DOI: 10.1111/jrh.12584

THE JOURNAL OF RURAL HEALTH

BRIEF REPORT

Antibiotic prescribing to Kentucky Medicaid children, 2012-2017: Prescribing is higher in rural areas

Bethany A. Wattles PharmD, MHA[1] | **Navjyot K. Vidwan MD, MPH**[2] | **Yana Feygin MS**[1] | **Kahir S. Jawad MD, MPH**[1] | **Liza M. Creel PhD, MPH**[3] | **Michael J. Smith MD, MSCE**[4]

[1] Department of Pediatrics, University of Louisville School of Medicine, Louisville, Kentucky, USA

[2] Norton Children's and University of Louisville School of Medicine, Louisville, Kentucky, USA

[3] School of Public Health and Information Sciences, University of Louisville, Louisville, Kentucky, USA

[4] Duke University Medical Center, Pediatric Infectious Diseases, Durham, North Carolina, USA

Correspondence
Bethany A. Wattles, Department of Pediatrics, University of Louisville, 571 S. Floyd St., Louisville, KY 40202, USA.
Email: Bethany.wattles@louisville.edu

Funding information
Kentucky Cabinet for Health and Family Services: Department for Medicaid Services, State University Partnership

Abstract

Purpose: Antibiotic resistance is a major public health threat. Antibiotic use is the main driver of resistance, with children and the state of Kentucky having particularly high rates of outpatient antibiotic prescribing. The purpose of this study was to describe patient and provider characteristics associated with pediatric antibiotic use in Kentucky Medicaid children.

Methods: We used Medicaid prescription claims data from 2012 to 2017 to describe patterns of pediatric antibiotic receipt in Kentucky. Patient and provider variables were analyzed to identify variations in prescribing.

Findings: Children who were female, less than 2 years old, White, and living in a rural area had consistently higher rates of antibiotic prescriptions. There was significant geographic variability in prescribing, with children in Eastern Kentucky receiving more than 3 courses of antibiotics a year. Most antibiotic prescriptions for children were written by general practitioners and nurse practitioners rather than pediatricians.

Conclusion: These findings support the need for extensive antibiotic stewardship efforts inclusive of rural outpatient practices.

KEYWORDS
antibiotic stewardship, antibiotic use, health services research, Medicaid, rural children

Antibiotic resistance is a major public health threat in the United States. The Centers for Disease Control and Prevention (CDC) estimates there are nearly 3 million infections and more than 35,000 deaths annually due to antibiotic-resistant bacteria and fungi.[1] Antibiotic use is the most important contributing factor to antibiotic resistance.[1] The majority of antibiotic prescribing occurs in the outpatient setting, and 30% of all outpatient antibiotic prescriptions are estimated to be inappropriate.[2]

Outpatient antibiotic prescribing has been a focus of the CDC for many years, and state-level prescribing data are published annually.[3] There is significant geographic variation across the United States, with southern states consistently having the highest antibiotic prescribing rate (923 antibiotics per 1,000 persons) compared to the western region (598 antibiotic prescriptions per 1,000 persons).[3] A national study showed antibiotic prescribing to children decreased approximately 13% from 2011 to 2016.[4] This could be attributed to the introduction of pneumococcal vaccines and/or stricter diagnostic criteria for treatment of acute otitis media, the most common indication for antibiotic prescriptions in children.[4] However, there remains a wide variation in antibiotic prescribing to children across states. In 2017, Kentucky had the second highest rate of outpatient antibiotic prescribing to children at 1,281 prescriptions per 1,000 children per year as compared to 760 per 1,000 children nationally (CDC Office of Antibiotic Stewardship, Personal Communication, August 18, 2020). Less is known about antibiotic prescribing variation and patient characteristics within individual states.

