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A spatial analysis of race, local health-promoting resources and preventable hospitalizations

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ABSTRACT

Introduction: Preventable hospitalizations (PHs) for chronic conditions could have been avoided if treated with primary healthcare. PH rates are higher among African Americans, and in areas with less healthcare. Little is known about the effects of non-healthcare local health-promoting resources (LHPRs). The objective of this study is to determine associations between LHPRs and chronic PH rates in Maryland, and to assess spatial clustering of areas with high PH rates.

Methods: Hospitalizations in 2010 were obtained from the Maryland Health Services Cost Review Commission by zip code of residence. Negative binomial regressions were used to determine associations between PH rates and LHPRs by race. Clusters of zip codes with high PH rates were assessed using the spatial Scan Statistic.

Results: PH rates were associated with family practitioners (IRR = 0.98, 95% CI = 0.97–0.99), physicians' assistants (IRR = 0.98, 95% CI = 0.96–0.99), internists (IRR = 1.02, 95% CI = 1.01–1.03), teaching hospitals (IRR = 1.21, 95% CI = 1.04–1.40), and local health departments (IRR = 1.19, 95% CI = 1.03–1.37). No LHPRs were associated with PHs among whites, but African American PH rates were associated with family practitioners (IRR = 0.97, 95% CI = 0.94–0.99), nurse practitioners (IRR = 1.03, 95% CI = 1.01–1.06), teaching hospitals (IRR = 1.37, 95% CI = 1.08–1.75) and gyms/recreational centers (IRR = 0.85, 95% CI = 0.73–0.99). Clusters of areas with high PH rates varied by race. African American PH clusters had fewer family practitioners and more federally qualified health centers and teaching hospitals.

Conclusions: Public health practitioners should look to LHPRs beyond physician supply or public clinics to address PHs, particularly among African Americans. Specific LHPRs could be used to target African American PH rates and clusters.

1. Introduction

Preventable hospitalizations (PHs) are inpatient hospital visits that could have been precluded with effective and timely primary care (U.S. Department of Health and Human Services, 2014). These are hospitalizations for ambulatory care-sensitive conditions which include both acute and chronic conditions (Agency for Healthcare Research and Quality, 2012). PHs account for one in ten hospitalizations (Stranges and Stocks, 2010), cost $30 billion annually (Jiang et al., 2009), and are considered a proxy for deficits in the local primary healthcare system (U.S. Department of Health and Human Services, 2014; Stranges and Stocks, 2010; Bindman et al., 1995).

In general, studies find that more primary healthcare access is associated with lower PH rates (Bindman et al., 1995; Epstein, 2001; Probst et al., 2009; Rosano et al., 2013; Parchman and Culler, 1994). Many of these studies have examined demographic and other predisposing factors (Rosano et al., 2013; Basu and Mobley, 2010). The role of local healthcare resources has been examined as well (Epstein, 2001; Probst et al., 2009; Rosano et al., 2013; Parchman and Culler, 1994; Basu and Mobley, 2010; Derose, 2008; Mobley et al., 2006; Hossain and Laditka, 2009; Rothkopf et al., 2011; Rust et al., 2009; Zhang et al., 2006). In a review of primary health care and PHs, seven of 11 studies found an inverse association between physician supply and PHs (Rosano et al., 2013). Rosano et al. also found that all eight studies that examined the presence of community health centers reported an inverse association with PHs (Rosano et al., 2013).

Non-healthcare resources could potentially reduce PHs for chronic conditions, which account for a larger percentage of the overall PH rate

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(Stranges and Stocks, 2010). The management of conditions like hypertension or diabetes can include improvement in diet and physical activity (American Diabetes Association, 2006; Hayes and Kriska, 2008), which can be associated with local access to healthy foods and recreational facilities or spaces (Casagrande et al., 2009). These types of resources have not been addressed in the PH literature.

The objective of this study was to examine the associations between various (healthcare and non-healthcare) local health-promoting resources (LHPRs) and chronic PH rates. Because PHs are highly associated with spatial access to healthcare resources (Fishman et al., 2016; Lin et al., 2016), a secondary aim was to determine if chronic PHs cluster spatially, and whether spatial clusters had fewer LHPRs. It was hypothesized that areas with more LHPRs would have lower chronic PH rates, and that spatial clusters of areas with high PH rates would have fewer LHPRs.

