PREVENTING CHRONIC DISEASE

PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY

PCD Collection: The Behavioral Risk Factor Surveillance System (BRFSS)

Throughout the world, public health workers conduct research and implement programs and policies to improve the health and well-being of communities. Public health professionals have different backgrounds and areas of expertise that are all important to the success of this effort. In addition to traditional public health workers, community members and professionals from other sectors are often engaged in improving public health. The goal of public health professionals and their engagement with partners and stakeholders is to reduce disease and premature death and to help all people achieve optimal health. *Preventing Chronic Disease: Public Health Research, Practice, and Policy* (*PCD*) recognizes the importance of bringing the experience and perspective of diverse public health professionals together to examine and improve health.

Successful interventions, programs, and policies must be followed by publication to achieve their full public health impact. Publication is necessary to share successes and challenges and facilitates widespread implementation and adoption to multiple settings. *PCD* is dedicated to reporting practical scientific research, programs, and policy efforts to improve the health of communities. Our articles advance current knowledge and contribute to the welfare of people beyond the interventions they describe. Advances in technology have helped to turn this knowledge sharing into a fast-paced, dynamic, and global collaboration. We hope this collection of previously published research informs and inspires all readers — researchers and community members, practitioners and patients, experts and novices — to implement science-based interventions with community-based preferences that improve the health of all populations. We encourage you to share your work by publishing in *PCD.*

Samuel F. Posner, PhD
Editor in Chief
Preventing Chronic Disease

About this Collection

Each manuscript in this collection incorporates data from The Behavioral Risk Factor Surveillance System (BRFSS). BRFSS is a state-based system of health surveys that collects information on health risk behaviors, preventive health practices, and health care access primarily related to chronic disease and injury. For many states, the BRFSS is the only available source of timely, accurate data on health-related behaviors.

BRFSS was established in 1984 by the Centers for Disease Control and Prevention (CDC); currently data are collected monthly in all 50 states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and Guam. More than 350,000 adults are interviewed each year, making the BRFSS the largest telephone health survey in the world. States use BRFSS data to identify emerging health problems, establish and track health objectives, and develop and evaluate public health policies and programs. Many states also use BRFSS data to support health-related legislative efforts.

Preventing Chronic Disease

Preventing Chronic Disease (*PCD*) is a peer-reviewed electronic journal established to provide a forum for public health researchers and practitioners to share study results and practical experience. The journal is published by the National Center for Chronic Disease Prevention and Health Promotion.

The mission of the journal is to address the interface between applied prevention research and public health practice in chronic disease prevention. *PCD* focuses on preventing diseases such as cancer, heart disease, diabetes, and stroke, which are among the leading causes of death and disability in the United States. For more details, visit www.cdc.gov/pcd.

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ORIGINAL RESEARCH

Workers' Health Risk Behaviors by State, Demographic Characteristics, and Health Insurance Status

Yi Huang, MD; Peggy A. Hannon, PhD, MPH; Barbara Williams, PhD; Jeffrey R. Harris, MD, MPH, MBA

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PEER REVIEWED

Abstract

Introduction
Employers often lack data about their workers' health risk behaviors. We analyzed state-level prevalence data among workers for 4 common health risk behaviors: obesity, physical inactivity, smoking, and missed influenza vaccination (among workers older than 50 years).

Methods
We analyzed 2007 and 2008 Behavioral Risk Factor Surveillance System data, restricting the sample to employed respondents aged 18 to 64 years. We stratified health risk behavior prevalence by annual household income, educational attainment, health insurance status, and race/ethnicity.

Results
For all 4 health risk behaviors, we found significant differences across states and significant disparities related to social determinants of health — income, education, and race/ethnicity. Among uninsured workers, prevalence of smoking was high and influenza vaccinations were lacking.

Conclusion
In this national survey study, we found that workers' health risk behaviors vary substantially by state and by workers' socioeconomic status, insurance status, and race/ethnicity. Employers and workplace health promotion practitioners can use the prevalence tables presented in this article to inform their workplace health promotion programs.

Introduction

Health risk behaviors are common among workers, are strongly related to chronic illness and death, increase health care costs, and reduce productivity (1). One key to a successful workplace health promotion program is to measure workers' baseline health needs and use the data to inform the program (2,3). However, most employers do not have access to data about their workers' health behaviors. Many midsized and small employers lack the resources to conduct health risk appraisals (HRAs). In addition, employer-run HRAs often have low response rates and overrepresent healthy workers (4).

