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RESEARCH ARTICLE

Use of a Preventive Index to Examine Clinic-Level Factors Associated With Delivery of Preventive Care

Brigit A. Hatch, MD, MPH,[1,2] Carrie J. Tillotson, MPH,[2] Nathalie Huguet, PhD,[1] Megan J. Hoopes, MPH,[2] Miguel Marino, PhD,[1,3] Jennifer E. DeVoe, MD, PhD[1,2]

Introduction: There is an increasing need for the development of new methods to understand factors affecting delivery of preventive care. This study applies a new measurement approach and assesses clinic-level factors associated with preventive care delivery.

Methods: This retrospective longitudinal cohort study of 94 community health centers used electronic health record data from the OCHIN community health information network, 2014–2015. Clinic-level preventive ratios (time covered by a preventive service/time eligible for a preventive service) were calculated in 2017 for 12 preventive services with A or B recommendations from the U.S. Preventive Services Task Force along with an aggregate preventive index for all services combined. For each service, multivariable negative binomial regression modeling and calculated rate ratios assessed the association between clinic-level variables and delivery of care.

Results: Of ambulatory community health center visits, 59.8% were Medicaid-insured and 10.4% were uninsured. Ambulatory community health centers served 16.9% patients who were Hispanic, 13.1% who were nonwhite, and 68.7% who had household incomes <138% of the federal poverty line. Clinic-level preventive ratios ranged from 3% (hepatitis C screening) to 93% (blood pressure screening). The aggregate preventive index including all screening measures was 47% (IQR, 42%–50%). At the clinic level, having a higher percentage of uninsured visits was associated with lower preventive ratios for most (7 of 12) preventive services.

Conclusions: Approaches that use individual preventive ratios and aggregate prevention indices are promising for understanding and improving preventive service delivery over time. Health insurance remains strongly associated with access to needed preventive care, even for safety net clinic populations.

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INTRODUCTION

Adequate and timely preventive care is critical. In recognition of its importance, the Affordable Care Act mandated all private Marketplace insurance plans and Medicare to cover fully, without cost sharing, all A or B recommended services by the U.S. Preventive Services Task Force. Similar policies were subsequently adopted by most state Medicaid programs.[1] Preventive care delivery is also increasingly linked to performance-based reimbursement with metrics identified by the National Quality Forum, National Committee for Quality Assurance, and others.[2,3] As the stakes for delivering excellent preventive care increase and payment methods shift toward value-based incentives, primary care clinics are being increasingly proactive in their population health approaches.[4,5] Furthermore, data on service delivery can now be obtained from electronic health records (EHRs), whereas prior quality improvement

From the [1]Department of Family Medicine, Oregon Health & Science University, Portland, Oregon; [2]OCHIN, Inc., Portland, Oregon; and [3]Biostatistics Group, Portland State University School of Public Health, Oregon Health & Science University, Portland, Oregon

Address correspondence to: Brigit A. Hatch, MD, MPH, Oregon Health & Science University, Department of Family Medicine, 3181 SW Sam Jackson Park Road, Portland OR 97239. E-mail: adamusb@ohsu.edu.

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efforts relied on insurance claims data, which did not include uninsured patients, or survey data that lacked information on nonrespondents.

In this setting, there is a need for monitoring tools that are more precise in nature coupled with the understanding of multilevel factors associated with prevention. Most prior studies relied on cross-sectional methodology and assumptions about the expected rates of preventive care.[6–10] New data sources facilitate more precise tracking of preventive care over time, and new methods can eliminate the need for these assumptions.

Foundational work has demonstrated that patient-, provider-, and visit-level factors are associated with the receipt of needed preventive care.[6,8–12] Patient-level factors associated with better receipt of preventive care include having a usual source of primary care,[7–9,13] having health insurance,[11,14] being female, white/non-Hispanic, and having a higher income.[15] Associated provider factors include female sex and specialty type.[6,12] A few studies have shown that clinic characteristics such as proportion of visits insured by Medicaid are related to the delivery of preventive care,[6,7] though an in-depth assessment of clinic-level factors associated with preventive care is lacking. Because the delivery of preventive care is increasingly measured at the clinic level, it is important to assess preventive care delivery at this level.