In 2016, the CDC published the Core Elements of Outpatient Antibiotic Stewardship,[5] but due to organizational barriers and provider recognition, uptake of outpatient stewardship efforts remains suboptimal.[6] A few studies have described successful antibiotic stewardship interventions in rural settings, but many small, private practices lack the support or infrastructure to establish or maintain such efforts.[7,8] Kentucky is a largely rural state with 70% of counties classified as rural and 42% of the state's population living in rural areas.[9] The objective of this study was to analyze trends in antibiotic prescribing to Kentucky Medicaid children over time and describe variations among those who were prescribed antibiotics. Findings from this study will guide subsequent outpatient antibiotic stewardship efforts at a statewide level.

METHODS

Kentucky Medicaid insures nearly half of all children living in Kentucky, 58% of whom live in a rural area.[10] In 2014, Kentucky underwent Medicaid expansion under the Affordable Care Act, a change which narrowed coverage disparities in rural areas.[11] We used Kentucky Medicaid outpatient pharmacy claims from 2012 to 2017. The study population included all enrollees under 20 years of age with at least 1 medical claim during the calendar year. Antibiotics were identified using National Drug Codes and verified by author review.

Patient demographics were abstracted from enrollment data. Race and ethnicity were subsequently categorized as White (non-Hispanic), Black (non-Hispanic), Hispanic, or other. Children with undisclosed race were also included in the other category. Patient home ZIP Codes were used to classify residential geography as urban or rural using Rural Urban Continuum Codes (RUCC codes).[9] Claims for which a ZIP Code was unavailable, corresponded to a military base, or was outside of Kentucky were excluded from the analysis. Provider specialty and cost data were obtained from pharmacy claims.

Rates of antibiotic use were reported as the number of prescriptions per 1,000 children per year and stratified by demographic group. Trends in antibiotic use rates overall and within demographic groups were assessed using linear models, while differences in rates between groups and years were analyzed using 2-way ANOVA tests. Cochran-Armitage tests were used to assess for trend in proportions of medications prescribed by each provider type. Data were cleaned, described, and analyzed using R version 3.5.1 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

The total number of antibiotic prescriptions among the study population increased from 733,547 antibiotic prescriptions in 2012 to 774,303 prescriptions in 2017. Total Medicaid spending on antibiotics significantly increased from $14.6 million in 2012 to $16.8 million in 2017 ($P = .002$). Despite the increase in the absolute number of prescriptions, likely due to Medicaid expansion, the rate of antibiotic prescriptions per 1,000 children remained relatively stable over the 6-year period (Table 1). Children who were female, ≤ 2 years old, White, and living in a rural area had consistently higher rates of antibiotic prescriptions ($P < .001$).

Amoxicillin was the most prescribed antibiotic to children across the study period. Azithromycin was consistently the second most prescribed antibiotic but decreased from 184,329 prescriptions (25% of all antibiotics) in 2012 to 130,203 prescriptions (17% of all antibiotics) in 2017 ($P < .001$). Amoxicillin-clavulanate accounted for approximately 10% of all antibiotic use during all 6 years of the study period. Cefdinir use significantly increased from 59,507 prescriptions in 2012 (8% of all antibiotics) to 102,338 prescriptions in 2017 (13% of antibiotic use) ($P < .001$), leading to increased cost from $2.3 million (16% of all antibiotic spending) in 2012 to $4.8 million (28% of all antibiotic spending) in 2017. Trends in specific antibiotic use were similar across demographic groups, with the exception that Black and Hispanic children and children living in metropolitan areas did not have a significant increase in cefdinir prescribing over the study period.

Further analysis of prescribing across the state, by county, is shown in Figure 1. The highest prescribing county (Knott), a rural county not adjacent to a metropolitan area,[9] had a rate of 3,156 antibiotic prescriptions per 1,000 children in 2017. The lowest prescribing county (Jefferson), which includes the city of Louisville, had a prescribing rate of 1,069 antibiotics per 1,000 children in 2017.

