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Associations of Tobacco Retailer Density with Chronic Obstructive Pulmonary Disease Related Hospital Outcomes, United States, 2014

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Abstract

There are associations between tobacco retailer density and smoking behaviors, but little is known about whether places with more tobacco retailers have more smoking-related health problems. Using cross-sectional data from 2014, we investigated the relationships between tobacco retailer density and chronic obstructive pulmonary disease (COPD) related outcomes in a sample of 1510 counties across the United States. Higher retailer density was associated with a 19% (IRR, 1.19; 95% CI, 1.12–1.27) higher COPD-related hospital discharge rate and 30% (IRR, 1.30; 95% CI 1.21–1.39) higher total COPD-related hospital costs per population. The tobacco retailer environment may be an important target for reducing smoking-related health burdens and costs.

Keywords

tobacco retailer availability; tobacco retailer density; chronic obstructive pulmonary disease; hospital discharge

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CONFLICTS OF INTEREST

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INTRODUCTION

Tobacco use is the leading cause of preventable death in the United States (U.S.), estimated to cause more than 480,000 deaths annually.[1] Although smoking rates have declined over the past decade, 13.7% of adults smoke,[2] increasing the risk for premature death and/or disability. The health consequences of tobacco smoke are well documented, contributing to cardiovascular disease, chronic obstructive pulmonary disease (COPD), and one third of cancer deaths.[1,3] Furthermore, the health and financial costs due to smoking are enormous, amounting to over $170 billion each year in the U.S.[4]

Globally, the tobacco control community has called for discussion on, and evaluation of, novel 'tobacco endgame' strategies that could further reduce the burden of tobacco use.[5–7] One such strategy is to decrease the number of retailers that sell tobacco products in a community in an effort to reduce the supply of tobacco products in a community.[7] Internationally, some places (South Australia, Finland) have observed decreases in tobacco retailer availability after increasing tobacco license fees.[8,9] In the U.S., several jurisdictions (San Francisco, New York City) have set a limit on the number of retailers that can sell tobacco in a neighborhood.[10,11]

Tobacco retailer availability is often operationalized as the number of tobacco retailers per population (i.e. tobacco retailer density). In 2012, U.S. metropolitan counties with the greatest tobacco retailer density had 1.9 percentage points higher smoking prevalence compared to those with the lowest retailer density.[12] In places with greater tobacco retailer availability, there may be lower travel costs to obtain tobacco products[13] and a greater amount of and exposure to marketing,[14,15] which could cue smokers to purchase and use products, reducing smoking cessation.[16–24]

Few studies have investigated associations between retail availability and tobacco-related health outcomes, and none, to our knowledge, have been conducted on a national level for the U.S. Research conducted in Baltimore (Maryland) found that in 2011, a greater number of tobacco retailers per 10,000 people was significantly associated with a lower life expectancy, greater age-adjusted mortality, and greater rates of death from chronic lower respiratory disease.[25] A 1997 cross-sectional study in Louisiana investigated census tract-level associations of tobacco retailers per 1000 people with birthweight and gestational age at birth and found no significant results in models that adjusted for both neighborhood-level socioeconomic factors and individual-level factors.[26] In Western Australia, retailer density was associated with a greater diagnosis of and hospitalization for heart disease among smokers.[27]

One health outcome that may be associated with tobacco retailer density is COPD-related hospitalization. COPD is a pulmonary disease, characterized by emphysema, chronic bronchitis, and obstructed breathing that affects millions of adults each year.[4,28] Smoking cigarettes is the main cause of COPD development, and exposure to secondhand smoke may also contribute to its development or exacerbation.[28] Smoking also contributes to COPD hospital admissions,[29] which account for the greatest cost of COPD-related care.[28,30] In

places where the tobacco retail environment may prompt greater tobacco use or undermine successful cessation, there may be greater hospitalization due to COPD exacerbation.