The aims of this study were as follows: (1) to use EHR data and measurement methods that are more precise to conduct a broad inventory of preventive care among adult patients within a national network of community health centers (CHCs) and (2) to assess clinic-level factors associated with the receipt of needed preventive care.

METHODS

This project was a retrospective longitudinal cohort of 94 CHCs using EHR data from the OCHIN community health information network during the 2-year study period, from January 1, 2014 to December 31, 2015; data were analyzed in 2017. Preventive ratios (time covered by a preventive service/time eligible for a preventive service) were calculated for 12 preventive services with an A or B recommendation from the U.S. Preventive Task Force, as well as an aggregate preventive index to serve as an overall measure of clinic-level preventive care.

Study Population

The CHCs participating in the clinic cohort were members of OCHIN, a nonprofit organization that provides a fully hosted instance of the Epic EHR to safety net clinics.[16–18] EHR data are managed centrally at OCHIN, including regular validation and cleaning. Eligible clinics were primary care clinics that used OCHIN's EHR from January 1, 2012, to December 31, 2015. Clinics were excluded if they were school-based health centers, performed <100 total ambulatory visits, or had <5% adults aged ≥21 years during the study period. The active clinic population was defined as adult patients with at least one ambulatory visit to an eligible clinic between January 1, 2012, and December 31, 2013. This "look back" period allowed the authors to consider "established" patients who had documented medical history within the EHR. If patients had visits at more than one OCHIN CHC during the study period, they were assigned to the CHC that they visited the most during the study period.

Measures

Preventive ratios and a preventive index were calculated to provide a precise assessment of preventive care delivery over time. A preventive ratio is the total person-time covered (after delivery of a particular preventive service) divided by the total person-time eligible for a particular service (Figure 1). This calculation results in a percentage of time "covered" by a preventive service (e.g., a mammogram "covers" an individual for breast cancer screening for 2 years). The percentage ranges from 0% to 100%, where 100% represents complete coverage (i.e., no time that a service is due and not yet received). A preventive index is the weighted or unweighted average of multiple preventive ratios and is meant to summarize an organization's approach to prevention, focusing on a cluster of similar preventive services, or prioritizing specific measures.[8,13,19–24] These metrics have been used previously in managed care[23] but have not been used broadly elsewhere.

The advantage of preventive ratios and the preventive index compared with conventional metrics (i.e., binary receipt of a service over a certain period) is the inclusion of time covered by the preventive service (i.e., up to date) as a percentage rather than a dichotomous value. For example, a person who is 1 month overdue for a mammogram might be captured as having not received the screening in the past year by conventional measures, but using a preventive ratio, such a person would be more accurately shown as covered for 11 of the 12 studied months (i.e., 91.6% of the time). Advances in the EHR technology and availability of data make these ratios/indices relevant to primary care settings for assessment and tracking of performance and population health.[25–27]

Assessed outcomes included preventive ratios for 12 preventive services, as well as an unweighted aggregate preventive index. The 12 measured preventive services included U.S. Preventive Services Task Force grade A and B recommended preventive services, which could be readily measured in the EHR.[28,29] The aggregate preventive index reflected 11 of 12 services—excluding screening for abdominal aortic aneurysm, as many clinics had insufficient

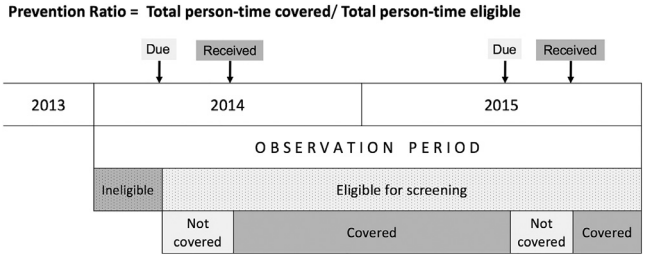

Figure 1. Defining the preventive ratio.

patients eligible for this service. Patient-level preventive ratios were pooled at the clinic level so that each clinic had a single preventive ratio for each of the 12 selected services as well as an aggregate preventive index.