There were significant changes in prescriber characteristics during the study period (Figure 2). In 2012, general practitioners wrote 39% of antibiotic prescriptions, which decreased to 31% in 2017 ($P < .001$). The percentage of antibiotic prescriptions written by nurse practitioners increased over the study period from 26% to 39% ($P < .001$). Importantly, the percentage of prescriptions written by pediatricians decreased from 13% to 10% ($P < .001$). The percentage of antibiotics written by physician assistants remained consistent over the study period at 7%-8%.

DISCUSSION

Using Kentucky Medicaid claims data, we confirmed the high rates of antibiotic use previously reported in Kentucky[3,12] and identified substantial variation in pediatric antibiotic use across the state. Although rates of prescribing decreased during the study period, 1,299 prescriptions per 1,000 Medicaid children statewide during 2017 remain well above the national rate of 760 antibiotics per 1,000 children.[13] In other words, each child covered by Kentucky Medicaid received, on average, more than 1 antibiotic prescription a year. Rates were even higher in areas of eastern and southern Kentucky, home to many rural communities, where children received up to 3 courses of antibiotics a year. This study provides additional patient-level data that may be used to better identify factors associated with antibiotic use.

We found variation in rates of antibiotic prescribing based on sociodemographic characteristics. Age, sex, race, and ethnicity findings within our patient population are consistent with previously published studies.[12,14,15] The concerning increase in cefdinir prescribing

TABLE 1 Antibiotic use per 1,000 children over time, 2012-2017

	2012	2013	2014	2015	2016	2017
			Prescriptions per 1,000 children[a]			
Overall	1,408	1,296	1,158	1,211	1,253	1,299
Gender						
Male	1,342	1,235	1,096	1,143	1,172	1,211
Female	1,475	1,358	1,231	1,284	1,338	1,392
Age group						
0-2 years	1,682	1,536	1,353	1,430	1,464	1,443
3-9 years	1,361	1,258	1,135	1,201	1,262	1,287
10-19 years	1,121	1,038	945	971	996	1,083
Race						
White, NH	1,551	1,440	1,322	1,391	1,412	1,473
Black, NH	850	748	690	721	732	753
Hispanic	1,011	914	806	823	807	822
Other	1,335	1,204	986	1,008	1,146	1,151
Geographic area						
Urban	1,153	1,015	902	956	992	1,005
Rural	1,660	1,571	1,417	1,477	1,511	1,604
			Number of prescriptions (cost, USD)			
Amoxicillin[b]	261,010 ($1,381,994)	251,193 ($1,248,307)	247,222 ($1,138,460)	270,882 ($1,165,405)	294,017 ($1,594,844)	297,224 ($1,481,165)
Azithromycin[c]	184,329 ($2,911,673)	155,271 ($2,244,835)	142,484 ($2,058,811)	139,515 ($1,875,226)	140,058 ($1,734,588)	130,203 ($1,455,951)
Amoxicillin-clavulanate[d]	75,137 ($2,478,399)	69,811 ($2,047,768)	63,305 ($1,813,244)	68,483 ($1,887,233)	70,684 ($1,853,172)	71,705 ($1,925,842)
Cefdinir[b]	59,507 ($2,313,396)	58,110 ($2,944,141)	69,089 ($3,933,627)	84,811 ($3,974,126)	97,090 ($4,649,193)	102,338 ($4,778,897)

[a] $P < .05$ for all demographic groups and time based on 2-way ANOVA. There was no significant trend within each level of demographic variable ($P > .05$).
[b] Increase in amoxicillin ($P < .05$) and cefdinir ($P < .01$) prescriptions from 2012 to 2017.
[c] Decrease in azithromycin prescriptions from 2012 to 2017 ($P < .05$).
[d] No statistically significant change in amoxicillin-clavulanate prescriptions over time ($P > .05$).