Readily available data about risk behaviors could help employers plan and evaluate their workplace health promotion programs. Obesity, physical inactivity, and tobacco use are 3 of the most common lifestyle health risk behaviors in the United States (5,6) and cause approximately one-third of all deaths (7). Influenza vaccination is also of interest to employers because influenza leads to lost productivity and can trigger severe pulmonary and cardiovascular diseases. Vaccination reduces the incidence of influenza and can save employers money in a short time frame (1 year or less) (8).

The objective of this study was to provide employers and other workplace health promotion practitioners with state-specific data for these 4 health risk behaviors (obesity, physical inactivity, smoking, and no influenza vaccination [among workers older than 50 years]) among workers. We stratified the behaviors by insurance status and social determinants of health: annual household income, educational attainment, and race/ethnicity. To meet this objective, we show the prevalence of each health risk behavior by state and workers' characteristics, using data from the 2007 and 2008 Behavioral Risk Factor Surveillance System (BRFSS), the most recent data available.

Methods

Design

We conducted a cross-sectional study by using BRFSS data collected in 2007 and 2008. With assistance from the Centers for Disease Control and Prevention (CDC), state health departments conduct BRFSS surveys among US resident civilian, noninstitutionalized adults aged 18 years or older in all 50 states, the District of Columbia, and US territories (9).

Using a multistage cluster design, BRFSS selects state-specific probability samples of households to produce a nationally representative sample (5). After calling a selected home telephone number, the interviewer randomly chooses 1 adult in that household to complete the telephone interview. BRFSS data are weighted by race/ethnicity, age, and sex distributions found in each state, along with the respondent's probability of selection.

Sample

The median cooperation rate, or the proportion of all respondents interviewed from all eligible units in which a respondent was selected and contacted, was 72.1% in 2007 and 75.0% in 2008 (10,11). Our study population included employed adults aged 18 to 64 years in 50 states and the District of Columbia. We considered adults *employed* if they were employed for wages or self-employed. We excluded adults older than 64 years because Medicare is available for most of this group.

Measures

The BRFSS questionnaire has 3 parts: core questions, optional modules, and state-added questions. All states must ask core questions every year or every other year. States may also choose optional modules or add their own questions to meet their specific data needs. Both English- and Spanish-language versions of the survey are provided to each state.

In this article, all data are from the core questions used in every state. The health risk behaviors are lifestyle behaviors (obesity, physical inactivity, and smoking) and no influenza vaccination in the past year. Obesity is defined as having a body mass index of at least 30 kg/m^2 (12). Physical inactivity is defined as not meeting the CDC physical activity guideline of at least 5 days per week for 30 minutes per day of moderate-intensity activity or at least 3 days per week for 20 minutes a day of vigorous-intensity activity (13,14). Tobacco use is defined as ever having smoked at least 100 cigarettes and currently smoking every day or some days. Workers aged 50 to 64 years who reported no influenza vaccination in the past 12 months (either by injection or nasal spray) were defined as not vaccinated. We restricted the influenza vaccination analysis to workers older than age 50 because CDC's Advisory Committee on Immunization Practices recommends influenza vaccination for those adults (15).

We analyzed workers' socioeconomic status (SES), race/ethnicity, health insurance status, and health risk behaviors. The SES measures are annual household income and educational attainment as reported in the BRFSS data. We used 2007 BRFSS data for the physical inactivity measure because these questions were not included in the 2008 survey. We used 2008 data for the rest of the measures.

Analysis

We calculated national and state rates for workers stratified by 1) annual household income (<$35,000, $35,000-$74,999, ≥$75,000), 2) educational attainment (high school graduate or less, some college, college graduate), 3) health insurance (any, none), and 4) race/ethnicity (African American, American Indian/Alaska Native, Asian/Hawaiian/Pacific Islander, Hispanic, and white). We identified the national prevalence of each health risk behavior among workers, the range across states, and the range across states for characteristics associated with the highest risk behavior prevalence nationally.