Services were recorded as completed only if the service had been "resulted" within the EHR. Services due and services received were identified through procedure codes, diagnosis codes, lab/imaging/scanned results, active problem lists, and longitudinal "health maintenance" records. Inclusion of data from longitudinal health maintenance records allowed for inclusion of services that patients or staff noted to be received outside the clinical network. In OCHIN's EHR, services that are ordered by primary care providers but performed outside the CHC (e.g., colonoscopy) can be documented as received directly in a result or indirectly within longitudinal health maintenance records. Services that were ordered but not verified as received (via a direct result or health maintenance result) were not counted. Previous assessment of OCHIN's preventive services data shows good agreement between automated EHR data extraction and other sources such as chart review and claims data, though agreement varies some by type of service.[30,31] For each measure, individuals were identified as "due" for screening based on sex, age, and comorbidity. For individual measures, patients for whom the screening was not indicated based on special circumstances were excluded (e.g., women with a history of total hysterectomy were excluded from cervical cancer screening). Appendix Table 1 (available online) provides complete measure-by-measure definitions.

Clinic-level variables were obtained from EHR data during the study period (from January 1, 2014 to December 31, 2015). Clinic-level variable selection was guided by the Andersen Behavioral Model of healthcare utilization[32] and based on EHR availability. These variables included the following: clinic size (number of total patients seen in 2014–2015); demographic composition as a proportion of visits (e.g., race/ethnicity, preferred language, gender, income); payer breakdown for ambulatory visits in 2014–2015 (i.e., proportion of Medicaid visits, proportion of uninsured visits); ratio of physician (medical doctor/doctor of osteopathic medicine) providers to total practicing providers; presence of a multidisciplinary practice (e.g., social workers, psychologists present in clinic); and ratio of nursing staff to total clinical staff. Provider training and specialty were determined by the National Provider Identifier. Because federally qualified health centers are required to routinely report on their patient demographic characteristics for continued federal funding, the completeness of these records is prioritized within the EHR in the study population.

Statistical Analysis

Analyses were conducted on a sample of adults aged ≥19 years. Preventive services indicated for youth (e.g., chlamydia screening) were assessed only among patients aged ≥19 years. The clinic sample was described using frequencies and percentages of categorical clinic characteristics and medians/IQRs for continuous clinic characteristics. Preventive ratios and box plots were then generated for each considered preventive service.

Given that the prevalence ratio is defined by a numerator (total person-time covered after a particular preventive service) divided by a denominator (total person-time eligible for a particular service), the authors were able to use a negative binomial regression to examine relationships between clinic characteristics and preventive ratios for each preventive service.[33] The negative binomial regression model was preferred over a Poisson model as it better accounts for overdispersion while avoiding SE estimates that might otherwise be underestimated.[34]

First, for each preventive outcome, univariable analyses were conducted; these associations are reported in Appendix Table 2A–M (available online). Next, to identify a final model for each preventive ratio outcome, a multivariable stepwise model selection process was employed to identify important clinic-level factors associated with preventive delivery performance. Models were not constrained to have the same variables because the authors were interested in the clinic characteristics associated with each preventive service. To arrive at a final model, multivariable stepwise negative binomial regression models were conducted with a p-value of 0.10 to enter and a p-value of 0.20 to exit. The stepwise procedure identifies a new model at each step until no other variables satisfy the p-value to enter or exit criteria. This results in a set of potential candidate models with a reduced set of predictors. From this reduced set, the final model was selected as the stepwise model with the smallest Schwarz Bayesian criterion.[35] For associations of clinic-level factors with preventive services, rate ratios (RRs) and 95% CIs were reported. In univariable and multivariable modeling, clinic factors defined as percentages of patient or provider characteristics (e.g., %Medicaid, %Uninsured) were scaled by a factor of 5, meaning that a 5% increase in any of these clinic characteristics was associated with the rate ratio shown. Similarly, median patient age was scaled by a factor of 5, and the number of patients eligible for screening was scaled by a factor of 100.

All analyses were conducted using SAS, version 9.4. This study was approved by the IRB of the Oregon Health & Science University.

