Time Trends in Racial and Ethnic Disparities in Asthma Prevalence in the United States From the Behavioral Risk Factor Surveillance System (BRFSS) Study (1999–2011)

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Objectives. We examined whether racial/ethnic disparities in the United States increased over time.

Methods. We analyzed data from 3 868 956 adults across the United States from the Behavioral Risk Factor Surveillance System from 1999 to 2011. We used random intercepts models (individuals nested in states) to examine racial/ethnic disparities and time trends in asthma lifetime and its current prevalence, adjusted for covariates. We also investigated the heterogeneity in asthma prevalence by ethnicity of the major zone of residence.

Results. Lifetime and current asthma prevalence were higher among non-Hispanic Black populations, with time trends highlighting increasing differences over time (b = 0.0078; 95% confidence interval [CI] = 0.0043, 0.0106). Lower odds ratios (ORs) of asthma were noted for Hispanic populations (OR = 0.74; 95% CI = 0.73, 0.76). Hispanics in states with more Puerto Rican residents reported greater risks of asthma (OR = 1.55; 95% CI = 1.24, 1.93) compared with Hispanics in states with larger numbers of Mexican or other ethnicities.

Conclusions. Disparities in asthma prevalence by racial/ethnic groups increased in the last decade, with non-Hispanic Blacks and Puerto Rican Hispanics at greater risk. Interventions targeting asthma treatments need to recognize racial, ethnic, and geographic disparities. (*Am J Public Health.* 2015;105: 1269–1275. doi:10.2105/AJPH.2014.302172)

Asthma is a major public health issue in the United States that affected nearly 9.4% of the US population in 2009.[1] The burden of asthma morbidity has been borne by both patient households (productive days lost) and the health system (rising health care costs).[1,2] Most population studies on asthma have focused on the role of asthma biology (i.e., predisposition to developing asthma), the hygiene hypothesis (weakened immune defense in countries with higher rates of sanitation problems), and environmental hazards (pollutants both inside and outside the household, including air quality and smoking) in asthma morbidity. However, a small number of studies in the United States and other countries have indicated racial/ethnic and socioeconomic gradients for asthma outcomes among adults and children.[3] Studies have identified racial/ethnic minorities as being at greater risk for morbidity,[4–9] although the direction of these patterns has been disputed by others.[10–13]

Studies on racial/ethnic disparities have explained the differences in asthma prevalence through 3 interconnected pathways. First, racial/ethnic differences in income and living standards may explain patterning of exposure to environmental hazards both inside and outside the household.[2,9,14,15] Living conditions within the household (quality of household, dust, and poor pest control) and exposure to air pollution (distance from highways or living in dense areas) may explain racial gradients in asthma to some extent.[2,3,9,11,14–17] Second, racial/ethnic differences in asthma may also be attributed to the patterns of stress (from material deprivation or sociocultural discrimination) that affect immune and allergic responses.[3,18–20] Evidence on this so far has been limited to a couple of critical time windows (pregnancy and postpregnancy), which may have a greater bearing on asthma risks.[20] Third, racial/ethnic disparities in access to regular health care may be another factor, affecting the development, continuation, and worsening of the asthma burden.[10,21,22]

Although there is limited understanding of the racial/ethnic disparities in asthma outcomes, a major gap in the current research pertains to the knowledge of time trends in these disparities. Two studies, conducted before 2005, provided some information on changing patterns; both studies examined the changing gradients of hospitalizations and emergency department visits.[6,23] These study authors, Gupta et al.[6] and Ginde et al.,[23] found widening Black–White differences in asthma exacerbations that led to hospitalizations. No other studies have examined asthma prevalence differences between racial/ethnic groups and disparities over time. Furthermore, although some researchers have claimed a "protective Hispanic effect,"[24–27] others have highlighted greater morbidity among specific ethnicities.[7,22,28–31] It is less established if this protective effect does exist and whether it extends to all major Hispanic ethnicities.