Only two U.S.-based study have examined associations of the tobacco retail environment with COPD-related hospitalizations, and these have been limited to a single state.[31,32] Lipton and colleagues documented positive associations between the number of tobacco retailers and COPD-related hospital charges per capita in California in both 1993 and 1999.[31] Specifically, in 1999, they found that a higher count of tobacco retailers in California zip codes was significantly associated with 0.23 higher COPD-related hospitalization counts and $4,838.17 higher COPD-related hospital charges.[32]

Between 2010 and 2030, COPD-related hospitalizations are estimated to increase by 210% in the U.S.[30] Identifying place-based factors that contribute to COPD-related hospitalizations could help health systems plan for the associated care burden, prioritize places most in need of preventive health resources, and generate innovative retail environment programs and policies. Additionally, there are very few U.S.-based or international studies assessing relationships between tobacco retailer availability and smoking-related health outcomes, and these have primarily been limited to local areas. Given the paucity of this research on this topic, understanding whether there is replicability in associations between tobacco retailer availability and various smoking-related health outcomes across additional geographies is needed. The purpose of this cross-sectional study is to examine associations of tobacco retailer density with COPD-related inpatient hospital discharge outcomes in a recent sample of counties across the U.S.

MATERIALS & METHODS

Data Sources and Measures

Tobacco Retailer Density—In the U.S. there is no national licensing system of stores that sell tobacco products for in-person consumer purchase (i.e. tobacco retailers). Furthermore, the American Lung Association estimates that only 38 states require a tobacco retailer to have a license to sell cigarettes,[33] and some states may only update licensing lists periodically.

Using tobacco product sales data from the latest 2012 Economic U.S. Census, we identified a list of ten North American Industry Classification System (NAICS) codes that describe the types of stores (i.e. convenience stores; gasoline stations; gasoline stations with convenience stores; warehouse clubs and supercenters; tobacco stores; supermarkets and other grocery stores; pharmacies and drug stores; beer, wine and liquor stores; other general merchandise stores; discount department stores) that account for approximately 99% of all retail tobacco product sales.[34] Using these ten NAICS codes and the 2014 ReferenceUSA (RefUSA) national database[35] of business establishments that contains NAICS codes and geographic indicators (e.g., address, city, latitude, and longitude) for each retailer, we created a national list of probable tobacco retailers, similar to previous studies.[36–38] Specific retailer sub-types (e.g., specialty food markets, compounding pharmacies, marine services stations) and retailers known to not sell tobacco products (e.g., Target, Whole Foods, Trader Joes) were excluded from the sample. Though national validation of commercial lists, such as RefUSA,

has not been conducted, two studies have indicated good validation when compared to ground-truthed retailer locations (three counties in North Carolina)[36] and tract-level retail density using a state licensing list (Washington).[38]

Tiger/Line county boundary files were downloaded from the U.S. Census Bureau.[39] We used a spatial join in ArcMap 10.5 to assign each retailer to its respective county. To measure tobacco retailer availability, we calculated tobacco retailer density per 1000 residents by summing the number of retailers in each county, dividing this sum by the total county-level population, and multiplying this figure by 1000. We additionally created quartiles of this measure to investigate potential threshold effects that may not be apparent when using a continuous measure of retailer availability.

COPD-Related Hospital Discharge Data—The Healthcare Cost and Utilization Project (HCUP) is a U.S. longitudinal healthcare database that aggregates data from state and private data organizations, hospitals, and the federal government.[40] The publicly available 2014 HCUP State Inpatient Database (HCUP-SID) includes COPD-related hospital inpatient discharge data for a sample of 1510 counties across 31 states in the U.S. (Figure 1). Not all states participate in the publicly available HCUP-SID, and statistics are not reported for any estimates that are unreliable or that could potentially identify an individual. The sample includes nearly half (48.1%) of counties in the U.S. where approximately 69.4% of the 2014 U.S. population resided.