RESULTS

A total of 94 OCHIN clinics met the inclusion criteria. Clinics reflected the safety net population that they serve. The median patient panel provided 59.8% of visits as Medicaid-insured, 10.4% of visits as uninsured, and 68.7% of visits to patients residing in households earning <138% of the federal poverty line (Table 1). The median clinic size was 4,531 patients with a range from 121 to 17,641 patients. Nearly three quarters (72.3%) of the clinics had multidisciplinary practices, which included social workers, behavioral health specialists, podiatrists, and dentists, among others, but only a few were teaching clinics (7.5%) that included resident clinicians among their staff. The majority (88.3%) was located in urban areas.

Median preventive ratios ranged from a low of 3% for hepatitis C screening to a high of 93% for blood pressure screening (Figure 2). The aggregate preventive index including 11 of 12 screening measures was 47%. Screenings such as hepatitis C (3%), HIV (10%), depression (20%), and substance abuse (24%) had among the lowest preventive ratios overall. Screenings with the highest

Table 1. Clinic Characteristics

Variable	Clinics represented,[a] N	Median	Lower quartile	Upper quartile
Continuous				
Median patient age, years	94	41.4	34.0	50.1
Number of patients	94	4,531	2,212	8,133
Medicaid-insured visits, %	94	59.8	50.0	67.5
Uninsured visits, %	94	10.4	5.6	19.1
Visits with Hispanic patients, %	94	16.9	6.7	36.1
Visits with nonwhite patients, %	94	13.1	8.4	36.0
Visits with female patients, %	94	57.0	53.9	60.2
Visits with English-language preference, %	94	86.4	67.5	95.8
Proportion MD/DO visits/total visits	94	53.1	31.4	66.1
Proportion of nursing staff/total clinical staff[b]	94	29.9	19.2	41.7
Visits with patients <138% FPL, %	94	68.7	50.2	79.4
Categorical				
Proportion urban clinics, %	94	88.3	—	—
Proportion with multidisciplinary practice,[c] %	94	72.3	—	—
Proportion teaching clinics,[d] %	94	7.5	—	—
Number of patients eligible for . . .				
Breast cancer screening	91	438	223	764
Cervical cancer screening	94	911	428	1,641
Colorectal cancer screening	93	742	369	1,346
Blood pressure screening	94	1,749	1,009	3,317
Diabetes screening	94	898	431	1,555
Lipid screening	94	1,013	500	1,844
AAA screening	84	58	33	113
Chlamydia screening	87	188	59	291
Hepatitis C screening	93	632	326	1,124
HIV screening	93	1,564	874	2,888
Depression screening	94	1,749	1,009	3,317
Substance abuse screening	94	1,749	1,009	3,317
At least one (of the above) preventive services[e]	86	1,904	1,224	3,496
Preventive ratio for . . .				
Breast cancer screening, %	91	46	35	54
Cervical cancer screening, %	94	58	49	68
Colorectal cancer screening, %	93	35	25	47
Blood pressure screening, %	94	93	92	94
Diabetes screening, %	94	63	56	67
Lipid screening, %	94	81	74	89
AAA screening, %	84	15	5	24
Chlamydia screening, %	87	34	23	43
Hepatitis C screening, %	93	3	1	9
HIV screening, %	93	10	4	22
Depression screening, %	94	20	11	34
Substance abuse screening, %	94	24	7	44
Aggregate preventive index,[e] %	86	47	42	50

[a]Includes OCHIN primary care clinics with at least five screening-eligible patients per service.
[b]Proportion of nursing staff (certified clinic nurse specialists, community health nurses, licensed practical nurses, licensed vocational nurses, public health nurses, registered nurses) out of all clinical staff (nurses plus medical providers).
[c]Presence in clinic of nonmedical staff (e.g., social workers, behavioral health specialists, dentists, and podiatrists).
[d]Presence of resident physicians in clinic.
[e]Aggregate preventive index does not include AAA screening because of limited eligible patients.
AAA, abdominal aortic aneurysm; DO, doctor of osteopathic medicine; FPL, federal poverty level; MD, medical doctor.