2. Methods

2.1. Data sources

Preventable hospitalizations (PHs) were measured using data obtained primarily from the Maryland Health Services Cost Review Commission. This independent agency sets rates for services provided in Maryland hospitals and collects patient-level data (Health Services Cost Review Commission, 2012). Inpatient visits of Maryland residents hospitalized in the District of Columbia, Virginia, and Pennsylvania were obtained from the Maryland Health Care Commission, Virginia Health Information and the Pennsylvania Health Care Cost Containment Council, respectively. This resulted in a final dataset of 803,441 hospitalizations.

Data on LHPRs were obtained from several sources. Data on healthcare providers in Maryland in 2010 were obtained from SK & A, a company that obtains data on practicing healthcare providers from various sources. SK & A estimates that their data includes up to 97% of all office-based doctors in the U.S., and data is verified every six months. Federally qualified health centers (FQHCs) in each Maryland zip code were obtained from the Health Resources and Services Administration. The zip code in which every hospital and local health department in Maryland is located was obtained from the Maryland Department of Health and Mental Hygiene. Data for state and local parks were obtained from the Maryland Department of Natural Resources and local parks and recreation departments. Data for other LHPRs variables were collected from the 2010 Zip Code Business Patterns dataset (U.S. Census Bureau, 2017).

Population-based data were obtained from the U.S. Census Bureau by zip code tabulation area (ZCTA). The number of non-Hispanic blacks and non-Hispanic white residents (hereafter referred to as African Americans and whites), median income, education attainment, insurance status and rural residents in each ZCTA was obtained from the 2010 Census and 2008–2012 American Community Survey.

2.2. Variables

Chronic PHs were defined as a hospitalization where the primary diagnosis was for: angina, asthma, chronic obstructive pulmonary disease, congestive heart failure, diabetes or hypertension. This set of conditions was derived from a list frequently used to broadly define preventable hospitalizations in the literature (Bindman et al., 1995; Billings et al., 1996; McCall et al., 2004). Each hospitalization record included the patient's race, ethnicity and zip code of residence. Hospitalizations where the race was recorded as “Black/African American” or “White” and the ethnicity was recorded as “Not Hispanic” were included in these analyses. An algorithm was used to match patients' reported zip code of residence with the corresponding ZCTA (American Academy of Family Physicians, 2015). From this, a dataset was created with the number of chronic PHs by race in each Maryland ZCTA in 2010. The dataset also included the total population, and the number of white and African American residents in each ZCTA.

Continuous variables to represent the number of family physicians, internists, nurse practitioners' and physicians' assistants per 10,000 ZCTA population were created. Internist supply also included physicians who identify as general practitioners. Dummy variables were used to represent whether no hospital, a teaching or non-teaching hospital was located in a ZCTA. A dichotomous variable representing whether a local health department was located in a ZCTA was created. Similar variables for FQHCs, commercial urgent care centers, pharmacies, grocery stores, commercial gyms/recreational centers and parks were created. Commercial urgent care centers, pharmacies, grocery stores and commercial gyms/recreational centers were those with the North American Industry Classification Code System (NAICS) code of 621493, 446110, 445110 and 713940, respectively. Only those grocery stores with > 20 employees were included (Hendrickson et al., 2006).

ZCTA demographics were included as covariates and measured continuously. Racial composition was measured as the percentage of African American ZCTA residents. Rurality was calculated as the percentage of ZCTA residents who did not live in an urban cluster or urbanized area. Insurance status was measured as the percentage of ZCTA residents who did not have any health insurance. ZCTA median income was included and measured in tens of thousands ($10,000). Educational attainment was measured as the percentage of ZCTA residents with more than a high school education.

2.3. Statistical analyses

The mean and proportional differences between ZCTAs included in PH spatial clusters and non-cluster ZCTAs for demographics and LHPRs were evaluated using Student's *t* and chi-square tests for continuous and categorical variables. Due to overdispersion (Cameron and Trivedi, 1998), negative binomial regressions were used to determine the associations between LHPRs and chronic PH rates in Maryland ZCTAs adjusting for covariates. Models were repeated for PHs among whites and African Americans using a race-specific population count as an offset. All analyses were stratified by race because PHs are more prevalent among African Americans compared to whites (Derose, 2008; Chang et al., 2008; Gaskin and Hoffman, 2000; Laditka et al., 2003; O'Neil et al., 2010), and areas with more African American residents have less access to healthcare (White et al., 2012), fewer grocery stores (Kwate, 2008), and recreational facilities such as parks (Hughey et al., 2016).