We examined the racial/ethnic gradients and time trends in asthma lifetime and current prevalence in the United States by comparing non-Hispanic White, non-Hispanic Black, and Hispanic populations between 1999 and 2011. In addition, we assessed whether racial/ethnic differences over time persisted after accounting for socioeconomic status (SES) and the heterogeneity in asthma by major Hispanic ethnicities.

METHODS

We analyzed data from the Behavioral Risk Factor Surveillance System (BRFSS) surveys collected between 1999 and 2011.[32] BRFSS is a nationally representative annual health survey made available for use by the Centers for Disease Control and Prevention. Surveys were

conducted via telephone interviews (nearly 350 000 in 2010) and provided data on health risk behaviors and preventive health practices across the United States. BRFSS is a useful source for examining the progress of health policies and tracking public health programs. Response rates for BRFSS were conservative, ranging between 40% and 80%, but these rates were expected because of the size of the survey. In addition, variation was noted in response rates by the completeness of interviews; for example, the response rate for the completed interview index was 55.6%, whereas that for the Council for American Survey Research Organization measure, which accounted for partial completion of interviews, was 82.6%. Response rates for surveys also varied by state, year, and percentage of residents with telephones. For example, nearly 87% of the residents in Mississippi had access to telephones, whereas in Massachusetts, this was estimated to be 98%.

Study Population and Outcomes

The total pooled sample across the years comprised 4 303 036 adult respondents. Missing values on asthma prevalence and socioeconomic covariates were excluded, with the final analyses restricted to the 3 main racial/ethnic groups of interest (non-Hispanic Whites, non-Hispanic Blacks, and Hispanics). The final sample size for analysis included 3 860 219 adults across the 50 US states and the District of Columbia over 12 years (male = 38.39%, female = 61.61%).

Outcomes of interest in our analysis included lifetime and current asthma prevalence. Lifetime asthma prevalence was defined by self-reported, physician-diagnosed prevalence of asthma: "(Ever told) by a doctor, nurse or other health professional that you had asthma?" with responses coded as yes or no. Current asthma prevalence was assessed among those who reported physician-diagnosed asthma. Asthma prevalence data were available in the surveys from 1999 onward, with further details on morbidity available for subsamples from 2003 onward. Systematic measures for outcome reliability and validity were unavailable. One published account reported moderate sensitivity rates of 68% (48%–100%) and high specificity rates of 94% (78%–100%) for self-reported asthma, with higher specificity (99%) for physician-diagnosed asthma.[33] A study in China, which used a modified version of the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire, found moderate to high 2-week test–retest reliability with a Cronbach α of 0.82 and κ of 0.81.[34] However, a Danish study that used national registries found self-reports of asthma were underestimated compared with prescription registries.[35]

Main Predictor and Covariates

The main predictor variable in the analysis was self-reported race, categorized as non-Hispanic White, non-Hispanic Black, and Hispanic. BRFSS does not provide data on specific respondent ethnicity or country of birth. Socioeconomic and demographic characteristic covariates in the analysis included SES (measured as household income and respondent education), access to insurance, age, gender, survey year, state, and region of residence.

Household income (current) was categorized as less than $15 000, $15 000 to $35 000, $35 000 to $50 000, $50 000 to $75 000, greater than $75 000, and not reported or refused to answer. Education categories included less than high school, finished high school, some college, and college or more. Access to any kind of health insurance or plan was assessed as yes or no. Region of residence was classified using census criteria (Northeast, Midwest, South, West and other).

Statistical Analysis

Descriptive differences. We estimated asthma lifetime and current prevalence along with 95% confidence intervals (CIs) for each survey year. We conducted bivariate analyses of asthma prevalence outcomes with the main predictor and other covariates. We estimated analytical and graphical comparisons of relative differences (prevalence ratios) and absolute differences (prevalence differences) comparing non-Hispanic Blacks and non-Hispanic Whites, non-Hispanic Blacks and Hispanics, and Hispanics and non-Hispanic Whites.