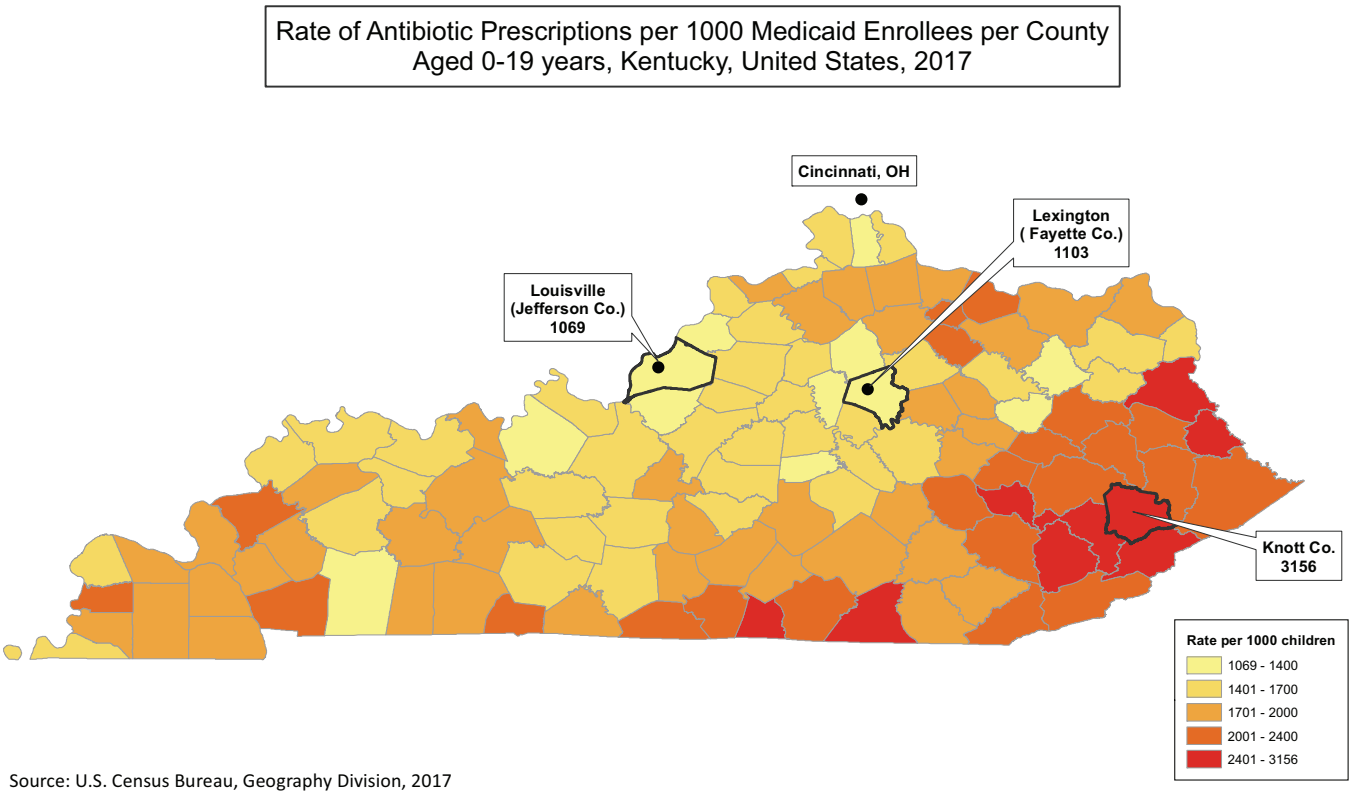

FIGURE 1 Rate of antibiotic prescriptions per 1,000 Medicaid enrollees by county, 2017. Patient home ZIP Codes from Medicaid enrollment files were used to generate county-level prescribing rates. Additional labels highlight the discrepancy between urban areas and the highest prescribing county in rural, eastern Kentucky