Spatial clusters of ZCTAs with high chronic PH rates were assessed by race/ethnicity using the spatial Scan Statistic. Described in depth elsewhere (Kulldorff, 1997), this identifies clusters of ZCTAs that have greater than the expected number of PHs based on population and the overall PH rate. Using Poisson models, several Monte Carlo simulations are replicated to determine whether each cluster supports or rejects the null hypothesis that PH rates are spatially random. The primary PH cluster was considered as the PH cluster that has the greatest observed-to-expected ratio. Once smaller clusters are identified, the simulations are repeated to determine if adjacent clusters should be combined into larger clusters. White and African American spatial clusters were determined from the race-specific mean chronic PH rate. Only PH clusters with > 20 PHs were reported.

Dichotomous variables were created to indicate whether a ZCTA was included in a chronic PH cluster for the total, white or African American population. Analysis of covariance analyses were used to detect differences in LHPRs between PH clusters. These analyses were adjusted for covariates.

Software.

Regression and analysis of covariance analyses were performed using Stata Version 14 (StataCorp LP, College Station, TX). SatScan Version 9.4 (SatScanTM, New York, NY) was the statistical software package used to detect PH clusters with the spatial scan statistic

Table 1
Demographics and local health-promoting resources in Maryland ZCTAs, 2010.

	Total ZCTAs	Non-cluster ZCTA	Chronic PH cluster ZCTA	*p*-value
	n = 468	*n* = 364	*n* = 104	
Chronic preventable hospitalizations (per 100,000 population), mean ± S.E.				
Total	1154.1 ± 92.6	882.1 ± 409.6	2166.4 ± 3141.7	< 0.001
White	1058.5 ± 38.2	910.1 ± 457.3	1614.1 ± 799.1	< 0.001
African American	1608.2 ± 88.8	1347.7 ± 1011.0	2334.9 ± 865.3	0.264
African American residents, %	17.4	16.0	22.5	0.006
Rural, %	46.0	45.7	46.8	0.833
Uninsured, %	9.3	8.8	11.3	0.002
Median income ($10,000), mean ± S.E.	7.8 ± 0.2	8.5 ± 0.2	5.1 ± 0.2	< 0.001
More than high school education, %	58.4	61.5	47.5	< 0.001
Family practitioners per 10,000 population, mean ± S.E.	12.0 ± 10.7	15.2 ± 13.8	0.9 ± 0.2	0.579
Internists per 10,000 population, mean ± S.E.	18.4 ± 16.1	22.7 ± 20.7	3.5 ± 1.2	0.618
Nurse practitioners per 10,000 population, mean ± S.E.	17.4 ± 16.1	22.0 ± 20.7	1.4 ± 0.4	0.595
Physicians' assistants per 10,000 population, mean ± S.E.	1.3 ± 0.4	1.3 ± 0.5	1.2 ± 0.4	0.906
FQHC, %	13.3	10.2	24.0	< 0.001
Commercial urgent care, %	15.4	14.6	18.3	0.355
Local health department, %	5.1	4.7	6.7	0.401
Hospital, %				
None	90.0	92.0	81.7	0.003
Teaching	5.3	3.6	11.5	
Non-teaching	4.8	4.4	6.7	
Pharmacy, %	47.4	48.6	44.2	0.429
Grocery store, %	44.2	46.2	37.5	0.117
Commercial gym/recreational facility, %	42.3	45.1	32.7	0.024
Public park, %	62.9	65.4	52.9	0.020

(Kulldorff, 1997). ArcGIS Version 10.3 (Esri, Redlands, CA) was used to display PH clusters.

3. Results

Table 1 displays demographic and LHPRs in Maryland ZCTAs by chronic PH cluster status. The average chronic PH rate in Maryland ZCTAs was 1154.1 per 100,000 population. The rate was more than double in PH cluster ZCTAs (2166.4 per 100,000 population) compared to non-cluster ZCTAs (882.1 per 100,000 population, $p < 0.001$). The African American PH rate (1608.2 per 100,000) was higher than the white PH rate (1058.5 per 100,000 population). ZCTAs in chronic PH clusters were more likely to have a teaching hospital (11.5% versus 3.6%, $p = 0.003$) and a FQHC (24.0% versus 10.2%, $p < 0.001$) located in the ZCTAs. They were less likely to have a gym/recreational facility (32.7% versus 45.1%, $p = 0.024$) or a public park (52.9% versus 65.4%, $p = 0.020$).