Regression models. We used state-fixed effects logistic models and 2-level random effects models to examine the relationship between race/ethnicity and log odds of asthma prevalence. We compared unadjusted and SES-adjusted, state-fixed effects models with unadjusted and SES-adjusted, 2-level (individuals nested in states) random effects models with region dummies. We used Poisson models with robust variance estimating prevalence ratios to check for overestimations in the logistic models. To examine the time trends, we estimated interaction parameters for non-Hispanic Blacks versus non–non-Hispanic Blacks and Hispanics versus non-Hispanics with time from random effects models, unadjusted and adjusted for SES.

Hispanic heterogeneity. We assessed Hispanic heterogeneity in a subsample of respondents (n = 249 223) who reported as Hispanic in the race/ethnicity questions. We used data from the US Census 2010[36] and the Pew Hispanic Center[37] to create a categorical variable "zone" for the largest Hispanic ethnicity in the state of residence. Four zones were created: Zone 1 (states in which the largest Hispanic ethnicity was Mexican, Guatemalan, Salvadorian, and other Hispanic ethnicities): Arizona, California, Colorado, Illinois, Maryland, Nevada, New Mexico, and Texas; Zone 2 (in which the largest Hispanic ethnicity was Puerto Rican and Dominican Republican): Connecticut, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island; Zone 3 (states in which the largest Hispanic ethnicity was Cuban): Florida; and other states (Tables A and B, available as supplements to the online version of this article at http://www.ajph.org). Multilevel models estimated the unadjusted and SES-adjusted log odds of asthma lifetime and current prevalence by zones of residence. To assess time trends, we estimated multilevel models that examined Hispanic heterogeneity by zone for 3 time points (1999–2001, 2004–2006, and 2009–2011). All models were implemented in Stata version 12 (StataCorp, College Station, TX).

RESULTS

The final study sample (3 860 219 adult respondents) showed an overall lifetime asthma prevalence rate of 12.54% (95% CI = 12.51, 12.58) and a current asthma prevalence rate of 8.54% (95% CI = 8.51, 8.57; Table C, available as a supplement to the online version of this article at http://www.ajph.org). Increases in lifetime asthma prevalence were noted between 1999 and 2011 from 10.95% (95% CI = 10.67, 11.24) to 12.66% (95% CI = 12.62, 12.81; Table C and Figure A,

available as supplements to the online version of this article at http://www.ajph.org). Gradual but smaller increases were also noted in current asthma prevalence rates from 7.15% (95% CI = 6.92, 7.38) to 8.83% (95% CI = 8.75, 8.91). Women reported higher rates of lifetime asthma (14.1%) compared with 10.17% among men; the same was seen for current asthma (10.08% among women vs 6.03% among men; Table D, available as a supplement to the online version of this article at http://www.ajph.org).

Non-Hispanic Black populations reported higher lifetime asthma prevalence (14.09%) compared with non-Hispanic White (12.41%) and Hispanic (12.92%) populations (Table E, available as a supplement to the online version of this article at http://www.ajph.org). Patterns were similar for current asthma prevalence, with higher rates among non-Hispanic Black populations (9.77%) compared with 8.46% among non-Hispanic White and 7.90% among Hispanic populations (Table D). Relative differences in asthma prevalence comparing non-Hispanic Black and non-Hispanic White populations showed sharper rising patterns for lifetime compared with current asthma prevalence (Table A and Figure B, available as supplements to the online version of this article at http://www.ajph.org). Higher rates of lifetime asthma prevalence among Hispanic populations, especially before 2003 relative to non-Hispanic Black populations implied a low non-Hispanic Black–Hispanic relative ratio in the early years, with a high and increasing non-Hispanic Black–Hispanic relative ratio after 2003. Absolute differences across groups showed higher Hispanic or non-Hispanic Black differences up to 2003, which reversed with high and increasing lifetime and current asthma prevalence rates among non-Hispanic Black populations (Figure B).