The primary study outcome of interest is the total number of COPD-related hospital discharges in a county. We also investigated associations of retailer density with COPD-related total number of days spent in the hospital and total actual hospital costs for providing care for all COPD-related inpatient stays (rounded to the nearest dollar). Data are classified by HCUP-SID as “COPD-related” based on Clinical Classification Software (CCS), which uses International Classification of Diseases (ICD) codes to create an overall clinically meaningful category that researchers can then use to assess outcomes related to particular illnesses.[41] See Supplement A for a list of the 15 ICD-9 codes used to classify a hospital discharge as due to “Chronic obstructive pulmonary disease and bronchiectasis.” HCUP-SID statistics are based on the patient’s county of residence, rather than the county where the treatment hospital is located;[40] our analysis therefore assessed both tobacco retailer availability and COPD-related hospital outcomes in reference to place of residency.

Control Variables—To control for potential confounders documented in other studies,[31,32] we included county-level estimates of percent of the population aged 45 years or older, percent male, percent Hispanic or Latino ethnicity, percent non-Hispanic Black or African American (Black), and percent living below 150% of the federal poverty level (FPL) in adjusted models. Demographic data were from the 2010–2014 American Community Survey (ACS), a survey of a nationally representative sample of households conducted by the U.S. Census Bureau,[42] and downloaded from Social Explorer.[43] Urbanicity may also confound the relationship between tobacco retailer density and COPD diagnosis.[38,44] The U.S. Department of Agriculture has developed Rural-Urban Continuum Codes (RUCC) which can be combined to designate counties as urban or rural based on population size and

adjacency to metro areas.[45] Using RUCC, we created an urbanicity variable designating counties as either metropolitan, urbanized non-metropolitan, or rural.

Finally, air quality may be poorer in more disadvantaged areas, and air quality has been associated with both tobacco retailer density[46] and COPD.[4,28] We retrieved data from the U.S. Environmental Protection Agency's Air Quality System (AQS), which measures air pollution through the use of an Air Quality Index (AQI) in select counties.[47] Data from the AQS have been deemed the gold standard for determining outdoor air pollution in urban areas[48] and 40.8% of the 1510 counties in the 2014 HCUP-SID had median AQI data (total sample). As a sensitivity test, we compared the results of analyses using the continuous measure of tobacco retailer density between models that did and did not include median AQI.

Analysis

All analyses were completed using SAS 9.4. Sample characteristics (mean, frequency, standard deviation, range) were calculated for both the full HCUP-SID sample (N=1510) and for the air quality control sample (N=616). We also present the mean age-sex standardized value, provided by HCUP-SID, of each COPD-related health outcome by quartile of retailer density for the full sample.

Negative Binomial Regression Models—Prior to fitting any models, we investigated the distribution of each COPD-related hospital outcome for the full sample, which indicated overdispersion in the count outcomes. To account for overdispersion, we fit negative binomial regression models and tested associations between both continuous and quartiles of tobacco retailer density and each COPD-related hospital outcome. As the population-at-risk for COPD-related hospital outcomes varies between counties, we included an offset (i.e. natural log of the total county-level population) in each model. We investigated correlation coefficients between all control variables and retailer availability and did not find evidence of high collinearity. Finally, all models included state indicators (i.e. fixed effects) to control for both the nesting of counties within states and any omitted time-invariant state-level factors. We present both unadjusted models, which only included state fixed effects, and adjusted models, which additionally included all control variables described above.

RESULTS

The full sample included 1510 counties, and the average number of counties per state was 48.7. Table 1 describes sample characteristics for both the full sample. Compared to national county-level population estimates (not shown), the full sample had counties with a lower percent of non-Hispanic Black (7.2 vs. 12.2) and Hispanic or Latino (9.4 vs. 16.9) residents, and a slightly higher percent of residents living below 150% FPL (27.6 vs. 25.2) and those aged 45 or older (44.3 vs. 40.1).

