LESS IS MORE

Ambulatory Antibiotic Use and Prescription Drug Coverage in Older Adults

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Background: Several studies have shown that use of medications to treat chronic conditions is highly sensitive to out-of-pocket price and influenced by changes in insurance coverage. Because antibiotics target infections and are used for a short period, one may expect antibiotic use to be less responsive to price. However, no studies have evaluated how antibiotic use changes with drug coverage. We evaluate changes in ambulatory oral antibiotic use after implementation of the Medicare drug benefit (Part D).

Methods: We conducted a comparison group analysis 2 years before and after implementation of Part D using insurance claims data from a large Medicare Advantage plan (January 1, 2004, through December 31, 2007). Outcomes included the likelihood of using any oral antibiotics and major antibiotic subclasses among 35 102 older adults and rates of antibiotic use among those with pneumonia and other acute respiratory tract infections.

Results: Overall antibiotic use increased most among those who did not previously have drug coverage (relative odds ratio [OR], 1.58; 95% confidence interval [CI], 1.36-1.85). Use of the broad spectrum antibiotic subclasses of quinolones (OR, 1.70; 95% CI, 1.35-2.15) and macrolides (1.59; 1.26-2.01) increased more than the use of other subclasses, especially for those with prior drug coverage. Rates of ambulatory antibiotic use associated with pneumonia increased (OR, 3.60; 95% CI, 2.35-5.53) more than those associated with other acute respiratory tract infections (2.29; 1.85-2.83).

Conclusions: Antibiotic use increased among older adults whose drug coverage improved after Part D implementation, with the largest increases for broad spectrum, newer, and more expensive antibiotics. Our study suggests reimbursement may play a role in addressing inappropriate antibiotic use.

Arch Intern Med. 2010;170(15):1308-1314

OVERUSE OF ANTIBIOTICS IS a common and important problem, potentially leading to unnecessary spending for prescription drugs, increased risks of adverse effects with no associated benefit, and the development of antimicrobial resistance.[1,2] Multiple programs have aimed to reduce inappropriate antibiotic use in inpatient and ambulatory care settings.[3,4] Although many of these interventions have helped curb antibiotic prescribing for acute respiratory tract infections and other conditions,[5] there may still be substantial room for additional reductions. While quality improvement programs have traditionally focused on altering prescriber behavior through education and/or audit and feedback, interventions increasingly include a patient education component because researchers have found that patient expectation of and demand for antibiotic prescriptions affect physicians' prescribing behavior.[6,7]

See Invited Commentary at end of article

An important moderator of patient demand for prescription drugs is out-of-pocket cost. Numerous studies have shown that pharmacy copayment increases are followed by reductions in the likelihood of use and refill adherence.[8] Likewise, when drug coverage becomes more generous, patients fill more prescriptions,[9-11] with resultant increases in appropriate and inappropriate use. However, nearly all studies of the impact of prescription drug coverage on drug use have focused on medication use overall or medication used to treat chronic conditions (eg, antidepressants, drugs to lower cholesterol levels, and antihypertensives).

If antibiotic prescription were appropriate, one might expect use of antibiotics to be somewhat less sensitive to out-of-pocket price changes because antibiotics are for short-term use and to treat specific infections that could worsen fairly rapidly without adequate antimicrobial treatment. In other words, price should not affect the incidence of infections, and the consequences of failing to treat will manifest within a short time.

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We used the 2006 implementation of the new Medicare drug benefit (Part D) as a natural experiment to study how changes in drug coverage affect the use of antibiotics. Studies indicate that, on average, Part D implementation increased drug use 6% to 74%, depending on the level of prior coverage, and reduced out-of-pocket spending 13% to 23%.[9,11] To our knowledge, no studies have evaluated how the use of antibiotics changed with Part D implementation, and very few have examined the impact of patient financial incentives on use of antibiotics.[12,13]

In this study, we evaluated the impact of Part D on the likelihood of use of any oral antibiotic and the major subclasses to determine, for example, whether use of newer, more expensive, and broader-spectrum macrolides might be more responsive to changes in coverage than older, less expensive, and narrower-spectrum penicillins. In addition, we examined whether changes in oral antibiotic use differ for pneumonia, a condition that could be life threatening and for which antibiotics are often although not always indicated compared with other acute respiratory tract infections (ARIs), conditions for which overuse is more common.[14,15]

METHODS

STUDY DESIGN

We used the implementation of Part D as a natural experiment to compare changes in antibiotic use for 4 groups of elderly beneficiaries who were continuously enrolled in Medicare Advantage plans offered by a large Pennsylvania insurance company. Our study period was January 1, 2004, through December 31, 2007, 2 years before and after the January 2006 implementation of Part D. We had 3 intervention groups who had no or limited drug coverage before the implementation of Part D and whose coverage improved in January 2006 because they enrolled in the Part D products of the same Medicare Advantage plan. One intervention group had no coverage before Part D implementation (no-coverage group), and the other 2 groups had an $8 or $20 copayment before their total pharmacy spending reached quarterly caps on plan payment for drugs of $150 or $350 ($150- and $350-cap groups). The level of drug coverage before Part D implementation in the latter 2 groups depended on members' county of residence (ie, the insurer only offered the $150- or $350-cap in 1 county). This mitigates the selection bias.