Regression Results for Disparities and Racial/Ethnic Time Trends

Pooled 2-level logistic regression models showed higher unadjusted log odds of asthma prevalence for non-Hispanic Black populations (odds ratio [OR] = 1.15; 95% CI = 1.14, 1.16) and lower log odds for Hispanic populations (OR = 0.86; 95% CI = 0.85, 0.88; Table 1). Adjusting for SES and health insurance reduced the non-Hispanic Black and non-Hispanic Black disparities by nearly 80% (adjusted odds ratio [AOR] = 1.035; 95% CI = 1.02, 1.05). However, adjusting for SES and health insurance increased the protective Hispanic effect and consequently the Hispanic–non-Hispanic White disparity (AOR = 0.76; 95% CI = 0.74, 0.77). Similar patterns were seen for current asthma prevalence (unadjusted ORs for non-Hispanic Black populations = 1.21; 95% CI = 1.19, 1.22, and unadjusted ORs for Hispanic OR = 0.86; 95% CI = 0.85, 0.88). Adjusting for income, education, and access to insurance reduced the non-Hispanic Black–White differential by 90% (AOR = 1.036; 95% CI = 1.02, 1.05) and increased the protective Hispanic effect (AOR = 0.7; 95% CI = 0.69, 0.71). Results were similar for both the fixed and random effects logistic models for both outcomes, and as well as for comparison of Poisson fixed-effects models.

Interaction parameters between race and survey year showed changing trends in asthma disparities between 1999 and 2011 for non-Hispanic Black populations; trends were not statistically significant for Hispanic populations (Table 2). Time trends rose for differences between non-Hispanic Black and non–non-Hispanic Black–Hispanic comparisons (unadjusted b = 0.0078; 95% CI = 0.0043, 0.0106), showing increasing Black–non-Black differences in lifetime asthma prevalence over time (Figure C, available as a supplement to the online version of this article at http://www.ajph.org). Time trends for Hispanic–non-Hispanic differences remained unchanged (unadjusted b = 0.0032; 95% CI = –0.0005, 0.007), showing no change in the disparities over time (Table 2; Figure C, available as a supplement to the online version of this article at http://www.ajph.org).

Hispanic Heterogeneity

Analyses by zone of residence showed greater risks of current and lifetime asthma prevalence among Hispanic populations living in states with a majority of Puerto Ricans and Dominican Republicans (Zone 2; Table 3). Hispanics in states with a majority of Puerto Ricans showed greater log odds of lifetime asthma (OR = 1.55; 95% CI = 1.24, 1.93) and current asthma (OR = 1.61; 95% CI = 1.26, 2.05) prevalence compared with Hispanic populations residing in other states. Hispanics in states with a majority of Mexicans reported lower log odds of asthma lifetime (OR = 0.86; 95% CI = 0.72, 1.01) and current prevalence (OR = 0.84; 95% CI = 0.7, 1.009). Trends over 3 time periods (1999–2001, 2004–2006, and 2009–2011) showed increases in ORs of lifetime asthma prevalence among Hispanics residing in Zone 2 from 1.31 (95% CI = 1.05, 1.63) in 1999 to 2001 to 1.62 (95% CI = 1.26, 2.07) in 2004 to 2005 and 1.65 (95% CI = 1.31, 2.08) in 2009 to 2011 (Table 4; Figure D, available as a supplement to the online version of this article at http://www.ajph.org). Trends over time also showed an increase in ORs of lifetime asthma among Hispanics in Zone 1 (Mexican majority states) from 0.8 (95% CI = 0.67, 0.96) in 1999 to 2001 to 0.92 (95% CI = 0.77, 1.09) in 2009 to 2011.