Associations between LHPRs and PH rates are displayed in Table 2 by race/ethnicity. As the number of family practitioners (incidence rate ratio [IRR] = 0.98, 95% CI = 0.97–0.99) and physicians' assistants (IRR = 0.98, 95% CI = 0.96–0.99) per 10,000 population increased the PH rate decreased for the total population. Internists (IRR = 1.02, 95% CI = 1.01–1.03), local health departments (IRR = 1.19, 95% CI = 1.03–1.37) and teaching hospitals (IRR = 1.18, 95% CI = 1.03–1.36) were positively associated with PH rates. Among whites, the PH rate was not associated with any LHPRs. African American PH rates decreased by 3% with every additional family practitioner per 10,000 population (IRR = 0.97, 95% CI = 0.94–0.99). ZCTAs with a commercial gym/recreational center had a 15% lower African American PH rate (IRR = 0.85, 95% CI = 0.73–0.99). African American PH rates increased by 3% with every increase in nurse practitioners per 10,000 population (IRR = 1.03, 95% CI = 1.01–1.06) and by 37% in ZCTAs with a teaching hospital (IRR = 1.37, 95% CI = 1.08–1.75).

Fig. 1 and Table 3 display chronic PH clusters in Maryland by race/ethnicity. For the total population, five PH clusters were detected with the PH rates ranging from 1900.8 (Baltimore) to 1277.2 per 100,000 population (Frederick). The radius of PH clusters among the total population ranged from 3.4 miles (Bushwood) to 38.2 miles (Salisbury). Among whites, seven PH clusters were detected. The principal (largest) city for the primary PH cluster was Baltimore with a PH rate of 1603.5 per 100,000 population, and the PH rate ranged to a low of 1239.3 per 100,000 population (Frederick). There was a PH cluster of a single ZCTA (Solomons) and one with a radius of 11.8 miles (Cumberland). The principal city of the primary PH cluster among African Americans was Baltimore as well. The PH rates ranged from 2720.7 (Baltimore) to 2095.5 per 100,000 population (Capitol Heights). There was a PH cluster of one ZCTA (Capitol Heights) and one with a radius of 28.8 miles (Salisbury).

Table 4 displays LHPRs in PH spatial clusters by race adjusted for covariates. For the total population, ZCTAs in a PH cluster had fewer family practitioners per 10,000 population (mean = 0.9, standard error (S.E.) = 0.2) than ZCTAs that were not in a cluster (mean = 15.2, S.E. = 13.8, $p = 0.001$). Twenty-four percent (24.0%) of ZCTAs in a PH cluster had a FQHC located in it, while only 10% of non-cluster ZCTAs had a FQHC ($p = 0.037$). A greater percentage of ZCTAs in PH clusters had a teaching hospital (11.5%) compared to non-cluster ZCTAs (3.6%, $p = 0.032$). For whites, ZCTAs in PH clusters did not differ from non-PH cluster ZCTAs with respect to LHPRs. ZCTAs in African American PH clusters had fewer family practitioners (mean = 1.0, S.E. = 0.3) compared to those not included in a PH cluster (mean = 14.4, S.E. = 13.0, $p = 0.044$). A higher percentage of ZCTAs in African American PH clusters had a FQHC (32.5%) compared to those that were not in a cluster (9.1%, $p < 0.001$). Fifteen percent (15.7%) of ZCTAs in African American PH clusters had a teaching hospital compared to 3.1% among non-cluster ZCTAs ($p < 0.001$).

4. Discussion

The objective of this study was to determine if LHPRs were associated with PH rates for chronic conditions. A secondary objective was to determine if high PH rates clustered spatially and if these clusters had fewer LHPRs. Chronic PH rates were lower in ZCTAs with higher family practitioners and physician assistants' supply, and higher in ZCTAs with more internists, a local health department and a teaching hospital. No LHPRs were associated with white PH rates, while family

Table 2
Association between local health-promoting resources and chronic preventable hospitalization rates in Maryland, 2010.