In January 2006, all members in the intervention groups switched to Part D products. The standard Part D benefit includes a $250 deductible, a 25% coinsurance before drug spending reaches $2250, a coverage gap for drug spending ranging from $2250 to $5100, and a 5% coinsurance in the catastrophic coverage period for drug spending of more than $5100 or out-of-pocket drug spending of more than $3600 (2006 figures). However, Part D plans are permitted to offer a benefit actuarially equivalent to the standard benefit or better; most plans, including the study plan, modified the benefit by eliminating the deductible and substituting copayments for coinsurance. Thus, beneficiaries in our 3 intervention groups did not have a deductible, faced tiered copayments ($8/$20 for generic/brand-name drugs) rather than 25% coinsurance, and could, for an additional premium, add coverage of generic drugs in the coverage gap (70% in our sample chose the plan that covered generic drugs vs 63% at the national level).[16] The Part D plans that members chose were comparable across the 3 intervention groups.

Our comparison group consisted of enrollees who had stable drug coverage, without quarterly caps, through their former employers throughout the 4-year study (no-cap group). Because the comparison group's coverage depended on decisions by their former employers to offer supplementary drug coverage, and few people decline this coverage because it is normally more generous, we believe selection bias is minimal.

All enrollees in the 4 groups obtained their nondrug medical coverage from the same Medicare Advantage plans, and this coverage did not change during the 4-year study period. The University of Pittsburgh Institutional Review Board approved this study.

STUDY COHORTS

The first study cohort consisted of a random sample of 36 858 members who were continuously enrolled in the Medicare Advantage plans from January 1, 2004, through December 31, 2007. We excluded 1756 members who were younger than 65 years in 2004 and enrolled in Medicare because of a disability. The remaining 35 102 members constituted our continuously enrolled overall study cohort.

We then constructed 2 condition-specific subcohorts. For each 2-year study period before and after Part D implementation, we identified individuals who had outpatient visits or inpatient hospital admissions for pneumonia or other ARIs. Individuals were identified as having pneumonia if they had outpatient visits or inpatient admissions with *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes 481, 482, 483, 485, or 486. For other ARIs, we identified visits or admissions for which the primary diagnosis carried *ICD-9* codes for sinusitis (461 and 473), pharyngitis (034, 462, and 463), bronchitis (466 and 490), or nonspecific upper respiratory tract infection (460 and 465). Any return office visits occurring within 28 days after the first diagnosis of pneumonia or ARI were defined as the same incident. This approach to identifying these diagnoses in administrative claims data has been shown to have a sensitivity of 68% to 79% and a specificity of 84% to 91%, depending on the condition.[17,18]

OUTCOMES

We calculated the proportion of members in the overall cohort who filled at least 1 oral antibiotic prescription at both quarterly and yearly levels from January 1, 2004, through December 31, 2007. We also calculated the proportion using any antibiotics by major antibiotic drug subclass, including cephalosporins, penicillins, tetracyclines, quinolones, macrolides, sulfonamides, and others.

For the subcohorts undergoing treatment for pneumonia and ARIs, we constructed a measure of antibiotic use based on whether the individual filled an antibiotic prescription within 2 days (before or after) of the incident visit or admission. This method for linking outpatient pharmacy claims to incident diagnoses of pneumonia and ARIs in medical claims has high level of sensitivity and specificity.[17,18] We then calculated the rate of outpatient antibiotic prescriptions filled conditionally for a diagnosis of pneumonia or other ARI during the periods before and after Part D implementation.

We also conducted a sensitivity analysis relaxing the time from diagnosis to prescription fill from 2 to 5 days and excluding those incident visits associated with an institutional stay (including an acute care hospital or nursing home stay).

STATISTICAL ANALYSIS

Although selection bias was small, we used propensity score weighting to enhance comparability between each intervention group and the comparison group.[9,19,20] Propensity score weights were calculated in 2 steps. First, we calculated the prob-

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Table 1. Characteristics of the Study Population in 2005[a]