Our analysis took into account the survey design and weighted sampling probabilities of the data source and was performed by using Stata version 10.0 (StataCorp LP, College Station, Texas). All the statistical tests were 2-sided and significance was set at $P < .05$. We calculated 95% confidence intervals (CIs) for all prevalence rates (versions of the tables with CIs are available from the corresponding author on request). Because of the very small numbers of respondents in some categories, we restricted the prevalence estimates to the categories in which there were 50 or more respondents.

Results

Final sample

There were 430,912 respondents in the 2007 BRFSS, and 414,509 respondents in the 2008 BRFSS. When we restricted our data sample to employed respondents aged 18 to 64 years, 48.3% of the 2007 sample (physical inactivity) and 47.5% of the 2008 sample (obesity, smoking, and influenza vaccination) remained. For each of the analyses described below, we excluded respondents who were missing data for the health risk behavior under study; therefore, the number of subjects varies slightly across the analyses. We further excluded respondents who were missing data for SES, insurance status, or race/ethnicity from all analyses stratified by these characteristics (8.3% in 2007 and 8.0% in 2008 were missing 1 or more of these variables). Thus, of the respondents who met our employment and age criteria, we were able to include more than 85% in our analyses (range: 87.0% for physical activity to 91.8% for smoking).

Obesity

In 2008, 27.0% of employed adults in the United States were obese (Table 1); obesity rates were lowest in Colorado (19.5%) and were highest in West Virginia (34.6%). Nationally, the highest obesity rates were reported by those with annual household incomes less than $35,000 (30.2%), those who did not graduate from college (30.5%), and African Americans (37.3%). Obesity rates among workers with these characteristics varied significantly across states, from 21.8% (95% CI, 18.3%-25.2%) in Colorado to 39.2% (95% CI, 35.0%-43.4%) in Mississippi for low-income workers; from 23.5% (95% CI, 21.0%-26.1%) in Massachusetts to 39.1% (95% CI, 33.1%-45.1%) in Tennessee among workers with a high school education or less; and from 17.9% (95% CI, 6.5%-29.4%) in Nevada to 49.9% (95% CI, 33.3%-66.4%) in Nebraska for African American workers.

Physical inactivity

In 2007, 49.2% of employed adults did not meet physical activity recommendations (Table 2); physical inactivity rates were lowest in Alaska (37.2%) and highest in Louisiana (58.4%). Nationally, the highest physical inactivity rates were reported by workers with household incomes less than $35,000 (54.3%), high school education or less (52.5%), and Asians/Hawaiians/Pacific Islanders (63.1%). Physical inactivity rates for workers with these characteristics varied significantly across states, from 42.5% (95% CI, 37.8%-47.2%) in Montana to 68.7% (95% CI, 63.0%-74.3%) in Tennessee for low-income workers; from 36.1% (95% CI, 29.4%-42.8%) in Alaska to 61.0% (95% CI, 57.0%-65.1%) in Louisiana for workers with a high school education or less; and from 40.1% (95% CI, 22.1%-58.1%) in Pennsylvania to 70.2% (95% CI, 63.3%-77.1%) in California for Asian/Hawaiian/Pacific Islander workers.

Smoking

In 2008, 19.2% of employed adults reported that they currently smoke cigarettes (Table 3); smoking rates were lowest in Utah (9.8%) and highest in Indiana (27.6%). Nationally, the highest smoking rates were reported by workers with household incomes less than $35,000 (28.9%), high school education or less (29.3%), no health insurance (32.5%), and American Indians/Alaska Natives (27.8%). Among workers with these characteristics, smoking rates varied significantly across states, from 15.3% (95% CI, 11.1%-19.5%) in Utah to 45.6% (95% CI, 38.4%-52.8%) in Indiana for low-income workers; from 17.6% (95% CI, 14.2%-21.0%) in Utah to 41.1% (95% CI, 35.7%-46.5%) in Indiana for workers with high school education or less; from 13.8% (95% CI, 9.1%-18.5%) in Utah to 54.9% (95% CI, 45.9%-63.9%) in Indiana for uninsured workers; and from 10.9% (95% CI, 2.3%-19.5%) in Arizona to 53.1% (95% CI, 32.6%-73.5%) in North Dakota for American Indian/Alaska Native workers.