	Total	White	African American
	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
Local health-promoting resources			
Family practitioners[a]	0.98 (0.97–0.99)	0.99 (0.97–1.00)	0.97 (0.94–0.99)
Internists[a]	1.02 (1.01–1.03)	1.01 (1.00–1.03)	1.00 (0.98–1.02)
Nurse practitioners[a]	1.00 (0.98–1.02)	1.00 (0.98–1.02)	1.03 (1.01–1.06)
Physicians' assistants[a]	0.98 (0.96–0.99)	0.99 (0.97–1.00)	0.98 (0.95–1.01)
FQHCs	1.02 (0.93–1.12)	0.93 (0.83–1.04)	1.12 (0.96–1.31)
Commercial urgent care centers	1.05 (0.96–1.15)	1.03 (0.92–1.14)	1.04 (0.90–1.21)
Local health departments	1.20 (1.04–1.38)	1.14 (0.97–1.35)	1.22 (0.97–1.54)
Hospitals			
None	1.00	1.00	1.00
Teaching	1.21 (1.04–1.40)	1.12 (0.94–1.33)	1.37 (1.08–1.75)
Non-teaching	1.08 (0.94–1.23)	1.05 (0.89–1.25)	1.06 (0.85–1.32)
Pharmacies	1.01 (0.91–1.13)	1.04 (0.92–1.18)	0.86 (0.70–1.07)
Grocery stores	1.02 (0.92–1.15)	1.05 (0.92–1.20)	1.16 (0.94–1.43)
Commercial gyms/recreational centers	0.93 (0.85–1.02)	0.92 (0.83–1.02)	0.85 (0.73–0.99)
Public parks	1.05 (0.97–1.13)	1.00 (0.91–1.09)	1.12 (0.97–1.29)
Demographics			
% African American	1.63 (1.38–1.92)	1.77 (1.45–2.17)	1.04 (0.78–1.39)
% rural	1.06 (0.94–1.20)	0.91 (0.79–1.05)	1.49 (1.16–1.92)
% uninsured	0.17 (0.08–0.33)	0.51 (0.23–1.12)	0.18 (0.05–0.61)
Median income ($10,000)	0.93 (0.92–0.95)	0.96 (0.94–0.98)	0.94 (0.91–0.97)
% more than high school	0.15 (0.11–0.22)	0.12 (0.08–0.19)	0.41 (0.21–0.82)

Notes: IRR = incidence rate ratios which are interpreted as estimated preventable hospitalization (PH) rate ratios comparing zip code tabulation areas (ZCTAs) with local health-promoting resources (LHPRs) compared to those without that LHPR. Regression analyses account for demographics as co-variates.
[a] Per 10,000 population.

practitioners and gyms/recreational centers were negatively associated with African American PH rates. Nurse practitioners supply and teaching hospitals were positively associated with African American PH rates. Several clusters of ZCTAs with high PH rates were detected, and locations varied by race. African American PH clusters had fewer family practitioners, and were more likely to have a FQHC or teaching hospital located in them. PH clusters among whites were not associated with any LHPRs.

The results of the current study agree with previous studies to an extent (Rosano et al., 2013). Most studies find that PH rates are inversely associated with physician supply, however, some studies find a positive association or none at all (Rosano et al., 2013). In the current study, family practitioners were negatively associated with PH rates and clusters among the total and African American populations, which concurs with the literature. However, internists were positively associated with PH rates. Previous literature does find some variation in associations by type of physician supply (Rosano et al., 2013; Parchman and Culler, 1994; Derose, 2008). A formative and influential study by Parchman and Culler found that general and family practitioners were negatively associated with PHs, while internists were not (Parchman and Culler, 1994). However, a study of PHs in Florida zip codes found no association between general or family practitioners and PHs, but