Characteristic	Intervention Groups: No Coverage	Intervention Groups: $150 Cap	Intervention Groups: $350 Cap	No-Cap Group
No. (%) of population	3939 (11.2)	2662 (7.6)	19 014 (54.2)	9487 (27.0)
Female sex	55.4	62.3	62.1	52.5[b,c]
Age, y				
≤65 to 74	47.4	49.7	52.5	60.7[b,c]
75 to ≤84	44.3	40.6	39.3	34.1[b,c]
≥85	8.3	9.7	8.2	5.3[b,c]
Race				
White[d]	93.0	96.0[b,e]	91.9	92.1
African American[d]	5.2	2.4[b,e]	6.0	5.7
Below poverty line, %[d]				
<100	10.6	11.1	10.1	9.9
100 to 200	18.3	20.9[b,e]	17.2	16.9
>200	71.2	68.0[b,e]	72.7	73.2
Urban residence[d]	73.7[b,e]	57.7[b,e]	79.1	79.7
Diagnosed chronic conditions				
Hypertension	54.5[b,e]	62.8	62.6	61.2
Hyperlipidemia	48.2	55.7	57	60.4[b,c]
Diabetes	19.6[b,e]	22.5	22.3	23.3
Prospective risk scores, mean (SE)[f]				
2004	0.83 (0.01)	0.85 (0.01)	0.86 (0.02)	0.84 (0.01)
2005	0.92 (0.01)	0.95 (0.02)	0.94 (0.01)	0.92 (0.01)
2006	1.03 (0.02)	1.04 (0.02)	1.04 (0.01)	1.03 (0.01)
2007	1.15 (0.02)	1.19 (0.02)	1.18 (0.01)	1.14 (0.01)
Use of medical services in 2005				
Emergency department visits	26.8[b,e]	24.1	25.9	24.4
Hospitalizations	18.5	16.8	18.3	17.1
Mean (SE) No. of outpatient visits	23 (0)[b,e]	25 (1)	25 (0)	26 (0)
Mean (SE) outpatient costs, $	3498 (93)	3533 (124)	3741 (47)	3869 (66)
Mean (SE) medical costs, $	6000 (187)	5838 (227)[b,e]	6209 (88)	6267 (130)

[a] Values consist of unweighted raw data and are given as percentage of the population unless otherwise indicated. Percentages have been rounded and may not total 100. The intervention groups consisted of Medicare Part D enrollees with no coverage or with $150 or $350 caps before Part D implementation. The comparison (no-cap) group had stable drug coverage before and after Part D implementation.

[b] $P < .05$. We used χ^2 tests for categorical variables and 1-way analysis of variance test for continuous variables.

[c] Differences are significant compared with each intervention group.

[d] These numbers are at zip-code level.

[e] Differences are significant compared with the no-cap group.

[f] Prospective risk scores were calculated with the use of an algorithm that is described in the "Statistical Analysis" subsection of the "Methods" section, with higher scores indicating greater expected future medical spending.

ability of being in each intervention group vs the comparison group by using 3 logistic regressions (one for each intervention group) and adjusting for zip-code level of income, race, poverty rate, urban/suburban address, and individual-level variables such as age, sex, and health status measured by annual prospective risk scores during the baseline years (2004 and 2005). The risk scores were calculated using risk-grouper software involving a series of proprietary algorithms (DxCG system; Urix, Inc, Boston, Massachusetts) based on *ICD-9* diagnoses or Healthcare Common Procedure Coding System codes reported on claims.[21] Higher risk scores indicate worse health status and greater expected future medical care spending.

Second, the estimated propensity scores were assigned to each individual in proportion to the estimated probability of the enrollee's assignment to the other group in the pairwise comparisons. That is, enrollees in each intervention group who had characteristics similar to those of enrollees in the comparison group were given higher weights.

We then calculated weighted averages of the proportion of members in each study group who used any antibiotics and plotted changes over time for each intervention group and the comparison group.

We used random effects logistic regression models to estimate the changes in outcomes between the 2 years before and 2 years after the implementation of Part D. Random effects models estimate subject-specific changes and changes before and after Part D implementation. We applied propensity score weights in the logistic models to balance study groups. In particular, logistic regression estimated the effects on the likelihood of using any antibiotics as well as each major subclass, including cephalosporins, penicillins, tetracyclines, quinolones, macrolides, sulfonamides, and others. We also used random effects logistic regressions to estimate changes in the likelihood of ambulatory antibiotic prescriptions among those with diagnoses of pneumonia or ARI before and after Part D implementation between each intervention group and the comparison group. All reported *P* values are 2 sided. We used commercially available software (SAS, version 9.2 [SAS Institute Inc, Cary, North Carolina], and Stata 10 [StataCorp, College Station, Texas]) for estimation.

RESULTS

STUDY POPULATION

Characteristics of the study population are reported in **Table 1**. The comparison group was slightly more likely