Negative Binomial Regression Results

Unadjusted models (Table 2) indicated that tobacco retailer density was positively associated with all outcomes. Controlling for all other variables in the full model (adjusted), one

additional retailer per 1000 people was associated with a 19% (IRR, 1.19; 95% CI, 1.12–1.27) higher COPD-related hospital discharge rate. We found similar positive and significant associations for the number of days in the hospital and aggregate costs of hospital stays. An additional retailer per 1000 people was associated with 1.22 (95% CI, 1.44–1.30) times the number of days stayed in the hospital, and with a 30% (IRR, 1.30; 95% CI, 1.21–1.39) higher aggregate cost ($) per population.

In a sensitivity test, we fit a negative binomial model that included a spatial lag of each of the COPD-related health outcomes to account for spatial autocorrelation. We specified a first order Queen contiguity weights matrix that omitted ten counties that did not have neighbors (N=1500 vs. N=1510). Results from this spatial regression (not shown) were unchanged (largest difference in magnitude IRR, 1.19 [95% CI 1.13–1.27] vs. IRR, 1.21 [95%CI 1.14–1.28]). Therefore, we focused presentation and discussion on the more parsimonious model for the larger sample (N=1510).

Analyses of quartiles of retailer density suggest this relationship may differ by level of retailer density. For example, compared to counties with the lowest retailer density (Q1: 0.45–1.07), counties with the highest retailer density (Q4: 1.65–5.09) had a 22% (IRR, 1.22; 95% CI, 1.13–1.32) higher discharge rate, those in Q3 (1.33–1.64) had a 15% (IRR, 1.15; 95% CI, 1.07–1.22) higher discharge rate, and those in Q2 (1.08–1.32) had a 12% (IRR, 1.12; 95% CI, 1.05–1.18) higher discharge rate.

In Table 3, we describe model-predicted averages of each CODP-related hospital outcome by quartile of tobacco retailer density. Overall, there was a positive relationship between level of tobacco retailer density and rates of all COPD-related outcomes. For example, those counties with the lowest retailer density (Q1: 0.45–1.07) had an average of 199.4 (95% CI: 189.3–210.0) COPD-related discharges per 100,000 people while counties with the highest retailer density (Q4: 1.65–5.09) had 243.9 discharges per 100,000 people (95% CI: 231.4–257.1), representing a 44.5 difference.

Using the smaller air quality control sample and the continuous measure of tobacco retailer density, we fit and compared adjusted models that included and excluded median AQI as a control variable. The air quality control sample included 616 counties and the average number of counties per state was 20.5. Compared to the full sample, the air quality control sample was more metropolitan (66.6% vs. 44.2%) and less urbanized (22.6% vs. 31.6%) and rural (10.9% vs. 24.2%), had lower average retailer density (1.22 vs. 1.40), had a greater proportion of Hispanic or Latino residents (12.6% vs. 9.4%), and had a higher mean of all COPD-related hospital outcomes. All other characteristics were similar between the two samples. Despite these differences, the magnitude, direction, and significance of associations were unchanged or similar (largest change: IRR, 1.46; 95% CI, 1.28–1.66 vs. IRR, 1.44; 95% CI, 1.27–1.65), and the direction and significance were identical across all outcomes; therefore, we focused our interpretation and discussion on the adjusted results of the larger full analytic sample.

DISCUSSION

Even after controlling for a number of area-level factors, counties with higher retailer availability had greater COPD-related discharges, hospital stays, and financial costs. While there are very few studies investigating relationships between tobacco retailer availability and health outcomes in general, our findings are consistent with two related earlier cross-sectional studies that examined the relationship between tobacco retailer availability and area-level COPD-related hospital outcomes in California.[31,32]

Greater retailer availability may result in higher smoking intensity and decreased chances of quitting.[20–24,49] Both of these behaviors may contribute to more secondhand smoke exposure, affecting smokers and non-smokers and potentially contributing to COPD exacerbation,[28,29] which may then result in hospital admissions. Though we cannot make causal interpretations or claims of temporality due to our cross-sectional study design, we indeed find that counties with greater retailer density are expected to have a 19% higher COPD discharge rate, and the number of days stayed in the hospital upon admission was also significantly higher. In fact, our model-predicted results indicated that compared to counties with the lowest retailer density, those counties with the highest retailer density had 196.9 more COPD-related days in the hospital per 100,000 people.