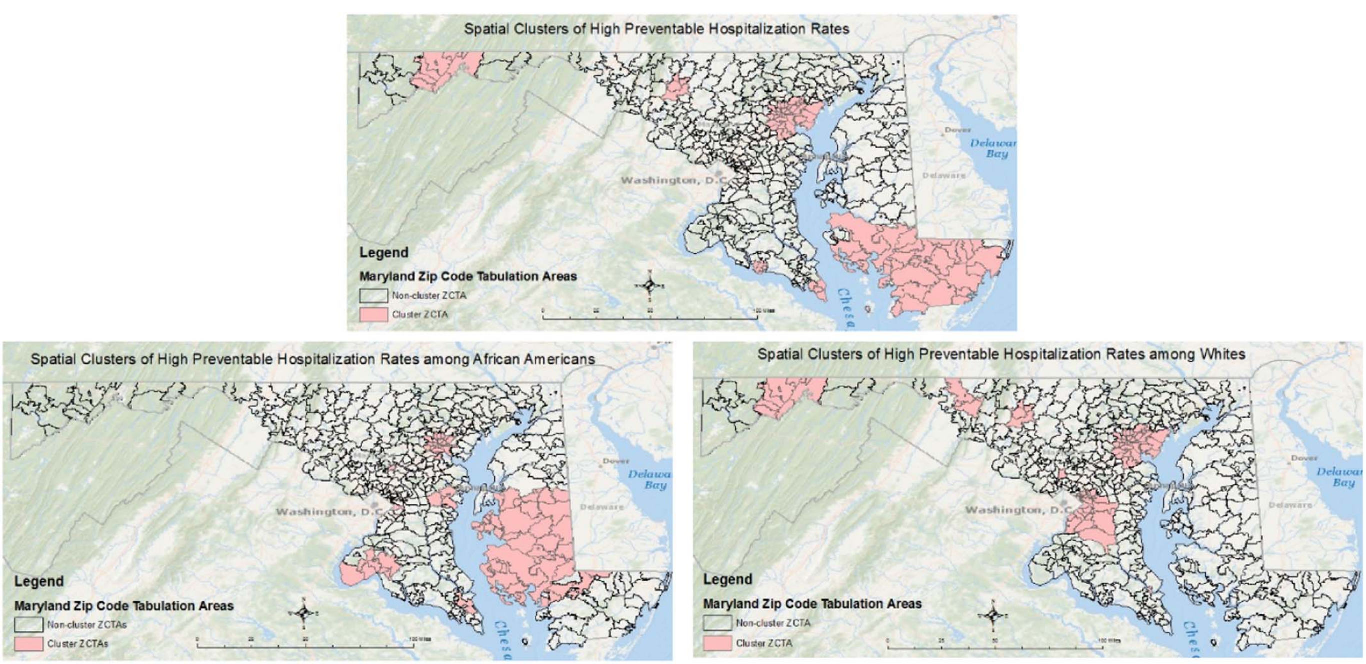

Fig. 1. Spatial clusters of chronic preventable hospitalizations in Maryland by race, 2010.

Table 3
Preventable Hospitalizations Spatial Clusters Characteristics in Maryland, 2010.

Total population					White population					African American population				
Spatial cluster[a]	Radius (miles)	Rate per 100,000 population	LLR[b]	p-value	Spatial cluster[a]	Radius (miles)	Rate per 100,000 population	LLR[b]	p-value	Spatial cluster[a]	Radius (miles)	Rate per 100,000 population	LLR[b]	p-value
Baltimore	9.7	1900.8	3894.6	< 0.001	Baltimore	9.7	1603.5	1,1130.0	< 0.001	Baltimore	5.1	2720.7	1872.5	< 0.001
Cumberland	11.9	1818.6	174.9	< 0.001	Cumberland	11.8	2006.7	295.3	< 0.001	Salisbury	28.8	2743.9	126.8	< 0.001
Clinton	11.8	1400.0	142.6	< 0.001	Bowie	11.1	1395.0	42.3	< 0.001	Capitol Heights	0.0	2095.5	29.0	< 0.001
Salisbury	38.2	1430.5	123.5	< 0.001	Hagerstown	5.8	1289.1	32.6	< 0.001	Annapolis	3.2	2515.6	19.2	< 0.001
Bushwood	3.4	2326.3	14.7	< 0.001	Silver spring	0.0	1469.5	25.5	< 0.001	LaPlata	7.9	2441.1	12.3	0.001
Frederick	5.4	1277.2	11.6	0.004	Frederick	5.4	1239.3	15.5	< 0.001					
					Solomons	0.0	2216.3	10.0	0.018					

[a] Identified by principal city included in the spatial cluster.
[b] LLR = log likelihood ratio.

internists were positively associated with PH rates (Derose, 2008). The units of analysis vary across studies (zip code versus health services area), and may be implicated in these discrepancies.

No previous studies have examined associations between physicians' assistants and PH rates specifically, but physicians' assistants were negatively associated with PHs in the current study. One study found that non-physician supply is negatively associated with PH rates among the elderly in the U.S (Mobley et al., 2006), which partially agrees with the current study. Another study found that non-physician healthcare supply was not associated with PH rates in Nebraska counties (Nayar et al., 2012), which also partially agrees with the results of the current study. Because physicians' assistants and nurse practitioners were not differentiated in these studies, it is unclear which is driving the associations.

Many studies have found negative associations between FQHCs and PH rates (Epstein, 2001; Probst et al., 2009; Hossain and Laditka, 2009; Rothkopf et al., 2011; Rust et al., 2009; Zhang et al., 2006), while the current study did not. These studies generally examine low-income, Medicaid or uninsured populations specifically, while the current study did not make this distinction. FQHCs were more likely to be located in ZCTAs that are included in chronic PH clusters among African Americans. These areas were more likely to be rural and have lower incomes, which fits the general profile of areas served by FQHCs.