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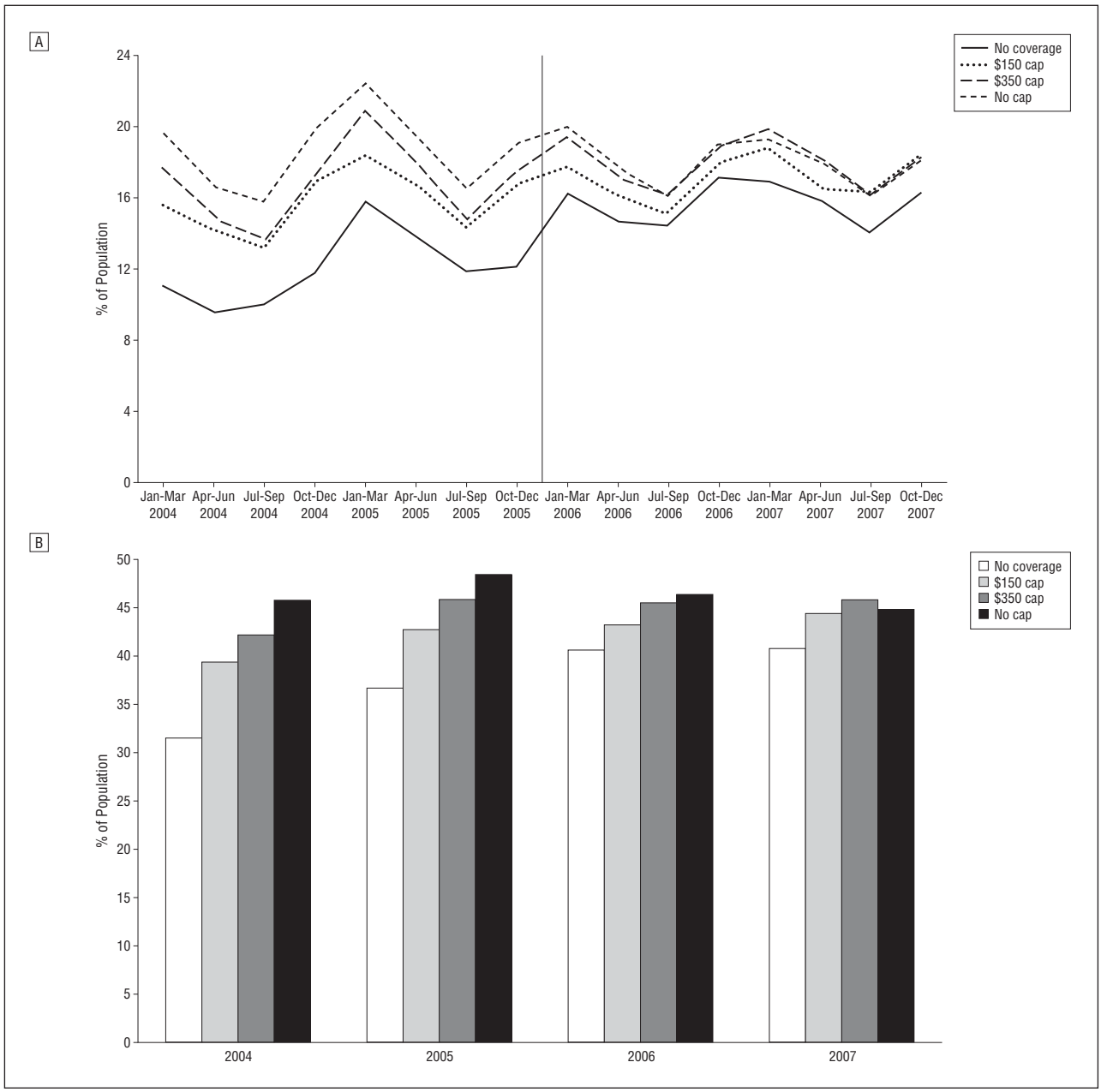

Figure. Proportion of the study population who filled at least 1 antibiotic prescription during the study period. A, Quarterly changes. B, Changes by year. The intervention groups consisted of Medicare Part D enrollees with no coverage or with $150 or $350 caps before Part D implementation. The comparison (no-cap) group had stable drug coverage before and after Part D implementation.

to be male and younger than the intervention groups. The $150-cap group was more likely to live in suburban areas and zip codes with a higher proportion of white residents. This is consistent with the fact that the level of the quarterly caps ($350 and $150) depended on the county of residence. The group with no prior drug coverage was slightly less likely to have diagnoses of hypertension or diabetes than the comparison group, whereas the comparison group was more likely to have a diagnosis of hyperlipidemia than the intervention groups. There were no statistically significant differences among the 4 groups in prospective risk scores (our measure of overall status and predictor of health service use) even before propensity score weighting.

EFFECTS ON LIKELIHOOD OF USE OF ANY ANTIBIOTICS AND EACH SUBCLASS OF ANTIBIOTICS

The **Figure** shows the proportion of the overall study population that ever filled any prescription for any antibiotics, by quarter (Figure, A) and year (Figure, B), from January 1, 2004, through December 31, 2007. There were clear seasonal trends in antibiotic use, with the highest use occurring in each year's first quarter and lowest use in each year's third quarter ($P < .05$). One can also observe a slight declining trend in the use of antibiotics during the 4-year study period.