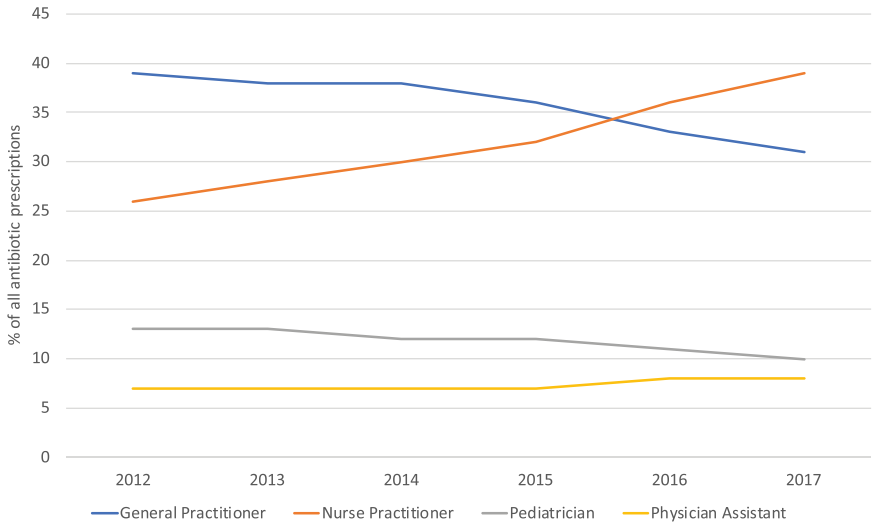

FIGURE 2 **Percentage of antibiotic prescriptions by provider type, 2012-2017.**[a] The majority of antibiotic prescriptions to Medicaid children in Kentucky are by nonpediatricians. During the study period, nurse practitioners surpassed general practitioners as the highest prescribing provider group

[a] $P < .001$ for trend differences in proportion

has been described in additional detail in a previous publication.[16] Notably, there was substantial geographic variation in antibiotic prescribing across the state. Rural areas in eastern and southern Kentucky, part of the Appalachian Region, have substantially higher rates of antibiotic prescribing. Comparatively, the urban areas of Louisville, Lexington, and greater Cincinnati, respectively, had much lower rates of antibiotic use.

According to CDC annual reports,[3,13] states in the southeastern region of the country consistently have the highest rates of outpatient antibiotic use. Previous studies in southern Ohio and Tennessee have also identified higher prescribing in rural areas.[17,18] It is well established in the literature that provider perceptions of patient and parent expectations can influence antibiotic prescribing to children,[19,20] but less is known about variations in culture and expectations of the

Appalachian area or whether higher prescribing rates can be attributed to poorer health quality in these areas. Our findings have led to additional efforts, including qualitative interviews in the highest prescribing area of the state and the development of a statewide campaign to educate providers and families about the importance of judicious antibiotic prescribing. Future research includes assessing the appropriateness of antibiotic prescribing in the pediatric Kentucky Medicaid population.

We also found a shift in the proportion of antibiotics written by general practitioners and nurse practitioners. This finding is not surprising, given the increasing presence of nurse practitioners in primary care, especially in rural areas,[21,22] but is important for guiding antibiotic stewardship education and initiatives. Previous studies identified characteristics of primary care physicians associated with high outpatient antibiotic prescribing volumes.[23] Based on our data, nurse practitioners should also be a priority target for stewardship initiatives.

High rates of antibiotic prescribing to children in Kentucky warrant action for outpatient antimicrobial stewardship initiatives. This study identifies patient and provider characteristics to target for initial stewardship efforts. Given the complexity of assessing appropriateness of antibiotic prescribing, volume of antibiotic prescribing is frequently used as a surrogate marker of antibiotic overuse.[3,4,12] The current study's findings provide additional insight to guide statewide stewardship interventions across Kentucky and highlight the importance of including rural areas and nurse practitioners in any educational efforts or initiatives. Current outpatient stewardship policies and initiatives are often limited to large health care organizations[24–26] and overlook many important sites, such as urgent cares, private practices, and rural settings. A few published interventions have decreased antibiotic prescribing for upper respiratory tract infections in targeted rural practices,[7,8] but additional work is needed to sustain and promote widespread implementation of such efforts.