No previous studies have examined associations between PH rates and commercial urgent care centers, local health departments, pharmacies, grocery stores, commercial gyms/recreational centers or parks. Some studies have found that distance to a hospital is inversely associated with PH rates (Epstein, 2001; Basu et al., 2004). These studies appear to agree with the current study which found that PH rates were positively associated with the presence of a teaching hospital.

The variation in associations between LHPRs with PH rates warrants some discussion. The associations between PH rates and family practitioner and physicians' assistant supply were as hypothesized. The number of internists per 10,000 ZCTA population was positively associated with PH rates. Internists may treat an older population with more chronic conditions who have more difficulty managing these conditions. A study by Shackelton-Piccolo et al. found that internists were more likely than family practitioners to be sure of a coronary heart disease diagnosis (Shackelton-Piccolo et al., 2011). It is possible that internists and other types of healthcare providers who specifically treat adults may be more aggressive in treating chronic conditions, and this may result in more PHs.

PHs in the total population were also positively associated with local health departments. Few local health departments provide primary healthcare (Wright and Nice, 2015); no local health department in Maryland does. However, a few provide services such as blood pressure screening, diabetes education, and chronic disease management. These services could be associated with increased awareness, but may not translate into increased preventive primary healthcare.

There was no association between PH rates and FQHCs, commercial urgent care centers or grocery stores. No association with FQHCs could be a function of the broad population included in this study. The lack of an association of commercial urgent care centers and grocery stores with PH rates could be due to the unit of analysis. Zip codes are based on U.S. Postal Service routes, and may not capture spatial access to these particular LHPRs.

No LHPRs were associated with white PH rates or clusters, while family practitioners, nurse practitioners, commercial gyms/recreational centers, FQHCs and teaching hospitals were associated with African American PH rates or clusters. This suggests that white PH rates and clusters may be a function of ZCTA-level demographics more so than LHPRs. No previous studies have stratified associations between PHs and LHPRs by race. It is possible that higher PH rates among whites are associated with some unmeasured healthcare-seeking factors that may be more prevalent in less well-educated areas with lower median incomes and more African American residents. Predictors of primary healthcare utilization include need, enabling and predisposing factors (Andersen, 1995). Among whites with chronic conditions (i.e., those that demonstrate need), predisposing factors such as attitudes toward primary healthcare utilization may be more important predictors of higher PH rates than enabling factors such as access to LHPRs.

Family practitioner supply was associated with chronic PH rates and clusters among African Americans. This suggests that African Americans living in areas with more family practitioners may be more likely to use primary healthcare to preempt PHs for chronic conditions. African American PH rates were lower in ZCTAs with a commercial gym or recreational center. It is possible that living in an area with access to gyms and recreational centers is associated with lower chronic disease prevalence (Casagrande et al., 2009). African Americans with chronic conditions such as hypertension or diabetes who live in areas with a gym or recreational center may be able to better control these conditions. Better chronic disease management would suggest lower PH rates. Contrary to hypotheses, ZCTAs in African American PH clusters were more likely to have a FQHC. FQHCs are located in medically underserved areas that may be fairly large, particularly in rural areas. It is possible that a centrally located FQHC may not be able to provide primary healthcare across the area, resulting in PH clusters in which FQHCs are located. Teaching hospitals were positively associated with African American PH rates and clusters. Sicker, potentially older patients may seek treatment at teaching hospitals, and these hospitals may more readily treat patients seeking care for PHs.

There are important implications to this study. This study utilized a tool to detect clusters of areas with high chronic PHs. Knowledge of where PH rates are high will allow policymakers and public health practitioners in Maryland to directly target those areas with more family practitioners and physicians' assistants to reduce PHs. Public health practitioners and policymakers should directly target African American PH clusters with specific LHPRs such as family practitioners

Table 4
Local health-promoting resources and demographics by race-specific chronic PH clusters in Maryland, 2010.