Table 2 presents numerical results. From December 31, 2005, to December 31, 2007, relative to the compari-

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Table 2. Effects of Part D Implementation on Likelihood of Use of Antibiotics

Antibiotic Use by Study Group[a]	2 y Before Implementation, % of Group[b]	2 y After Implementation, % of Group[b]	Relative OR[c] (95% CI)
Any antibiotics			
No-coverage	34.1	40.7	1.58 (1.36-1.85)
$150-cap	41.1	43.8	1.27 (1.06-1.53)
$350-cap	44.0	45.6	1.19 (1.10-1.30)
No-cap	47.2	45.5	1 [Reference]
Cephalosporins			
No-coverage	7.0	9.2	1.43 (1.11-1.84)
$150-cap	9.5	10.5	1.16 (0.88-1.53)
$350-cap	9.0	9.5	1.08 (0.95-1.24)
No-cap	10.2	10.0	1 [Reference]
Penicillin			
No-coverage	13.1	14.9	1.38 (1.12-1.71)
$150-cap	16.2	16.1	1.12 (0.88-1.43)
$350-cap	17.6	17.2	1.10 (0.36-3.32)
No-cap	19.5	18.1	1 [Reference]
Tetracyclines			
No-coverage	2.5	3.4	1.60 (1.05-2.42)
$150-cap	3.8	4.1	1.20 (0.77-1.88)
$350-cap	3.4	3.5	1.16 (0.94-1.44)
No-cap	4.2	3.8	1 [Reference]
Quinolones			
No-coverage	8.2	13.4	1.70 (1.35-2.15)
$150-cap	10.0	14.6	1.48 (1.14-1.93)
$350-cap	13.1	16.0	1.16 (1.04-1.31)
No-cap	13.6	15.0	1 [Reference]
Macrolides			
No-coverage	9.1	11.7	1.59 (1.26-2.01)
$150-cap	12.5	13.0	1.20 (1.00-1.56)
$350-cap	13.2	13.4	1.17 (1.03-1.31)
No-cap	14.4	13.3	1 [Reference]
Sulfonamides			
No-coverage	0.0	0.1	1.65 (0.11-23.77)
$150-cap	0.1	0.1	0.67 (0.03-14.22)
$350-cap	0.1	0.1	1.21 (0.31-4.74)
No-cap	0.2	0.2	1 [Reference]
Others			
No-coverage	4.7	6.6	1.37 (1.00-1.89)
$150-cap	6.4	7.4	1.05 (0.74-1.50)
$350-cap	5.9	7.1	1.12 (0.95-1.32)
No-cap	6.1	6.7	1 [Reference]

Abbreviations: CI, confidence interval; OR, odds ratio.
[a] The intervention groups consisted of Medicare Part D enrollees with no coverage or with $150 or $350 caps before Part D implementation. The comparison (no-cap) group had stable drug coverage before and after Part D implementation.
[b] Expressed as unadjusted raw numbers. These numbers are proportions of members who ever filled an antibiotic prescription in the study period.
[c] Indicates adjusted difference-in-difference estimates from logistic regression random-effects regression models with propensity score weighting. The adjusted variables used in calculating the propensity score include zip-code level of income, race, poverty rate, urban, and individual-level variables such as age categories, sex, and 2004 and 2005 risk scores. Relative ORs measure changes in outcomes 2 years before and after Part D implementation in each intervention group relative to the changes in outcomes in the comparison group.

son group, the relative odds ratios (ORs) of the use of any antibiotic increased by 1.58 (95% confidence interval [CI], 1.36-1.85) among enrollees who transitioned from no drug coverage to Part D coverage. Relative ORs of use of any antibiotics in a year increased slightly in the $150-cap group and $350-cap group by 1.27 (95% CI, 1.06-1.53) and 1.19 (1.10-1.30), respectively.

Table 3. Rates of Outpatient Antibiotic Prescriptions Filled Among Those With Visits for Pneumonia or ARIs

Antibiotic Use by Study Group[a]	2 y Before Implementation, % of Group[b]	2 y After Implementation, % of Group[b]	Relative OR[c] (95% CI)
Pneumonia			
No-coverage	28.4	46.8	3.60 (2.35-5.53)
$150-cap	44.4	48.7	1.64 (1.01-2.67)
$350-cap	42.2	40.0	1.27 (0.98-1.65)
No-cap	47.6	40.2	1 [Reference]
Pneumonia, institutional stays excluded			
No-coverage	28.2	44.0	3.07 (1.94-4.85)
$150-cap	42.4	49.8	1.97 (1.17-3.32)
$350-cap	40.9	38.9	1.29 (0.97-1.70)
No-cap	46.6	38.8	1 [Reference]
ARIs			
No-coverage	45.1	59.5	2.29 (1.85-2.83)
$150-cap	57.8	62.6	1.40 (1.10-1.79)
$350-cap	59.5	62.5	1.36 (1.18-1.57)
No-cap	64.9	62.0	1 [Reference]
ARIs, institutional stays excluded			
No-coverage	45.2	59.7	2.32 (1.87-2.87)
$150-cap	57.7	62.7	1.42 (1.11-1.82)
$350-cap	59.7	62.6	1.38 (1.19-1.59)
No-cap	65.3	62.2	1 [Reference]

Abbreviations: ARIs, acute respiratory tract infections; CI, confidence interval; OR, odds ratio.
[a] The intervention groups consisted of Medicare Part D enrollees with no coverage or with $150 or $350 caps before Part D implementation. The comparison (no-cap) group had stable drug coverage before and after Part D implementation.
[b] Expressed as unadjusted raw numbers. These numbers are proportions of members who ever filled an antibiotic prescription in the study period.
[c] Relative ORs and comparisons are explained in the last footnote to Table 2.