We additionally examined associations between retailer density and COPD-related financial costs. In adjusted models, we found that when comparing two counties, a county with a 1-unit higher retailer density would be expected to have a 30% higher rate of COPD-related hospital costs. Additionally, compared to counties with the lowest retailer density, those with the highest were predicted to have $543,450 higher total COPD-related hospital costs per 100,000 people. In 2010, the economic costs due to COPD were $32.1 billion and were projected to reach $49.9 billion by 2020, averaging to over $4000/year per COPD patient.[28,50]

Comprehensive smoke-free air policies are one of the most effective tobacco control policies and may protect against cardiovascular disease and COPD-related hospitalizations.[51–53] Our results suggest that strategies focused on reducing tobacco retailer availability could also be an important policy strategy for reducing COPD-related burdens. Understanding the potential long-term health implications related to different levels of tobacco retailer availability may help policymakers anticipate future burdens on the healthcare system, especially for financially costly diseases such as COPD. Policymakers interested in reducing tobacco retailer density have many options to consider, including banning tobacco sales at pharmacies, increasing retailer licensing fees, setting caps on the number of tobacco retailers, and restricting their proximity to schools or other retailers.[7,13,54,55]

While the current study does not provide evidence for whether retailer-focused policies will be effective in reducing smoking-related disease, our results do suggest that there are associations between retailer availability and health that deserve exploration over time. Smoking cessation is the most important modifiable determinant in COPD management,[28] associated with a 40% reduced risk of COPD hospital admission.[56] Places with high rates of COPD may want to examine the local tobacco retailer environment, which could be

undermining cessation efforts. However, future longitudinal studies are needed to better disentangle the causal mechanisms and relationships between tobacco retailer availability, smoking behavior, and resulting health outcomes and financial costs.

Several considerations should be made when interpreting the results of this study. First, this is a cross-sectional study and therefore, we cannot conclude that retailer density leads to higher COPD-related hospital admissions or costs. We chose outcome variables related to COPD-related exacerbation, rather than COPD development, recognizing that exacerbation may be more tied to the immediate environment in the short-term, whereas disease development may be impacted by exposure to risks over longer time periods. This study is ecological, and our study results are thus, limited to inference at the county-level. However, given the paucity of U.S.-based and international research on whether tobacco retailer availability is associated with smoking-related health outcomes (vs. behaviors), the associations documented may help provide needed rationale and support for researchers to investigate multilevel and longitudinal associations that could strengthen causal inference

To the best of our knowledge, this is the first study that uses a multi-state sample to investigate associations of retailer availability and related health outcomes. However, as the analytic sample does not include all states, generalizability cannot be made to the overall national level or to other time periods. Because there is no national tobacco retailer list in the U.S., we had to generate a probable list of tobacco retailers; however, this generated list does not represent stores with verified tobacco sales. There could be retailers on the list that are not actually tobacco retailers, or there could be tobacco retailers missing from this list. We have no reason to believe that this potential error is systematic, however.

Tobacco retailer availability is a latent construct. We chose to operationalize retailer availability as the number of retailers per population; however, this measure may not truly capture how available retail tobacco products are to a population. Other factors that might influence accessibility, such as retailer hours of operation, marketing and pricing of products, and someone’s proximity and resources to reach retailers may also be important components of operationalizing availability. Finally, while HCUP-SID statistics are based on the patient’s county of residence, it is entirely plausible that patients spend time in other counties with varying retailer availability that may additionally impact their smoking or cessation behaviors.