	Total			White			African American		
	Non-cluster ZCTA	Cluster ZCTA	p-value	Non-cluster ZCTA	Cluster ZCTA	p-value	Non-cluster ZCTA	Cluster ZCTA	p-value
Family practitioners per 10,000 population, mean ± S.E.	15.2 ± 13.8	0.9 ± 0.2	0.001	14.3 ± 13.0	1.4 ± 0.3	0.208	14.4 ± 13.0	1.0 ± 0.3	0.044
Internists per 10,000 population, mean ± S.E.	22.7 ± 20.7	3.4 ± 1.2	0.385	21.6 ± 19.5	3.5 ± 0.7	0.351	21.7 ± 19.5	3.4 ± 1.5	0.172
Nurse practitioners per 10,000 population, mean ± S.E.	22.0 ± 20.7	1.4 ± 0.4	0.753	20.7 ± 19.5	1.9 ± 0.5	0.546	20.8 ± 19.5	1.8 ± 0.5	0.079
Physicians' assistants per 10,000 population, mean ± S.E.	1.3 ± 0.5	1.2 ± 0.4	0.565	1.2 ± 0.5	1.6 ± 0.5	0.904	1.3 ± 0.5	1.0 ± 0.3	0.378
FQHC, %	10.2	24.0	0.037	10.4	26.8	0.317	9.1	32.5	< 0.001
Commercial urgent care center, %	14.6	18.3	0.356	12.7	28.0	0.343	15.3	15.7	0.698
Local health department, %	4.7	6.7	0.696	5.2	4.9	0.175	4.4	8.4	0.654
Hospital, %									
None	92.0	81.7		92.5	76.8		91.7	80.7	
Teaching	3.6	11.5	0.032	3.1	15.9	0.084	3.1	15.7	0.001
Non-teaching	4.4	6.7	0.281	4.4	7.3	0.961	5.2	3.6	0.624
Pharmacy, %	48.6	44.2	0.608	43.3	68.3	0.589	49.1	41.0	0.322
Grocery store, %	46.2	37.5	0.276	40.2	63.4	0.433	45.7	37.3	0.543
Commercial gym/recreational center, %	45.1	32.7	0.456	40.9	48.8	0.111	45.2	28.9	0.164
Public park, %	65.4	52.9	0.678	63.5	58.5	0.092	64.7	53.0	0.420
African American residents, %	16.0	22.5	0.742	13.2	37.3	< 0.001	15.8	24.7	0.002
Rural, %	45.7	46.8	0.059	53.0	13.2	< 0.001	43.0	59.8	< 0.001
Uninsured residents, %	8.8	11.3	0.200	8.8	11.8	0.133	8.9	11.2	0.696
Median income ($10,000), mean ± S.E.	8.5 ± 0.2	5.1 ± 0.2	< 0.001	8.2 ± 0.2	5.6 ± 0.3	0.011	8.1 ± 0.2	6.2 ± 0.3	0.003
More than high school education, %	61.5	47.5	0.017	59.6	52.4	0.001	59.6	52.7	0.066

and recreational facilities. The African American PH rate is 34% higher than whites in Maryland. In other studies, African Americans have up to three times the rate of PHs compared to whites (Derose, 2008; Chang et al., 2008; Gaskin and Hoffman, 2000; Laditka et al., 2003; O'Neil et al., 2010). Targeting African American PH clusters with more physician supply and recreational facilities could reduce disparities.

This study is strengthened by a number of factors. LHPRs include measures beyond FQHCs and physician supply, which are the most frequently studied measures of primary healthcare associated with PHs (Rosano et al., 2013). The study stratified analyses by race, and also included spatial analyses for more direct targeting of resources to those populations and areas in need. There are, however, some limitations to the study. This study was conducted in the State of Maryland and may not be generalizable to other jurisdictions. The unit of analysis was the ZCTA. Many studies of PHs and FQHCs or primary care physician supply are conducted on the county or health services area-level. The results of the current study could differ if county-level analyses were performed. Also, PHs did not represent individual patients, so repeated PHs among a small number of patients could inflate PH rates in small, particularly rural ZCTAs. This study was unable to compare the associations between LHPRs and PHs in urban to rural ZCTAs because rural ZCTAs had too few of some LHPRs to detect statistical significance. A spatial analysis of PHs among Hispanics could not be included because of the sparse concentrations of Hispanic residents across the state. Only 12.6% of ZCTAs had a Hispanic population > 10%. Public parks in Allegany and Garrett counties were not included because an official list from a Department of Parks and Recreation was not available as in other jurisdictions. Though the locations of local health departments were identified, the potential for variations in location of preventive screenings and education could not be identified.

In conclusion, chronic PH rates were negatively associated with family practitioner and physicians' assistant supply, and positively associated with increased numbers of internists per 10,000 population and LHDs. African American PH rates decreased with family practitioner supply and the presence of a gym/recreational center. Spatial clusters of ZCTAs with higher chronic PH rates were detected. Spatial PH clusters among African Americans had more FQHCs and fewer family practitioners per 10,000 population. Public health policymakers should target chronic PH rates with increased LHPRs, particularly among African Americans.

Conflict of interest statement

Caryn Bell, Janice Bowie, Roland Thorpe and David Levine have no conflicts of interest.

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