Relative to the comparison group, the no-coverage group was more likely to fill prescriptions for each of the pharmacologic subclasses we studied after Part D implementation than before, with the exception of sulfonamides (Table 2). The $150- and $350-cap groups were more likely to fill prescriptions for broad spectrum antibiotics after Part D implementation. For example, the relative ORs of filling prescriptions for quinolones were 1.48 (95% CI, 1.14-1.93) for the $150-cap group and 1.16 (1.04-1.31) for the $350-cap group. The relative ORs of filling prescriptions for macrolides were 1.20 (95% CI, 1.00-1.56) for the $150-cap group and 1.17 (1.03-1.31) for the $350-cap group.

EFFECTS ON RATES OF OUTPATIENT ANTIBIOTIC PRESCRIPTIONS FOR PNEUMONIA OR OTHER ARIs

Table 3 shows the rates of ambulatory antibiotic use for those diagnosed as having pneumonia or other ARIs before and after Part D implementation, as well as changes associated with Part D coverage. There were 5079 and 6534 visits related to pneumonia in the 2 years before and after Part D implementation, respectively, of which 670 and 715, respectively, were institutional visits. There were 10 246 and 10 390 visits related to other ARIs in the 2 years before and

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after implementation, respectively, of which 155 and 182, respectively, were institutional visits. The rates of outpatient antibiotic prescriptions for those visits for which a pneumonia or an ARI diagnosis was recorded declined in the no-cap comparison group over time. However, rates increased among members switching to more generous Part D drug coverage from no or limited (only $150-cap) drug coverage. The increase in rates of antibiotic use was larger for pneumonia-related visits than the increase for other ARI-related visits. After controlling for the declining trend in antibiotic use in general in the comparison group, the proportion of members in the no-coverage group with visits for pneumonia who filled outpatient antibiotics prescriptions more than doubled, with a relative OR of 3.60 (95% CI, 2.35-5.53). The relative OR in the $150-cap group was 1.64 (1.01-2.67).

All 3 intervention groups with other ARI visits increased the rates of antibiotics filled at a smaller magnitude of change compared with those with pneumonia visits. The no-coverage group increased the most at a relative OR of 2.29 (95% CI, 1.85-2.83), and relative ORs were 1.40 (1.10-1.79) for the $150-cap group and 1.36 (1.18-1.57) for the $350-cap group.

The sensitivity analysis relaxing the time from the diagnosis to the prescription fill to 5 days did not change the rates of antibiotic use associated with pneumonia and ARIs (results not shown). Results after excluding institutional stays were quantitatively similar (Table 3).

COMMENT

We found that the use of antibiotics increased in response to reductions in out-of-pocket price after Part D implementation. However, it is difficult to discern whether these increases represent appropriate use, inappropriate use, or some combination of both because we cannot accurately assess the quality of antibiotic prescribing using insurance claims data. For pneumonia, we found that Part D implementation was associated with a triple increase in the rates of antibiotic treatment among those previously lacking drug coverage, with a relative OR of 3.60 after adjusting for secular trends in the comparison group. Given the high mortality associated with community-acquired pneumonia among the elderly,[22] the finding that changes in drug coverage improve the likelihood of treatment is encouraging.

However, we also found increases in antibiotic use for other ARIs (sinusitis, pharyngitis, bronchitis, and nonspecific upper respiratory tract infection) for which antibiotics are generally not indicated.[18] We found that rates of antibiotic use for ARIs declined from 2004 to 2005 and 2006 to 2007 for the group whose drug coverage did not change. In contrast, the 3 groups who moved from limited or no drug coverage to Part D increased their use of antibiotics for ARIs. The magnitude of these increases was smaller than that for pneumonia. Inappropriate use of antibiotics has contributed to the development of antibiotic-resistant bacteria and has as a result been the target of numerous interventions to reduce use.[3] Our findings suggest that changes in drug coverage among the elderly may exacerbate problems with antibiotic overuse.

Increased antibiotic prescription fill rates may be explained by a change in patient behavior, physician behavior, or some combination. Patients with generous drug coverage may be more likely to request and to fill an antibiotic prescription. Likewise, surveys suggest that physicians' decisions about whether and what to prescribe may be influenced by their perceptions about their patients' ability to pay for drugs, although communication between older adults and physicians about drug cost burden is known to be inadequate.[23,24] Systematic reviews suggest that more complex, multifaceted interventions are more effective at reducing inappropriate antibiotic prescribing.[3,4] Our findings suggest that health care systems may consider changes to patient cost-sharing as another potential lever to alter patient and provider behavior.