No influenza vaccination

In 2008, 59.3% of workers aged 50 to 64 years reported no influenza vaccination (Table 4); the lowest rate was in South Dakota (47.1%) and the highest was in Nevada

(71.4%). Nationally, workers most likely to report no influenza vaccination had household income less than $35,000 (68.6%), high school education or less (66.3%), no health insurance (77.1%), and were Hispanic (67.1%). Among workers with these characteristics, rates of no influenza vaccination varied significantly across states, from 49.0% in Virginia (95% CI, 36.3%-61.7%) to 83.3% (95% CI, 77.1%-89.4%) in Nevada for low-income workers; from 51.6% (95% CI, 46.6%-56.6%) in South Dakota to 82.0% (95% CI, 75.5%-88.5%) in Nevada for workers with a high school education or less; from 59.5% (95% CI, 47.6%-71.4%) in Iowa to 90.2% (95% CI, 83.3%-97.1%) in Indiana for uninsured workers; and from 50.9% (95% CI, 34.7%-67.0%) in Hawaii to 84.3% (95% CI, 75.0%-93.6%) in Nevada for Hispanic workers.

Discussion

The most effective workplace health promotion efforts are tailored to the risk behaviors and needs of the workers (2,3). However, for many employers, data describing their workers are unavailable or unrepresentative of their workforce (4,16). To address this need, we used BRFSS data, a very large, recent data set of employed adults in the United States, and calculated prevalence for 4 common health risk behaviors stratified by state and by the worker characteristics that employers routinely collect to describe their workforce.

In this national sample of employed adults aged 18 to 64 years, we found significant disparities related to SES and race/ethnicity for all 4 health risk behaviors and significant disparities by insurance status for smoking and influenza vaccination. We also found significant variations in health risk behaviors within and across states. Our findings both replicate and extend our prior study of employed workers' health risk behaviors, which found significant disparities by SES and race/ethnicity among insured workers (6). The findings make state-level data for workers available for the first time, include uninsured workers, and show that disparities are worse for the uninsured for influenza vaccination and tobacco use than for obesity and physical inactivity.

Limitations

Our study and prevalence tables have several limitations. First, BRFSS includes only people who have home telephones and speak either English or Spanish. Second, all of the health risk behaviors are self-reported. These 2 limitations suggest that our results may underreport the prevalence of workers' health risk behaviors. Third, in many states, fewer than 50 members of some racial/ethnic groups were included in the sample, and we were not able to present health risk behavior rates in these cases. In other states, we were able to present health risk behavior rates for every racial/ethnic group, but some of the confidence intervals are wide because of small numbers in these groups. Fourth, our study was cross-sectional; our findings show associations between characteristics and health risk behaviors but not causation.

An important limitation of our study is that the prevalence tables are at the state rather than the local level. As such, they cannot provide employers with as accurate a view of their workers' health risk behaviors as they could achieve by surveying their workers. For many employers, acquiring health behavior data from their own workers is often not feasible. Finally, our findings do not address the time and financial challenges employers face in implementing workplace health promotion programs. However, our findings can serve employers by 1) providing data on the health risks of workers in their state with similar characteristics to those of their own workforce (comparable to the intent of county health-ranking systems that motivate policy makers to take action to improve health risks in their counties [17]) and 2) serving as a planning tool for an individual employer's health promotion efforts.

Conclusion

To our knowledge, this is the first time that state-level BRFSS tables summarizing health risk behaviors of the US *employed* population have been made available. We found significant differences in workers' health behaviors across states and within states, depending on their SES, insurance status, and race/ethnicity. Employers, workplace health promotion professionals, insurers, and vendors can use these tables to inform workplace health promotion planning when data for a given employer's workers are not available.

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Author Information

Corresponding Author: Peggy A. Hannon, PhD, MPH, University of Washington, 1107 NE 45th St, Ste 200, Seattle, WA 98105. Telephone: 206-616-7859. E-mail: peggyh@uw.edu.

Author Affiliations: Yi Huang, Barbara Williams, Jeffrey R. Harris, University of Washington, Seattle, Washington.