Limitations

These data are representative of Kentucky children insured by Medicaid and may not be generalizable to other patient populations. However, the rates of prescribing in our analysis are comparable to CDC estimates that include all payers. Furthermore, 5 of the 6 highest prescribing states are also in the Appalachian region[3,12,13] and likely have similar patterns of antibiotic prescribing. Additional limitations are those inherent to use of administrative claims data. The Kentucky Medicaid data available to us allow analysis of large quantities of data over time but reflect only dispensed prescriptions, thus some information could be missing or incomplete. We did not include medical claims in this initial analysis and cannot comment on the appropriateness of prescribing. Additionally, large sample sizes limit the clinical interpretations of statistical significance.

CONCLUSION

Rural areas of Kentucky are major contributors to the state's high rate of antibiotic prescribing to children. Outpatient stewardship efforts are needed to encompass all provider types, practices, and geographic areas.

ACKNOWLEDGMENTS

Authors acknowledge the following individuals for their expertise and assistance with this study: Deborah Davis, Natalie Pasquenza, Soutik Ghosal, Maiying Kong, John Myers, Charles Woods, and Jingchao Sun.

FUNDING

All authors receive support from the Kentucky Cabinet for Health and Family Services: Department for Medicaid Services under the contract titled "Improving Care Quality for Children Receiving Kentucky Medicaid," Norton Children's Hospital, and the University of Louisville School of Medicine, Department of Pediatrics and the School of Public Health and Information Sciences. Dr. Smith receives additional support from Duke University. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Kentucky Cabinet for Health and Family Services, Department for Medicaid Services.

DISCLOSURES

All authors have no actual or potential conflicts of interest to disclose.

ORCID

Bethany A. Wattles PharmD, MHA https://orcid.org/0000-0002-4114-8824

REFERENCES

1. Centers for Disease Control and Prevention (CDC). Antibiotic Resistance Threats in the United States, 2019. Atlanta, GA: US Department of Health and Human Services, CDC; 2019.
2. Fleming-Dutra KE, Hersh AL, Shapiro DJ, et al. Prevalence of inappropriate antibiotic prescriptions among US ambulatory care visits, 2010–2011. *JAMA*. 2016;315(17):1864-1873.
3. CDC. Measuring Outpatient Antibiotic Prescribing. 2018. Available at: https://www.cdc.gov/antibiotic-use/community/programs-measurement/measuring-antibiotic-prescribing.html. Accessed August 5, 2020.
4. King LM, Bartoces M, Fleming-Dutra KE, Roberts RM, Hicks LA. Changes in US outpatient antibiotic prescriptions from 2011–2016. *Clin Infect Dis*. 2020;70(3):370-377.
5. Sanchez GV, Fleming-Dutra KE, Roberts RM, Hicks LA. Core elements of outpatient antibiotic stewardship. *MMWR Recomm Rep*. 2016;65(6):1-12.
6. Zetts RM, Garcia AM, Doctor JN, Gerber JS, Linder JA, Hyun DY. Primary care physicians' attitudes and perceptions towards antibiotic resistance and antibiotic stewardship: a national survey. *Open Forum Infect Dis*. 2020;7(7):ofaa224.