We also found different responses to changes in drug coverage across antibiotic subclasses. Although the group transitioning from no or limited coverage to Part D increased their use of nearly all antibiotics (with the exception of sulfonamides), they increased their use of broad spectrum antibiotic subclasses (eg, macrolides and quinolones) more than the older, cheaper subclasses. We expected a larger effect of insurance coverage changes for these subclasses, which can cost up to $30 per day compared with less than $1 per day of treatment for older classes such as penicillin (authors' calculation based on average costs in our study sample). This might be a concern because broad spectrum antibiotics generally are more likely to lead to bacterial resistance.[25]

Our study is subject to certain limitations. First, because the individuals we studied were all enrolled in Medicare Part D prescription plans offered from a single insurance company, the results might not generalize to all older adults. Second, our results are based on drugs purchased at network pharmacies, but any bias from missing claims is likely negligible for several reasons. For the period during which beneficiaries paid entirely out-of-pocket, those using a network pharmacy received a 15% discount from the plan's negotiated prices, which were already well below the retail price. In addition, network pharmacies were numerous and covered almost all local pharmacies. Third, we could not distinguish between bacterial and viral pneumonia using claims data. Antibiotics are not indicated for viral pneumonia. However, our method of using a comparison group and a before-and-after approach should have controlled for temporal trends in viral and/or bacterial pneumonia that affect study groups, and we did not expect differences across study groups in the underlying causes of pneumonia. Similarly, we were not able to determine from claims data whether the use of broad spectrum antibiotics was appropriate.

In summary, use of antibiotics increased as individuals gained better drug coverage, especially for broad spectrum, newer, and more expensive antibiotics. We found increases in the likelihood of antibiotic treatment for pneumonia and other ARIs. These increases took place against a backdrop of national declines in antibiotic use overall.[5] Our study suggests that reimbursement may play a role in addressing the substantial role of inappropriate antibiotic prescribing and use.

Accepted for Publication: January 12, 2010.
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Author Contributions: *Study concept and design:* Zhang, Lee, and Donohue. *Acquisition of data:* Zhang and Donohue. *Analysis and interpretation of data:* Zhang, Lee, and Donohue. *Drafting of the manuscript:* Zhang, Lee, and Donohue. *Critical revision of the manuscript for important intellectual content:* Zhang, Lee, and Donohue. *Statistical analysis:* Zhang. *Obtained funding:* Zhang and Donohue. *Administrative, technical, and material support:* Zhang, Lee, and Donohue. *Study supervision:* Zhang and Donohue.
Financial Disclosure: Dr Zhang is the coprincipal investigator for a project in part funded by Highmark Inc (a Medicare-Advantage plan) to evaluate the economic impact of a high-deductible health care plan on medical care spending.
Funding/Support: Dr Zhang was supported by a challenge grant 1RC1MH088510-01, grant 1R01HS018657-01 from the Agency for Healthcare Research and Quality (AHRQ), RAND-University of Pittsburgh Health Institute, and the University of Pittsburgh's Graduate School of Public Health Computational and Systems Models in Public Health Pilot Program. Dr Lee was supported by the National Institutes of Health National Institute of General Medical Sciences Models of Infectious Disease Agent Study (MIDAS) grant 1U54GM088491-0109, and the Pennsylvania Department of Health Center of Excellence in Prevention and Control of Antibiotic-Resistant Bacterial Infections. Dr Donohue was supported by 1R01HS017695 from the AHRQ and 1R34 MH082682 from the National Institute of Mental Health.
Role of the Sponsors: The sponsoring institutions had no role in the study design or analysis.
Previous Presentation: This study was presented at the Seventh World Congress Meeting of the International Health Economics Association; July 13, 2009; Beijing China.