DISCUSSION

Four salient findings emerged from our study. First, we confirmed previously reported patterns of racial disparities, with evidence for higher risks of asthma prevalence among non-Hispanic Black populations and lower risks for Hispanics consistently between 1999 and 2011. Second, we found evidence for increasing Black–White disparities in asthma prevalence over time, along with consistent Hispanic–White differences. Third, regional variations in asthma prevalence among Hispanic populations showed heterogeneity. Hispanics living in states with large Puerto Rican and Dominican Republican populations reported higher asthma rates compared with Hispanics in other states. Finally, SES explained a majority of the Black–White differences in asthma prevalence, but the protective effect of being Hispanic increased after adjusting for SES.

Although racial/ethnic disparities in asthma outcomes were previously investigated to some degree, the reasons for these disparities were underresearched. The hygiene hypothesis,[38] which proposed positive relationships between SES and asthma, did not explain racial/ethnic differences. Three more plausible explanations were explored, including the role of health care, SES, and environmental factors. Unequal health coverage over the life course might play some role in explaining

TABLE 1—Pooled Analyses for Asthma Lifetime and Current Prevalence by Race/Ethnicity and Other Covariates: Behavioral Risk Factor Surveillance System, United States, 1999–2011

Variables	State Fixed Effects Models		Two-Level Logistic Models With Region Dummies	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
		Lifetime prevalence		
Race/ethnicity				
Non-Hispanic White (Ref)	1.00	1.00	1.00	1.00
Non-Hispanic Black	1.15* (1.14, 1.16)	1.035* (1.02, 1.05)	1.16* (1.14, 1.17)	1.038* (1.027, 1.04)
Hispanic	0.86* (0.85, 0.88)	0.76* (0.74, 0.77)	0.86* (0.85, 0.87)	0.75* (0.74, 0.76)
Income, $				
< 15 000 (Ref)		1.00		1.00
15 000–35 000		0.698* (0.69, 0.70)		0.69* (0.68, 0.70)
35 000–50 000		0.58* (0.58, 0.59)		0.58* (0.57, 0.59)
50 000–75 000		0.55* (0.54, 0.56)		0.545* (0.54, 0.55)
> 75 000		0.51* (0.51, 0.52)		0.51* (0.50, 0.515)
Don't know or refused		0.62* (0.61, 0.63)		0.61* (0.6, 0.62)
Education				
< high school (Ref)		1.00		1.00
Completed high school		0.766* (0.757, 0.77)		0.76* (0.75, 0.77)
Some college or technical		0.877* (0.864, 0.886)		0.87* (0.86, 0.88)
≥ college graduate		0.83* (0.82, 0.84)		0.82* (0.81, 0.83)
No health insurance		0.83* (0.82, 0.84)		0.83* (0.82, 0.84)
Region				
Northeast (Ref)			1.00	1.00
Mid-West			0.81* (0.75, 0.88)	0.80 (0.74, 0.87)
South			0.86* (0.80, 0.93)	0.84 (0.78, 0.91)
West			0.98 (0.91, 1.06)	0.98 (0.9, 1.06)
Random effects state SE			0.089 (0.0089)	0.0933 (0.0094)
ICC			0.0024 (0.0005)	0.0026 (0.0005)
		Current prevalence		
Race/ethnicity				
Non-Hispanic White (Ref)	1.00	1.00	1.00	1.00
Non-Hispanic Black	1.21* (1.19, 1.22)	1.036* (1.02, 1.05)	1.21* (1.198, 1.23)	1.038* (1.02, 1.052)
Hispanic	0.86* (0.85, 0.88)	0.7* (0.69, 0.71)	0.86* (0.84, 0.87)	0.69* (0.68, 0.71)
Income, $				
< 15 000 (Ref)		1.00		1.00
15 000–35 000		0.65* (0.64, 0.66)		0.64* (0.63, 0.65)
35 000–50 000		0.51* (0.50, 0.52)		0.51* (0.5, 0.52)
50 000–75 000		0.47* (0.46, 0.49)		0.47* (0.46, 0.48)
> 75 000		0.43* (0.42, 0.44)		0.43* (0.42, 0.44)
Don't know or refused		0.55* (0.54, 0.56)		0.55* (0.54, 0.56)
Education				
< high school (Ref)		1.00		1.00
Completed high school		0.71* (0.7, 0.72)		0.7* (0.69, 0.71)
Some college or technical		0.78* (0.77, 0.79)		0.77* (0.76, 0.78)
≥ college graduate		0.72* (0.71, 0.73)		0.71* (0.7, 0.72)