References

1. Loeppke R, Taitel M, Richling D, Parry T, Kessler RC, Hymel P, et al. Health and productivity as a business strategy. J Occup Environ Med 2007;49(7):712-21.
2. Goetzel RZ, Ozminkowski RJ. The health and cost benefits of work site health-promotion programs. Annu Rev Public Health 2008;29:303-23.
3. Sparling PB. Worksite health promotion: principles, resources, and challenges. Prev Chronic Dis 2010;7(1). http://www.cdc.gov/pcd/issues/2010/jan/09_0048.htm. Accessed February 4, 2010.
4. Wang PS, Beck AL, McKenas DK, Meneades LM, Pronk NP, Saylor JS, et al. Effects of efforts to increase response rates on a workplace chronic condition screening survey. Med Care 2002;40(9):752-60.
5. BRFSS: Behavioral Risk Factor Surveillance System: Survey data overview 2008. Centers for Disease Control and Prevention. http://www.cdc.gov/brfss/technical_infodata/surveydata/2008.htm. Accessed January 10, 2010.
6. Hughes MC, Hannon PA, Harris JR, Patrick DL. Socioeconomic disparities in health behaviors of insured workers. Am J Health Promot 2010;24(5):315-23.
7. Mokdad AH, Marks JS, Stroup DF, Gerberding JL. Actual causes of death in the United States, 2000. [Errata appear in JAMA 2005;293(3):293-4 and in JAMA 2005;293(3):298.] JAMA 2004;291(10):1238-45.
8. Maciosek MV, Coffield AB, Edwards NM, Flottemesch TJ, Goodman MJ, Solberg LI. Priorities among effective clinical preventive services: results of a systematic review and analysis. Am J Prev Med 2006;31(1):52-61.
9. BRFSS: Behavioral Risk Factor Surveillance System: frequently asked questions 2009. Centers for Disease Control and Prevention. http://www.cdc.gov/brfss/faqs.htm#1. Accessed September 9, 2010.
10. BRFSS: Behavioral Risk Factor Surveillance System: summary data quality report 2007. Centers for Disease Control and Prevention. ftp://ftp.cdc.gov/pub/Data/Brfss/2007SummaryDataQualityReport.pdf. Accessed September 9, 2010.
11. BRFSS: Behavioral Risk Factor Surveillance System: summary data quality report 2008. Centers for Disease Control and Prevention. ftp://ftp.cdc.gov/pub/Data/Brfss/2008_Summary_Data_Quality_Report.pdf. Accessed September 9, 2010.
12. Defining overweight and obesity. Centers for Disease Control and Prevention. 2009. http://www.cdc.gov/obesity/defining.html. Accessed August 25, 2009.
13. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 2007;39(8):1423-34.
14. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995;273(5):402-7.
15. Centers for Disease Control and Prevention. Recommended adult immunization schedule — United States, 2009. Morb Mortal Wkly Rep 2009;57(53):Q1-4.
16. McLellan RK, Mackenzie TA, Tilton PA, Dietrich AJ, Comi RJ, Feng YY. Impact of workplace sociocultural attributes on participation in health assessments. J Occup Environ Med 2009;51(7):797-803.
17. University of Wisconsin Population Health Institute. Wisconsin County health rankings. 2010. http://uwphi.pophealth.wisc.edu/pha/wchr.htm. Accessed March 28, 2010.

Tables

Table 1. Prevalence of Obesity[a] by State Among Workers Aged 18 to 64 Years, 2008 Behavioral Risk Factor Surveillance System (BRFSS)