REFERENCES

1. Arason VA, Sigurdsson JA, Erlendsdottir H, Gudmundsson S, Kristinsson KG. The role of antimicrobial use in the epidemiology of resistant pneumococci: a 10-year follow up. *Microb Drug Resist*. 2006;12(3):169-176.
2. Bergman M, Huikko S, Huovinen P, Paakkari P, Seppala H; Finnish Study Group for Antimicrobial Resistance (FiRe Network). Macrolide and azithromycin use are linked to increased macrolide resistance in *Streptococcus pneumoniae*. *Antimicrob Agents Chemother*. 2006;50(11):3646-3650.
3. Ranji SR, Steinman MA, Shojania KG, Gonzales R. Interventions to reduce unnecessary antibiotic prescribing: a systematic review and quantitative analysis. *Med Care*. 2008;46(8):847-862.
4. Arnold SR, Straus SE. Interventions to improve antibiotic prescribing practices in ambulatory care. *Cochrane Database Syst Rev*. 2005;(4):CD003539.
5. Grijalva CG, Nuorti JP, Griffin MR. Antibiotic prescription rates for acute respiratory tract infections in US ambulatory settings. *JAMA*. 2009;302(7):758-766.
6. Macfarlane J, Holmes W, Macfarlane R, Britten N. Influence of patients' expectations on antibiotic management of acute lower respiratory tract illness in general practice: questionnaire study. *BMJ*. 1997;315(7117):1211-1214.
7. Kravitz RL, Bell RA, Azari R, Kelly-Reif S, Krupat E, Thom DH. Direct observation of requests for clinical services in office practice: what do patients want and do they get it? *Arch Intern Med*. 2003;163(14):1673-1681.
8. Huskamp HA, Deverka PA, Epstein AM, Epstein RS, McGuigan KA, Frank RG. The effect of incentive-based formularies on prescription-drug utilization and spending. *N Engl J Med*. 2003;349(23):2224-2232.
9. Zhang Y, Donohue JM, Lave JR, O'Donnell G, Newhouse JP. The effect of Medicare Part D on drug and medical spending. *N Engl J Med*. 2009;361(1):52-61.
10. Zhang Y, Lave JR, Newhouse JP, Donohue JM. How the Medicare Part D drug benefit changed the distribution of out-of-pocket pharmacy spending among older beneficiaries [published online December 14, 2009]. *J Gerontol B Psychol Sci Soc Sci*. doi:10.1093/geronb/gbp111.
11. Yin W, Basu A, Zhang JX, Rabbani A, Meltzer DO, Alexander GC. The effect of the Medicare Part D prescription benefit on drug utilization and expenditures. *Ann Intern Med*. 2008;148(3):169-177.
12. Flottorp S, Oxman AD, Havelsrud K, Treweek S, Herrin J. Cluster randomised controlled trial of tailored interventions to improve the management of urinary tract infections in women and sore throat. *BMJ*. 2002;325(7360):367. doi:10.1136/bmj.325.7360.367.
13. Foxman B, Valdez RB, Lohr KN, Goldberg GA, Newhouse JP, Brook RH. The effect of cost sharing on the use of antibiotics in ambulatory care: results from a population-based randomized controlled trial. *J Chronic Dis*. 1987;40(5):429-437.
14. Gonzales R, Malone DC, Maselli JH, Sande MA. Excessive antibiotic use for acute respiratory infections in the United States. *Clin Infect Dis*. 2001;33(6):757-762.
15. Gonzales R, Steiner JF, Sande MA. Antibiotic prescribing for adults with colds, upper respiratory tract infections, and bronchitis by ambulatory care physicians. *JAMA*. 1997;278(11):901-904.
16. Centers for Medicare & Medicaid Services. Medicare prescription drug benefit symposium: Part D data symposium fact sheet. http://www.cms.gov/PrescriptionDrugCovGenIn/09_ProgramReports.asp. Published October 2008. Accessed December 6, 2009.
17. Maselli JH, Gonzales R; Colorado Medical Society Joint Data Project Investigators. Measuring antibiotic prescribing practices among ambulatory physicians: accuracy of administrative claims data. *J Clin Epidemiol*. 2001;54(2):196-201.
18. Gonzales R, Sauaia A, Corbett KK, et al. Antibiotic treatment of acute respiratory tract infections in the elderly: effect of a multidimensional educational intervention. *J Am Geriatr Soc*. 2004;52(1):39-45.
19. Hirano K, Imbens GW. Estimation of causal effects using propensity score weighting: an application to data on right heart catheterization. *Health Serv Outcomes Res Methodol*. 2001;2(3-4):259-278.
20. Sato T, Matsuyama Y. Marginal structural models as a tool for standardization. *Epidemiology*. 2003;14(6):680-686.
21. Pope GC, Kautter J, Ellis RP, et al. Risk adjustment of Medicare capitation payments using the CMS-HCC model. *Health Care Financ Rev*. 2004;25(4):119-141.
22. National Heart Lung and Blood Institute. Pneumonia. http://www.nhlbi.nih.gov/health/dci/Diseases/pnu/pnu_whatis.html. Published August 2008. Accessed November 8, 2009.
23. Alexander GC, Casalino LP, Meltzer DO. Physician strategies to reduce patients' out-of-pocket prescription costs. *Arch Intern Med*. 2005;165(6):633-636.
24. Wilson IB, Schoen C, Neuman P, et al. Physician-patient communication about prescription medication nonadherence: a 50-state study of America's seniors. *J Gen Intern Med*. 2007;22(1):6-12.
25. Peterson LR. Squeezing the antibiotic balloon: the impact of antimicrobial classes on emerging resistance. *Clin Microbiol Infect*. 2005;11(suppl 5):4-16.

INVITED COMMENTARY

Decreasing Out-of-pocket Costs of Antibiotics

The Good, the Bad, and the Unknown

Antibiotics are among the most commonly prescribed medications worldwide. Despite their benefits, substantial evidence indicates that antibiotics are overprescribed and frequently used inappropriately.[1] The impact of inappropriate antibiotic use is substantial, including unnecessary costs, avoidable adverse events, and contribution to the development of drug-resistant organisms.

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