Continued

TABLE 1—*Continued*

No health insurance	0.78* (0.77, 0.79)		0.77* (0.76, 0.78)
Region			
Northeast (Ref)		1.00	1.00
Mid-West		0.83 (0.76, 0.90)	0.81 (0.75, 0.88)
South		0.82 (0.76, 0.89)	0.79 (0.72, 0.88)
West		0.92 (0.85, 0.99)	0.92 (0.85, 1.004)
Random effects state		0.0968 (0.009812)	0.0965 (0.0097)
ICC		0.0028 (0.0006)	0.0028 (0.0005)

Note. CI = confidence interval; ICC = intraclass correlation coefficient; OR = odds ratio. Models with State Fixed Effects: Unadjusted models control for age, gender, survey year and state fixed effects, and adjusted models in addition include income, education and insurance. Two level logistic models with region dummies: Unadjusted models control for age, gender, survey year and region, while adjusted models in addition control for income, education and insurance. Analysis from 50 US states and District of Columbia.
*P = <.05.

racial differences in asthma morbidity, particularly for current asthma or for treatments. However, sensitivity analyses from this sample showed that 18.15% and 26.27% of the non-Hispanic Black and Hispanic populations, respectively, reported lack of access to any health coverage compared with 9.38% of the non-Hispanic White population, which highlighted the potential role health care might play as determinants of asthma or in the reporting of physician-diagnosed asthma. However, it was unclear what role health care played in asthma development or in its lifetime prevalence.

The role of environmental risk factors, with and without the role of SES, might be less contentious. SES (patterned by race) might influence asthma through multiple mechanisms, including exposure to environmental determinants (poor housing, exposure to pollutants, and other within-household factors).[14,39] In this sample, 18.64% of the non-Hispanic Black and 22.54% of the Hispanic populations reported income less than $15 000 compared with only 8.25% of the non-Hispanic White population. Moreover, increasing Black–White differences in both current and lifetime asthma trends might be attributed to increasing inequalities in SES at multiple levels. Our analysis was unable to model socioecological exposures such as neighborhood poverty and residential segregation, which might explain the relationships with race and SES at higher levels.[3,40,41] The role of SES in explaining Hispanic heterogeneity was also less clear. Although Hispanic–White differences remained unchanged over time, the between zone differences highlighted potential clustering of asthma risks among certain regional zones and ethnic groups (Puerto Rican and Dominican Republican). It was not possible to disentangle the zone versus ethnicity effects, which need greater examination in future analyses.

We found evidence that the overall rates of asthma prevalence steadily increased in the last decade. This resonated to an extent with 2 previous analyses on asthma morbidity. Trends from emergency department visits between 1993 and 2005 showed plateauing of rates for all population groups, with racial differences persisting over time.[23] Hospitalization rates from asthma among adults (aged 19–34 years) were seen to decline between 1979 and 2002, with sharper falls for Black compared with White populations.[6] Because no recent studies on hospitalization and emergency department visits have been conducted since 2005, research on racial disparities comparing multiple asthma morbidity outcomes is needed to understand the implications of its increasing prevalence on diverse measures of morbidity.