		Prevalence of Obesity[b], %													
			Annual Household Income, $			Educational Attainment			Health Insurance Status		Race/Ethnicity				
State	No. of Respondents[c]	Overall	<35,000	35,000-74,999	≥75,000	High School Graduate or Less	Some College	College Graduate	Any	None	White	African American	Asian/Hawaiian/Pacific Islander	American Indian/Alaska Native	Hispanic
Alabama	2,561	32.3	37.2	36.4	26.7	35.0	35.9	26.7	32.9	29.4	30.3	39.1	–	–	–
Alaska	1,631	25.3	25.2	25.7	26.5	26.9	28.6	20.4	27.5	15.8	25.8	–	–	34.0	9.4
Arizona	2,214	25.7	26.2	32.1	23.2	29.6	24.8	23.1	25.3	27.5	22.7	–	–	49.5	31.5
Arkansas	2,369	30.8	34.1	33.9	25.9	33.7	31.0	27.3	31.1	30.1	30.4	37.0	–	–	30.8
California	5,258	24.5	27.5	26.5	21.3	28.9	27.0	18.5	24.1	26.5	23.2	33.3	7.5	–	29.3
Colorado	5,946	19.5	21.8	20.0	18.2	23.7	22.4	15.1	19.3	20.6	18.2	27.6	5.7	–	25.4
Connecticut	2,884	20.6	24.3	22.2	19.6	24.7	22.8	17.5	20.6	19.4	19.8	30.2	9.7	–	28.9
Delaware	1,934	29.0	36.4	32.0	24.8	33.4	34.8	22.7	28.2	39.0	25.7	47.6	–	–	46.8
District of Columbia	2,170	20.9	28.4	26.8	15.9	32.3	36.9	14.1	20.5	26.1	9.6	34.4	–	–	19.9
Florida	4,353	25.0	30.3	23.7	24.8	32.4	25.8	18.4	25.1	24.1	23.5	33.2	–	–	28.3
Georgia	2,650	27.6	32.3	28.6	24.8	32.0	34.7	20.6	27.4	29.1	24.2	39.1	–	–	27.5
Hawaii	3,466	23.2	25.0	23.9	21.6	27.4	25.2	18.6	23.4	20.2	19.0	–	17.4	–	29.2
Idaho	2,382	26.1	29.2	26.2	23.7	25.2	32.8	21.2	25.7	27.7	25.3	–	–	–	26.3
Illinois	2,494	27.9	33.3	29.8	24.4	31.4	32.9	22.2	26.5	36.0	25.6	38.9	15.8	–	33.8
Indiana	2,299	26.7	26.0	30.0	25.8	24.9	31.3	25.6	28.1	20.4	27.5	36.5	–	–	15.0
Iowa	3,069	27.2	35.1	28.4	23.2	29.9	30.4	21.8	27.1	28.5	26.9	–	–	–	34.6
Kansas	4,352	29.3	31.1	32.5	26.6	31.4	31.7	26.1	29.8	24.4	28.8	48.5	–	–	33.2
Kentucky	3,225	31.0	36.7	32.2	26.4	32.8	32.3	28.1	30.6	31.5	30.0	48.5	–	–	–
Louisiana	2,738	29.4	33.3	34.8	24.6	32.7	31.4	24.8	29.4	29.0	26.6	35.3	–	–	35.9
Maine	3,267	26.4	27.8	29.7	22.5	30.7	30.8	20.2	26.2	27.9	26.5	–	–	–	–
Maryland	4,787	26.3	29.6	27.8	25.3	29.7	31.8	22.1	26.3	26.4	23.4	35.2	18.8	–	22.9
Massachusetts	10,188	21.6	23.3	23.8	20.3	23.5	25.9	18.6	21.7	20.2	21.6	28.2	4.5	–	26.0
Michigan	3,918	28.9	31.9	31.9	25.6	30.2	33.9	24.0	28.8	29.4	28.3	43.6	–	–	19.8
Minnesota	2,299	25.2	29.0	25.9	24.1	27.1	27.9	22.4	26.0	16.2	25.6	23.3	–	–	–
Mississippi	3,181	34.5	39.2	35.6	28.6	36.3	36.1	30.9	34.2	35.2	31.3	41.4	–	–	42.0
Missouri	2,314	30.6	31.3	32.5	27.7	29.4	36.0	27.9	30.6	31.4	29.9	34.9	–	–	–
Montana	3,204	24.3	28.9	23.0	21.4	26.6	28.1	19.8	23.7	26.6	23.5	–	–	43.3	21.9
Nebraska	8,285	28.0	29.2	32.1	26.1	28.8	33.2	23.4	28.3	26.9	27.6	49.9	–	–	25.4
Nevada	2,244	26.5	30.3	27.2	23.5	30.5	25.3	22.6	26.3	28.0	23.9	17.9	22.4	–	33.5
New Hampshire	3,460	24.5	27.2	26.7	22.6	27.2	29.3	20.7	24.6	24.8	24.6	–	–	–	–
New Jersey	5,706	23.4	25.8	27.2	21.4	28.8	26.5	18.4	23.5	22.8	23.3	34.1	8.4	–	24.3

[a] Obesity is defined as having a body mass index ≥30 kg/m^2.
[b] We restricted the prevalence estimates to the categories in which there were 50 or more respondents; blank cells indicate fewer than 50 respondents in this category. Confidence intervals are available from the authors on request.
[c] The total number of employed respondents in the 2008 BRFSS data stratified by 50 states and Washington, DC (excluding respondents missing obesity data).