7. Cummings PL, Alajajian R, May LS, et al. Utilizing behavioral science to improve antibiotic prescribing in rural urgent care settings. *Open Forum Infect Dis*. 2020;7(7):ofaa174.
8. Chiswell E, Hampton D, Okoli CT. Effect of patient and provider education on antibiotic overuse for respiratory tract infections. *J Healthcare Qual*. 2019;41(3):e13-20.
9. US Department of Agriculture (USDA). Economic Research Service. Rural-Urban Continuum Codes. 2013. Available at: https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx. Accessed September 30, 2020.
10. Kaiser Family Foundation (KFF). Health Insurance Coverage of Children 0–18. Available at: https://www.kff.org/other/state-indicator/children-0-18/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D. Accessed December 14, 2020.
11. Hoadley J, Alker J, Holmes M. Health Insurance Coverage in Small Towns and Rural America: the Role of Medicaid Expansion. 2018. Available at: https://ccf.georgetown.edu/wp-content/uploads/2018/09/FINALHealthInsuranceCoverage_Rural_2018.pdf. Accessed January 8, 2021.
12. Hicks LA, Bartoces MG, Roberts RM, et al. US outpatient antibiotic prescribing variation according to geography, patient population, and provider specialty in 2011. *Clin Infect Dis*. 2015;60(9):1308-1316.
13. CDC. Outpatient Antibiotic Prescriptions – United States. 2017. Available at: https://www.cdc.gov/antibiotic-use/community/programs-measurement/state-local-activities/outpatient-antibiotic-prescriptions-US-2017.html. Accessed July 28, 2020.
14. Gerber JS, Prasad PA, Localio AR, et al. Racial differences in antibiotic prescribing by primary care pediatricians. *Pediatrics*. 2013;131(4):677-684.
15. Goyal MK, Johnson TJ, Chamberlain JM, et al. Racial and ethnic differences in antibiotic use for viral illness in emergency departments. *Pediatrics*. 2017;140(4):e20170203.
16. Wattles B, Vidwan N, Ghosal S, et al. Cefdinir use in the Kentucky Medicaid Population: a priority for outpatient antimicrobial stewardship. *J Pediatric Infect Dis Soc*. 2021;10(2):157-160.
17. Watson JR, Wang L, Klima J, et al. Healthcare claims data: an underutilized tool for pediatric outpatient antimicrobial stewardship. *Clin Infect Dis*. 2017;64(11):1479-1485.
18. Katz SE, Staub M, Ouedraogo Y, et al. Population-based assessment of patient and provider characteristics influencing pediatric outpatient antibiotic use in a high antibiotic-prescribing state. *Infect Control Hosp Epidemiol*. 2020;41(3):331-336.
19. Yates TD, Davis ME, Taylor YJ, et al. Not a magic pill: a qualitative exploration of provider perspectives on antibiotic prescribing in the outpatient setting. *BMC Fam Pract*. 2018;19(1):96.
20. Kohut MR, Keller SC, Linder JA, et al. The inconvincible patient: how clinicians perceive demand for antibiotics in the outpatient setting. *Fam Pract*. 2020;37(2):276-282.
21. Barnes H, Richards MR, McHugh MD, Martsolf G. Rural and nonrural primary care physician practices increasingly rely on nurse practitioners. *Health Affairs*. 2018;37(6):908-914.
22. Xue Y, Smith JA, Spetz J. Primary care nurse practitioners and physicians in low-income and rural areas, 2010–2016. *JAMA*. 2019;321(1):102-105.
23. Fleming-Dutra KE, Bartoces M, Roberts RM, Hicks LA. Characteristics of primary care physicians associated with high outpatient antibiotic prescribing volume. *Open Forum Infect Dis*. 2018;5(1):ofx279.
24. The Joint Commission. Antimicrobial Stewardship in Ambulatory Health Care. R3 Report. 2019. Available at: https://www.jointcommission.org/-/media/tjc/documents/standards/r3-reports/r3_23_antimicrobial_stewardship_amb_6_14_19_final2.pdf?db=web&hash=81604D26AD039EA9ABBFBBA8907F8430. Accessed September 30, 2020.
25. Gerber JS, Prasad PA, Fiks AG, et al. Effect of an outpatient antimicrobial stewardship intervention on broad-spectrum antibiotic prescribing by primary care pediatricians: a randomized trial. *JAMA*. 2013;309(22):2345-2352.
26. Meeker D, Linder JA, Fox CR, et al. Effect of behavioral interventions on inappropriate antibiotic prescribing among primary care practices: a randomized clinical trial. *JAMA*. 2016;315(6):562-570.

How to cite this article: Wattles BA, Vidwan NK, Feygin Y, Jawad KS, Creel LM, Smith MJ. Antibiotic prescribing to Kentucky Medicaid children, 2012-2017: Prescribing is higher in rural areas. *J Rural Health*. 2021;1–6. https://doi.org/10.1111/jrh.12584