Three policy areas related to racial disparities in asthma research merit examination. First, research is needed to understand the role and effectiveness of environmental regulations (e.g., smoking bans, the Clean Air Act, and Toxic Chemical Regulations), particularly in poor and high-minority areas.[2,3,15] Second, urban development and planning processes, particularly residential patterns of minorities in congested inner-city neighborhoods provide another relevant area for examination for asthma disparities.[40,41] Finally, new research has shown the linkages between asthma and

TABLE 2—Multilevel Models for Trend in Lifetime Asthma Prevalence: Behavioral Risk Factor Surveillance System, United States, 1999–2011

	Lifetime Prevalence		Lifetime Prevalence	
Variables	Unadjusted b (SE)	Adjusted b (SE)	Unadjusted b (SE)	Adjusted b (SE)
Race				
NHB–non-NHB	0.0993* (0.01368)	0.0245 (0.0137)		
Hispanic–Non-Hispanic			-0.1896* (0.0162)	-0.2923* (0.016)
NHB–non-NHB × Time	0.0078* (0.0016)	0.0055* (0.0016)		
Hispanic-Non-Hispanic × Time			0.0032 (0.0019)	-0.0003 (0.0019)
RE State SE	0.087 (0.0088)	0.089 (0.009)	0.089 (0.0091)	0.093 (0.0094)
ICC	0.0023 (0.0004)	0.0024 (0.0004)	0.0024 (0.0004)	0.0027 (0.0005)

Note. ICC = intraclass correlation coefficient; NHB = Non-Hispanic Black; RE = random effects; SE = standard errors. Analysis from individuals in 50 US states and the District of Columbia. Unadjusted models control for age, gender. Adjusted models control for age, gender, region, income, education and insurance.
*P = <.05.

TABLE 3—Heterogeneity in Lifetime and Current Asthma Prevalence by Ethnic Majority Zones for the Hispanic Subsample: Behavioral Risk Factor Surveillance System, United States, 1999–2011

Zone	Asthma Lifetime Prevalence		Asthma Current Prevalence	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Other states (Ref)	1.00	1.00	1.00	1.00
Zone 1	0.86 (0.72, 1.01)	0.86 (0.74, 1.005)	0.84 (0.7, 1.009)	0.83* (0.7, 0.99)
Zone 2	1.55* (1.24, 1.93)	1.55* (1.27, 1.59)	1.61* (1.26, 2.05)	1.59* (1.26, 2.02)
Zone 3	0.99 (0.62, 1.58)	0.98 (0.64, 1.51)	0.84 (0.50, 1.40)	0.83 (0.50, 1.36)

Note. CI = confidence interval; OR = odds ratio. Unadjusted models control for age, gender, and survey year. Adjusted models control for age, gender, survey year, and socioeconomic status. Zone 1: Mexican majority zone (including majority Mexican, Guatemalan, Salvadorian, and other Hispanics population). Zone 2: Puerto Rican majority zone (majority Puerto Rican and Dominican Republican populations). Zone 3: Cuban majority states (Florida). Baseline = Hispanics in other states. The sample size was n = 249 223.
*P = <.05.

obesity, and this research needs to amalgamate racial/ethnic disparities in investigating the potential joint burden of morbidity.[7]

Our study, which focused on understanding patterns in the prevalence of asthma, used nationally representative annual estimates across the United States over 12 years from the BRFSS. These estimates provided the most comprehensive assessment of prevalence for the United States in scale (large sample size), scope (measuring prevalence using physician-diagnosed and self-reported asthma used in population-based studies), and representation (measuring overall prevalence and by major race/ethnicity consistently across all of the US states), although smaller studies provided data for asthma hospitalizations and exacerbations. In addition to reliable measurement of asthma prevalence over time, the BRFSS also provided consistent information on major covariates, which was useful for robust testing of trends.