CONCLUSION

Smoking causes COPD, and the health and financial costs due to this burden are immense. Greater retail availability of tobacco products could increase smoking and reduce successful cessation. In a national sample, we document significant associations between tobacco retailer density and COPD-related hospital discharges, days spent in the hospital, and financial costs. As COPD-related cost are projected to grow substantially in the next decade, our study provides evidence that the tobacco retailer environment may be an important point of intervention to potentially prevent and decrease smoking-related hospital admissions and growing financial costs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights:

- Higher tobacco retailer density is associated with a higher COPD discharge rate.
- Higher retailer density is also associated with higher COPD health care costs.
- Retailer-based regulations may help reduce tobacco use and related health problems.

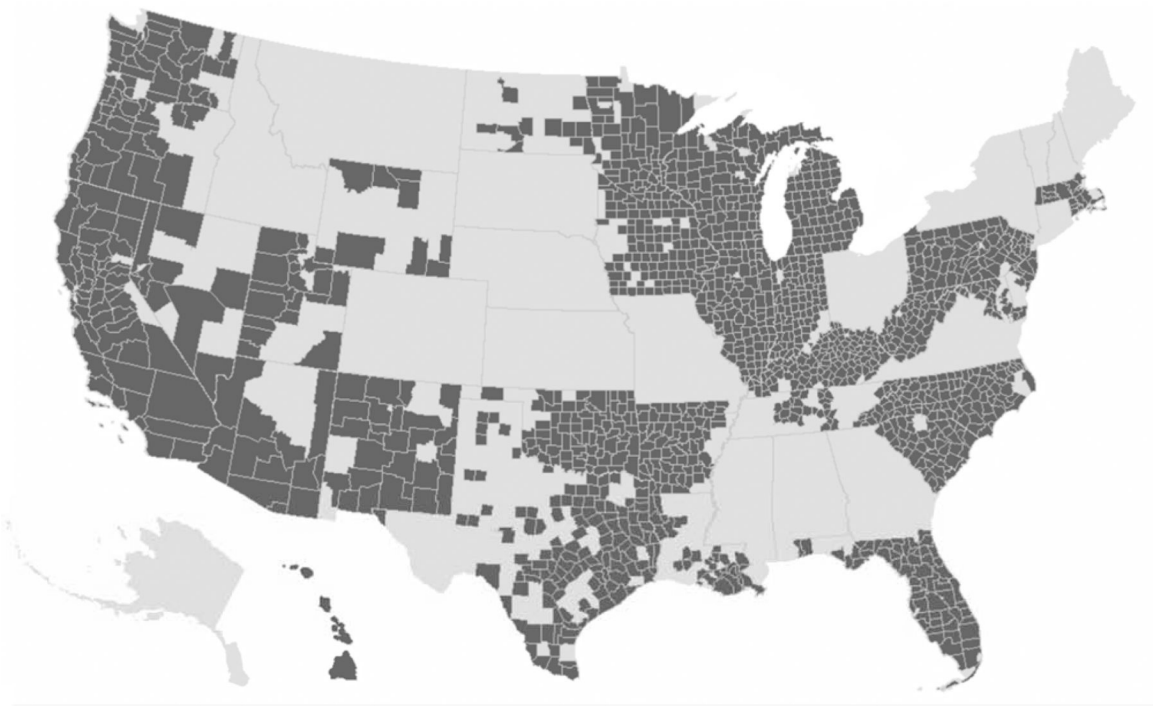

Figure 1.
Counties in publicly available Healthcare Cost & Utilization Project State Inpatient Database (HCUP-SID), United States, 2014 (N=1510)

Table 1.

