Plan} & \multicolumn{2}{c|}{Indemnity Plan} \\
 & \multicolumn{1}{c}{(n=4318)} & \multicolumn{1}{c|}{Original Data} & \multicolumn{1}{c}{(n=364)} & \multicolumn{1}{c|}{Original Data} & \multicolumn{1}{c}{(n=1169)} & \multicolumn{1}{c|}{Original Data} \\
 & \multicolumn{1}{c}{Mean} & \multicolumn{1}{c|}{Std Dev} & \multicolumn{1}{c}{Mean} & \multicolumn{1}{c|}{Std Dev} & \multicolumn{1}{c}{Mean} & \multicolumn{1}{c|}{Std Dev} \\
\hline
Actual ingredient costs, OM antibiotics & 17.98 & 31.99 & 33.87 & 46.96 & 31.08 & 59.34 \\
AWP ingredient costs, OM antibiotics & 23.08 & 36.79 & 38.07 & 50.64 & 43.42 & 73.70 \\
Actual ingredient costs, all prescriptions & 63.56 & 97.48 & 108.26 & 127.26 & 87.03 & 176.44 \\
AWP ingredient costs, all prescriptions & 81.29 & 118.88 & 123.18 & 139.43 & 121.33 & 226.80 \\
\hline
\end{tabular}
\end{table}

*Based on 95% joint multivariate confidence intervals. M=Medicaid IPA plan, N=Network plan, I=Indemnity plan.
59.9%, 11.1%, and 3.3%, respectively; combined first- and second-line use was 52.4%, 13.0%, and 3.6%, respectively. In the White study, which did not directly model the sequencing of antibiotic therapy but explored prior antibiotic use as a covariate, overall proportional OM antibiotic use for the three drugs was 52.6%, 6.6%, and 4.6%, respectively.

Berman et al.\textsuperscript{39} recently published an outcomes study of antibiotics to treat OM, using a cohort of 12,381 children under 30 months old enrolled in Colorado Medicaid in 1991–92. The authors tracked any switch in antibiotic prescriptions within 24 days of an initial OM visit and classified the new incident as either an unresponsive acute otitis media (UAOM) or adverse drug reaction (ADR). Overall UAOM rates were 11.6% when less-expensive antibiotics were prescribed at the initial visit and 13.2% when more-expensive antibiotics were used (p<0.029). ADR rates were 5.9% when less-expensive antibiotics were prescribed and 6.1% when more-expensive ones were prescribed (not significant). However, unexplored confounding variables, such as disease severity, might influence antibiotic selection. In addition to the inferior UAOM performance of the more-expensive antibiotics in this study, paradoxical findings such as the inferior performance of amoxicillin-clavulanate when compared to amoxicillin monotherapy suggest the possibility that some physicians may be selecting more-expensive antibiotics to treat more severe cases, resulting in inherently poorer outcomes.

**CLAIMS DATA AND THE RULE-BASED SYSTEM**

The rule-based program used in this study to link antibiotics with medical claims was a necessary analytical solution, given the fact that, like those of other health plans, prescriptions in our plans did not contain indications or diagnostic codes. A panel of judges reviewing each of the 5,851 patient profiles could have worked as well, if not better, but the time and expense would have been prohibitive. Sampling of cases would be a workable compromise, but checks on interreliability of the judges would be required.

The rule-based system has the additional advantages that all assumptions and rules for evaluating patient profiles must be stated a priori, yet these assumptions and rules can be changed readily when modeling against a subset of patient profiles to test the adequacy of the assumptions and rules proposed. However, the results from this study are challengeable because the degree to which this method selected antibiotics actually intended to treat OM is unknown.

Further, if the physician failed to note the diagnosis of OM in the medical claim, these diagnoses and related antibiotics would be missed. A study of ambulatory care claims from two IPA plans showed only 47% agreement between the medical service claim and the original medical record for a diagnosis of essential hypertension.\textsuperscript{34} Though the patient chart or medical record has been proposed as a reference standard for validation of claims data, it also is subject to validation problems, particularly for prescription data. In a recent study comparing the medical record to prescription claim files, the medical record was four times more likely to omit documentation of a patient prescription than was the prescription claim file; antidepressives was one of the three therapeutic classes with the most omissions.\textsuperscript{35}

We have noted problems in this study regarding plans providing incomplete physician and patient identification data, but experience shows that these problems are probably typical for most plans. As medical claims data become more relied upon for quality-related reporting and comparisons between plans, greater efforts will need to be made by plan management to address such issues. Pharmacy data is less problematic than medical claims because of the wide adoption of National Council for Prescription Drug Programs standards, but physician identification on the pharmacy claim remains inadequate for most medical plans. Proposed new standards for universal prescriber identification numbers show promise for alleviating this problem.\textsuperscript{36,37}

Several limitations specific to this study have been described: selection criteria that eliminate children born during the 18-month data collection period, some unreliable patient identification and physician specialty codes in one plan, and the uncertainty of assumptions used in the rule-based computer program. Other limitations, noted in studies of this type, also are present here: limited distinction between chronic and acute ICD codes on the medical service and hospital claims, inadequate physician identifiers on the prescription records, and possible differences in the coding of medical services that are attributable to plan design. Limitations ascribable to retrospective designs such as this one, as well as the general problems with using claim records to describe utilization, are explored in detail in a recent review by Motheral and Fairman.\textsuperscript{38}

**CONCLUSION**

Many health organizations are promoting greater emphasis on both establishing and reviewing ever-evolving consensual treatment protocols and on measuring patient outcomes associated with various treatment methods. The current study focused on a primary component of quality management: defining and measuring the treatment process itself. The goal of this study was to devise a method for drawing more useful information from available plan data to better understand the choice and sequencing of drug therapy to treat a medical problem—in this case, antibiotics to treat otitis media. Such inferential methods and the data they evaluate will need to be improved. An electronic rule-based analytical approach might be a viable method to describe the treatment processes used in medical plans by abstracting the information carried in routinely collected claims data. More elegant approaches to study treatment processes will probably evolve as trends such as
Evaluation of a Rule-Based Program to Describe Antibiotic Utilization for Otitis Media Among Three Medical Plans

faster and cheaper computer processing, client-server computing systems, data warehousing storage capabilities, and data-mining software combine to make routine the analytical techniques that only a few years ago were considered impractical, if they were considered at all.

References

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