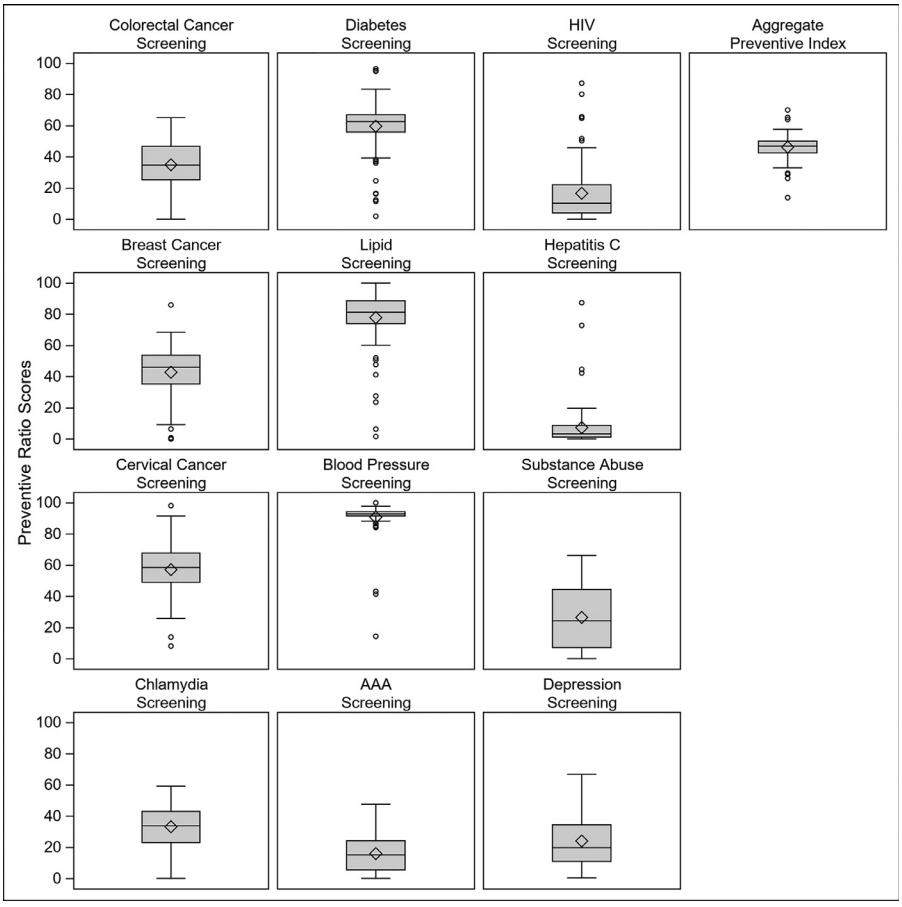

Figure 2. Percentage of patient-time covered by needed preventive services.
Note: Open circles denote outliers. Diamond shapes denote mean.
AAA, abdominal aortic aneurysm; HPV, human papillomavirus.

preventive ratios were blood pressure (93%), lipid screening (81%), and diabetes screening (63%).

Clinic-level characteristics significantly associated with a higher aggregate preventive index ($p<0.05$) included greater proportion of visits with nonwhite patients (RR=1.01, 95% CI=1.01, 1.02) and greater proportion of Medicaid-insured visits (RR=1.02, 95% CI=1.01, 1.03), though the magnitude of associations was small (Table 2). As these clinic characteristics were scaled by a factor of 5, the RR indicates that for every 5% increase in clinics' proportion of visits with nonwhite patients or Medicaid-insured patients, the aggregate preventive index increased by 1%. The proportion of uninsured visits was the only factor significantly associated with lower aggregate preventive index (RR=0.97, 95% CI=0.95, 0.99). For every 5% increase in a clinic's proportion of uninsured visits, the aggregate preventive index decreased by 3%. Clinic-level factors associated with preventive ratios for each needed preventive service varied by individual service. Serving a population with a higher percentage of uninsured visits was consistently associated with lower preventive ratios for most preventive services (7 of 12 assessed), including all cancer-screening services.

DISCUSSION

This study demonstrates how preventive ratios and indices can be used to advance measurement of preventive service delivery. Unlike other preventive care measures, preventive ratios and indices capture the exact window of time in which those eligible for a service are covered (up to date). This approach for measuring delivery of preventive services as a percentage rather than a binary outcome more precisely describes delivery of preventive care.