2014 Healthcare Cost & Utilization Project State Inpatient Database (HCUP-SID) Sample Characteristics, United States (N=1510 Counties)

	Mean (SD)	Range
Total population	144,297 (425,383)	2883–9,974,203
Tobacco retailers per 1000 people	1.40 (0.45)	0.45–5.09
COPD-Related Hospital Outcomes		
Total number of discharges	257.1 (599.9)	11–10,749
Total number of days in the hospital	1092.8 (2714.4)	24–48,059
Total costs for all hospital stays, $	2,108,703 (5,445,304)	44,995–115,105,788
Percent non-Hispanic Black	7.2 (11.4)	0–73.9
Percent Hispanic or Latino ethnicity	9.4 (14.0)	0–95.7
Percent below 150% FPL	27.6 (8.1)	7.1–58.6
Percent aged 45 or older	44.3 (6.2)	21.5–74.9
Percent male	50.0 (2.0)	45.6–69.7
Urbanicity (percent)		
Metropolitan	44.2%	-
Urbanized non-metropolitan	31.6%	-
Rural	24.2%	-

Table 2.

Associations of Tobacco Retailer Density and COPD-Related Hospital Outcomes, United States, 2014 (N=1510)

	Total number of discharges		Total number of days in the hospital		Aggregate costs for all hospital stays, $	
	Unadjusted IRR (95% CI)	**Adjusted IRR (95% CI)**	**Unadjusted IRR (95% CI)**	**Adjusted IRR (95% CI)**	**Unadjusted IRR (95% CI)**	**Adjusted IRR (95% CI)**
Tobacco retailers per 1000 (continuous)	1.64 (1.54–1.73)	1.19 (1.12–1.27)	1.60 (1.50–1.70)	1.22 (1.14–1.30)	1.70 (1.60–1.81)	1.30 (1.21–1.39)
Tobacco retailers per 1000 (quartiles)						
Q1: 0.45–1.07	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
Q2: 1.08–1.32	1.31 (1.23–1.40)	1.12 (1.05–1.18)	1.31 (1.23–1.41)	1.14 (1.07–1.22)	1.39 (1.30–1.49)	1.19 (1.12–1.28)
Q3: 1.33–1.64	1.51 (1.41–1.61)	1.15 (1.07–1.22)	1.49 (1.39–1.60)	1.18 (1.10–1.27)	1.55 (1.44–1.66)	1.22 (1.13–1.31)
Q4: 1.65–5.09	1.81 (1.69–1.94)	1.22 (1.13–1.32)	1.76 (1.64–1.90)	1.25 (1.15–1.36)	1.90 (1.76–2.05)	1.32 (1.23–1.46)

Note: All models include a state fixed effect indicator. Adjusted models additionally control for county-level percent non-Hispanic Black, Hispanic or Latino ethnicity, living below 150% of the federal poverty level, aged 45 years or older, male, and urbanicity.

Table 3.

Model-Predicted Average COPD-Related Hospital Outcome Rates for Quartiles of Tobacco Retailer Density, United States, 2014 (N=1510)

	Total number of discharges per 100,000 people	Total number of days in the hospital per 100,000 people	Total costs ($) for all hospital stays per 100,000 people
	Mean (95% CI)	**Mean (95% CI)**	**Mean (95% CI)**
Q1 (0.45–1.07)	199.4 (189.3–210.0)	790.9 (746.5–838.0)	1,601,040 (1,506,570–1,701,440)
Q2 (1.08–1.32)	222.5 (218.1–239.4)	903.9 (859.1–951.2)	1,912,820 (1,813,370–2,017,720)
Q3 (1.33–1.64)	228.5 (218.1–239.4)	932.6 (886.1–981.5)	1,945,970 (1,845,420–2,051,990)
Q4 (1.65–5.09)	243.9 (231.4–257.1)	987.8 (932.8–1046.0)	2,144,490 (2,020,110–2,276,510)

Note: All models include a state fixed effect indicator. Adjusted models additionally control for county-level percent non-Hispanic Black, Hispanic or Latino ethnicity, living below 150% of the federal poverty level, aged 45 years or older, male, and urbanicity.