(Continued on next page)

Table 1. (continued) Prevalence of Obesity[a] by State Among Workers Aged 18 to 64 Years, 2008 Behavioral Risk Factor Surveillance System (BRFSS)

State	No. of Respon-dents[c]	Prevalence of Obesity[b], %													
		Overall	Annual Household Income, $			Educational Attainment			Health Insurance Status		Race/Ethnicity				
			<35,000	35,000-74,999	≥75,000	High School Graduate or Less	Some College	College Graduate	Any	None	White	African American	Asian/Hawaiian/Pacific Islander	American Indian/Alaska Native	Hispanic
New Mexico	2,880	26.9	29.1	27.8	23.1	30.5	30.8	20.3	26.9	26.5	21.3	–	–	35.1	31.8
New York	3,634	25.3	26.8	29.6	22.8	28.6	30.3	20.6	25.2	26.8	24.1	34.2	7.4	–	30.2
North Carolina	7,070	30.8	34.0	32.5	27.9	34.2	35.2	23.9	29.5	36.4	29.1	41.4	5.7	37.6	26.7
North Dakota	2,643	28.8	30.6	30.6	26.7	32.3	28.9	25.8	28.9	25.8	28.6	–	–	47.6	–
Ohio	5,740	29.8	33.7	34.1	26.1	32.4	32.8	25.7	30.2	26.7	29.4	37.0	8.4	–	38.5
Oklahoma	3,317	32.3	32.2	34.8	30.8	31.6	35.7	30.5	33.1	29.0	31.2	41.0	–	39.3	33.0
Oregon	2,147	24.8	27.2	26.6	22.3	26.5	28.9	20.6	25.3	21.9	25.4	–	–	–	17.7
Pennsyl-vania	5,658	29.9	36.0	30.6	25.8	34.4	33.4	23.2	29.3	34.9	29.1	42.1	9.6	–	32.0
Rhode Island	2,237	22.9	29.5	23.5	21.4	27.3	24.2	19.4	22.8	23.8	21.6	30.3	–	–	27.8
South Carolina	4,217	30.9	39.0	31.7	24.9	35.3	33.4	24.7	29.9	36.2	26.6	43.4	–	–	34.0
South Dakota	3,491	29.1	34.4	30.3	24.4	32.6	30.7	24.7	28.9	30.8	28.5	–	–	41.1	–
Tennessee	1,896	32.3	33.9	34.5	25.6	39.1	33.3	23.4	32.5	31.4	29.9	38.4	–	–	–
Texas	4,525	29.1	30.1	33.1	27.2	30.0	35.1	24.4	29.8	27.3	28.2	37.7	3.7	–	31.7
Utah	2,838	24.0	28.2	24.6	23.3	25.9	23.1	23.0	24.0	24.4	24.4	–	–	–	20.8
Vermont	3,715	22.6	23.2	25.2	19.2	27.5	25.7	17.2	22.5	23.7	22.7	–	–	–	–
Virginia	2,389	26.1	24.3	26.8	25.4	30.4	27.9	23.0	26.9	18.5	27.3	33.7	–	–	17.7
Washington	10,222	26.1	26.6	28.4	24.7	29.7	30.2	20.8	26.4	23.8	26.5	28.3	15.0	36.8	25.5
West Virginia	1,729	34.6	34.5	35.7	32.5	37.1	36.5	29.4	34.6	34.8	34.4	–	–	–	–
Wisconsin	3,700	27.2	32.6	28.2	21.7	29.3	30.4	22.8	26.7	31.0	26.1	42.0	–	43.1	29.0
Wyoming	4,159	26.3	26.6	27.7	26.3	27.7	28.5	22.6	27.3	21.7	25.9	–	–	43.1	25.9
United States	189,055	27.0	30.2	29.3	24.1	30.5	30.5	21.9	26.9	27.6	26.1	37.3	9.1	32.5	29.3

[a] Obesity is defined as having a body mass index ≥30 kg/m^2.
[b] We restricted the prevalence estimates to the categories in which there were 50 or more respondents; blank cells indicate fewer than 50 respondents in this category. Confidence intervals are available from the authors on request.
[c] The total number of employed respondents in the 2008 BRFSS data stratified by 50 states and Washington, DC (excluding respondents missing obesity data).