In this safety net setting, preventive ratios are lower than previously described rates of preventive care delivery.[11,30,36] This is expected because preventive ratios capture additional coverage gaps compared with other measures. For some services, where receipt of a timely service is critical, capturing this delay in care may be important to improving the quality of care. For other services that are recommended infrequently (or only

Table 2. Multivariable Models: Clinic Factors Significantly Associated With Receipt of Preventive Services

Parameter	Rate ratio[a] (95% CI)	*p*-value
Colorectal cancer screening		
Multidisciplinary practice	1.43 (1.11, 1.84)	**<0.01**
Patients eligible for screening, *n*	1.02 (1.00, 1.04)	**0.04**
Uninsured visits, %	0.93 (0.89, 0.98)	**<0.01**
Breast cancer screening		
Uninsured visits, %	0.91 (0.86, 0.97)	**<0.01**
Cervical cancer screening		
Median patient age	0.95 (0.92, 0.98)	**<0.01**
Uninsured visits, %	0.92 (0.90, 0.95)	**<0.01**
Visits with Hispanic patients, %	1.02 (1.01, 1.04)	**<0.01**
Visits with nonwhite patients, %	1.02 (1.01, 1.03)	**<0.01**
Clinic visits by MD/DO, %	0.99 (0.98, 1.00)	**0.01**
Nursing staff per total clinicians,[b] %	1.01 (1.00, 1.03)	0.05
Visits with patients <138% FPL, %	1.01 (1.00, 1.03)	**0.03**
Chlamydia screening		
Medicaid visits, %	1.06 (1.03, 1.10)	**<0.01**
Visits with nonwhite patients, %	1.04 (1.02, 1.06)	**<0.01**
HIV screening		
Median patient age	0.76 (0.65, 0.88)	**<0.01**
Hepatitis C screening		
Visits with nonwhite patients, %	1.06 (1.01, 1.11)	**0.01**
Visits with female patients, %	0.88 (0.82, 0.95)	**<0.01**
Nursing staff per total clinicians,[b] %	1.09 (1.02, 1.16)	**0.02**
Visits with patients <138% FPL, %	1.09 (1.03, 1.14)	**<0.01**
Lipid screening		
Multidisciplinary practice	1.25 (1.08, 1.44)	**<0.01**
Uninsured visits, %	0.96 (0.93, 0.98)	**<0.01**
Diabetes screening		
Multidisciplinary practice	1.21 (1.06, 1.40)	**<0.01**
Uninsured visits, %	0.95 (0.92, 0.98)	**<0.01**
Visits with nonwhite patients, %	1.02 (1.00, 1.03)	**<0.01**
Blood pressure screening		
Uninsured visits, %	0.96 (0.95, 0.97)	**<0.01**
Visits with English-language preference, %	0.99 (0.98, 1.00)	**0.03**
Abdominal aortic aneurysm screening		
Medicaid visits, %	1.11 (1.03, 1.20)	**0.01**
Uninsured visits, %	0.87 (0.78, 0.97)	**0.02**
Depression screening		
Rural (vs urban)	1.90 (1.16, 3.11)	**0.01**
Visits with patients <138% FPL, %	1.09 (1.05, 1.13)	**<0.01**
Substance screening		
Multidisciplinary practice	1.78 (1.09, 2.91)	**0.03**
Aggregate preventive index[c]		
Medicaid visits, %	1.02 (1.01, 1.03)	**<0.01**
Uninsured visits, %	0.97 (0.95, 0.99)	**<0.01**
Visits with nonwhite patients, %	1.01 (1.01, 1.02)	**<0.01**

Note: Boldface indicates statistical significance ($p<0.05$). Clinic factors defined as percentages (e.g., % Medicaid, % Uninsured) were scaled by a factor of 5, meaning that a 5% increase in any of these clinic characteristics is associated with the rate ratio shown.

[a]Multivariable negative binomial regression models to assess the relationship between each clinic factor and clinic rates of up-to-date preventive services (preventive ratios), adjusted for covariates.

[b]Percent nursing staff per total clinicians is the proportion of nursing staff (community health nurses, certified clinic nurse specialists, licensed practicing nurses, registered nurses, licensed vocational nurses, public health nurses) out of nursing staff + clinical providers (MD/DO/NP/PA/CNM).

[c]The aggregate preventive index does not include abdominal aortic aneurysm screening because of the limited number of clinics with eligible patients.