Study Limitations

Our findings from this study need to be interpreted in light of 3 limitations. First, although the BRFSS provided comprehensive assessments, survey implementation differences across states might lead to some differences in participation (e.g., sample identification, refusal) and completeness of interviews, which could potentially lead to selection and response bias. It was not possible to address these limitations, if they arose, in our analysis. Operational research on training and implementation might be needed to understand the potential effects of these challenges. Second, self-reported asthma prevalence was criticized for its lower outcome validity, especially compared with hospital registry data and other asthma studies, like the ISAAC.[34,42] In the ISAAC study, respondents were shown videos to validate reported symptoms. This, however, could not be incorporated into surveys like the BRFSS, which was conducted through telephone interviews. This concern might be mitigated to some extent and validity strengthened through the inclusion of the phrase "diagnosis by a doctor, nurse or other health professional." Finally, BRFSS did not collect data on country of origin or migration history. Hence, stratifying Hispanic populations into specific ethnicities to examine within-group heterogeneity in asthma prevalence was not possible. In the absence of these data, we assessed Hispanic heterogeneity through an interaction between ethnicity and states, which was an innovative approach based on empirical data regarding the largest Hispanic ethnic group residing in a state to construct Hispanic zones of residence.

Conclusions

Asthma prevalence rates and racial disparities in the United States have increased over the last decade. Minorities (non-Hispanic Black and Hispanic populations) reported diverging risks of asthma prevalence. Our study noted further variability in the risks among Hispanic populations by country of origin and state of residence. Asthma prevention and treatment research and policies need to

TABLE 4—Time Trends for Asthma Lifetime and Current Prevalence Within the Hispanic Subsample by Majority-Ethnicity Zones in Three Time Periods (1999–2001, 2004–2006, and 2009–2011): Behavioral Risk Factor Surveillance System, United States, 1999–2011

Zone	1999–2001 (n = 26 704)		2004–2006 (n = 60 501)		2009–2011 (n = 84 201)	
	Lifetime Prevalence, OR (95% CI)	Current Prevalence, OR (95% CI)	Lifetime Prevalence, OR (95% CI)	Current Prevalence, OR (95% CI)	Lifetime Prevalence, OR (95% CI)	Current Prevalence, OR (95% CI)
Other states (Ref)	1.00	1.00	1.00	1.00	1.00	1.00
Zone 1	0.80* (0.67, 0.96)	0.76* (0.62, 0.92)	0.86 (0.71, 1.04)	0.83 (0.67, 1.02)	0.92 (0.77, 1.09)	0.94 (0.76, 1.15)
Zone 2	1.31* (1.05, 1.63)	1.33* (1.05, 1.68)	1.62* (1.26, 2.07)	1.68* (1.28, 2.21)	1.65* (1.31, 2.08)	1.76* (1.34, 2.29)
Zone 3	1.03 (0.67, 1.58)	0.82 (0.52, 1.31)	1.05 (0.63, 1.75)	0.84 (0.48, 1.48)	1.105 (0.68, 1.79)	1.03 (0.59, 1.79)

Note. CI = confidence interval; OR = odds ratio. Unadjusted models control for age, gender, and survey year. Adjusted models control for age, gender, survey year, and socioeconomic status. Zone1: Mexican majority zone (including majority Mexican, Guatemalan, Salvadorian, and other Hispanics population). Zone 2: Puerto Rican majority zone (majority Puerto Rican and Dominican Republican populations). Zone 3: Cuban majority states (Florida). Baseline = Hispanics in other states.
*P = <.05.

recognize these racial disparities, and investigate their determinants. ■

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This article was accepted June 25, 2014.

Contributors

N. Bhan, I. Kawachi, M. M. Glymour and S. V. Subramanian jointly conceptualized the study. N. Bhan led the data analysis, interpretation, and writing of the article. I. Kawachi, M. M. Glymour, and S. V. Subramanian contributed to the interpretation and writing of the article and provided overall supervision.

Acknowledgments

At the time of research, N. Bhan was a doctoral student at the Harvard School of Public Health and received the Presidential Scholarship at Harvard University (2009–2013). No direct funding was available for this study. S. V. Subramanian is supported by the Robert Wood Johnson Investigator Award in Health Policy Research and was partially supported by the National Institutes of Health Career Development Award (NHLBI K25 HL081275) when the study was conducted.

Human Participant Protection

Human participant protection was not required because the study was a secondary analysis of de-identified, publicly available data.

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