CNM, certified nurse-midwife; DO, doctor of osteopathic medicine; FPL, federal poverty level; MD, medical doctor; NP, nurse practitioner; PA, physician assistant.

once), the added precision provided by the preventive ratio may be less impactful. Therefore, preventive ratios cannot be compared directly with other measurements of service delivery. Even so, this more precise measurement could be used as an outcome for clinical quality improvement efforts or as a tool for researchers and policymakers to better understand the rates of preventive service delivery as well as the facilitators and barriers to delivery of timely services.

Prior studies have suggested that intrinsic clinic factors and the characteristics of a clinic's patient population affect preventive service delivery rates in primary care. Of the studied factors, only clinic-level proportion of uninsured visits was consistently associated with poorer preventive ratios. This finding was true for services offered within the context of a primary care visit (such as blood pressure screening) as well as referral services (such as mammography). The finding of a strong relationship between health insurance and receipt of needed preventive care is well established elsewhere,[37–39] and this project demonstrates its continued importance at the clinic level.

For the aggregate preventive index, having a higher proportion of visits with nonwhite patients was significantly associated with a higher aggregate preventive index—in other words, clinics that serve more patients of color (as a proportion of visits) tend to deliver more timely and complete preventive care compared with clinics that serve fewer patients of color. Although this may seem counterintuitive, these findings are consistent with previous research showing that in some settings, minorities and particularly Latino minorities may be more likely to receive preventive care.[40–42] Because this analysis takes the perspective of clinic factors (proportion of visits with nonwhite patients), no conclusion can be made regarding the receipt of preventive care among individual patients of color; however, this finding suggests that clinics providing more visits to minority patients tend to also deliver more timely and complete preventive care. More research is needed to understand how the complexities of race, ethnicity, country of origin, and language influence preventive care at individual and population levels.

Limitations

In this study, the use of the EHR had many advantages, including the ability to study preventive care among the uninsured (absent from claims data) and the avoidance of recall and response bias inherent to survey data; however, it also limits the scope of the study to a particular medical context, which may or may not reflect the entirety of care received. The EHR is increasingly adept at capturing preventive data from out-of-network settings through longitudinal preventive tracking tools (which were used in this study); however, these tools remain user-dependent and imperfect, and thus, it is possible that some services received outside the OCHIN network were missed. For services with longer screening intervals, there is a greater potential to miss receipt of historical services, which would underestimate preventive ratios.

For standardization, a service was considered "completed" only if data existed to confirm it was received, not simply ordered. This is important for items such as laboratory tests, which are ordered for a future date and the patient must follow through to obtain the service. For tests such as colonoscopy and mammography, there may be technologic limitations in some systems that prevent some referred services from being marked as completed. The authors suspect that these technical limitations may have lowered some preventive ratios, particularly those that are dependent on referrals outside the primary care office.

Though many factors were studied here, there may be additional clinic- or population-related factors—particularly some not recorded in the EHR such as staff turnover, participation in quality improvement projects, or community-level characteristics—that explain the observed patterns here. Clinic characteristics may also be misclassified within the EHR, particularly pertaining to clinic staffing, which could have contributed to a lack of consistently observed association between clinic staffing models and delivery of preventive care. A future mixed-method study is required to better understand the full view of factors affecting delivery of preventive care. As this study applied preventive ratios to examine delivery of preventive care at the clinic level, an additional study is warranted to evaluate the factors that affect receipt of preventive care at the individual level.

CONCLUSIONS

Preventive ratios provide a promising tool for measuring preventive care delivery with more precision than conventional methods. High prevalence of uninsured visits at the clinic level is consistently associated with poorer receipt of needed preventive care. This demonstrates the ongoing value of health insurance, even within the safety net setting.

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Author responsibilities were as follows: BAH led the study design and the manuscript writing team; CJT led the analysis, created the tables and figures, and substantively edited the manuscript; NH, MJH, MM, and JED substantively edited the manuscript; NH and MJH contributed to study design; NH contributed to context; MJH contributed to analysis; MM oversaw the data analysis; and JED conceptualized the project.

Preliminary data from this project were presented at the Annual Conferences of the North American Primary Care Research Group Annual in 2016 and 2017 as well as the Academy of Health Annual Research Meeting in 2018.

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2019.03.016.

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