Table 2. Prevalence of Physical Inactivity[a] by State Among Workers Aged 18 to 64 Years, 2007 Behavioral Risk Factor Surveillance System (BRFSS)

State	No. of Respon-dents[c]	Prevalence of Physical Inactivity[b], %													
		Overall	Annual Household Income, $			Educational Attainment			Health Insurance Status		Race/Ethnicity				
			<35,000	35,000-74,999	≥75,000	High School Graduate or Less	Some College	College Graduate	Any	None	White	African American	Asian/Hawaiian/Pacific Islander	American Indian/Alaska Native	Hispanic
Alabama	2,843	54.4	59.3	53.5	49.1	55.8	56.3	50.8	53.9	57.4	53.1	59.5	–	–	–
Alaska	1,475	37.2	43.1	38.1	31.6	36.1	38.7	37.0	36.2	43.2	36.4	–	–	47.3	–
Arizona	1,891	45.0	56.1	46.9	36.3	54.5	42.4	38.9	44.0	49.4	41.5	–	–	32.0	55.7
Arkansas	2,348	51.5	51.0	53.2	49.4	52.7	52.0	49.7	51.6	52.2	50.7	56.8	–	–	57.3
California	2,711	51.0	57.9	53.5	43.8	55.3	52.8	46.1	51.0	50.9	42.5	55.4	70.2	–	56.1
Colorado	6,245	43.8	51.5	45.4	37.0	50.2	45.6	38.5	42.4	50.6	41.4	52.8	40.4	–	52.4
Connecticut	3,537	45.9	55.4	43.8	44.6	47.2	46.0	45.2	45.6	48.7	43.9	55.6	68.9	–	53.7
Delaware	1,989	49.2	55.5	48.4	48.5	52.4	44.2	50.0	49.6	45.2	47.3	55.7	–	–	62.0
District of Columbia	2,005	41.3	54.7	44.8	35.9	58.4	42.0	36.7	41.0	45.6	31.6	47.6	45.1	–	57.5
Florida	16,435	50.8	56.3	50.4	46.7	56.1	49.0	47.7	49.8	55.0	48.5	53.7	46.1	47.2	58.4
Georgia	3,394	49.6	49.9	49.7	50.9	50.6	48.6	49.8	50.1	46.6	48.7	55.1	–	–	37.1
Hawaii	3,681	48.7	57.6	48.5	45.1	51.5	51.0	44.5	48.9	46.0	39.9	–	58.0	–	51.9
Idaho	2,566	43.2	49.2	42.2	39.3	45.3	42.8	40.9	42.4	46.1	42.8	–	–	–	50.9
Illinois	2,586	49.2	54.4	52.4	43.0	53.4	49.3	46.6	48.7	52.9	45.8	52.9	62.2	–	58.2
Indiana	2,809	48.8	52.9	50.1	43.2	51.6	48.4	46.0	49.3	46.5	48.6	45.4	–	–	53.7
Iowa	2,822	49.5	49.6	51.6	44.8	50.1	48.2	50.0	50.6	42.2	49.2	–	–	–	60.6
Kansas	4,384	48.7	54.4	48.6	44.6	52.9	46.1	47.5	48.4	52.5	48.3	48.7	–	–	55.4
Kentucky	2,398	50.0	51.3	52.4	44.5	50.9	49.9	48.6	50.3	48.3	51.1	41.3	–	–	–
Louisiana	3,013	58.4	62.9	59.1	55.3	61.0	60.5	54.4	57.4	62.1	58.9	55.3	–	–	71.1
Maine	3,391	41.1	44.5	41.7	38.6	41.2	44.6	38.6	42.8	30.9	40.9	–	–	–	–
Maryland	4,315	50.3	59.7	51.8	46.8	53.6	54.0	46.9	50.0	52.3	46.6	55.7	55.0	–	62.9
Massachu-setts	9,867	46.3	55.8	47.1	43.7	52.4	46.8	43.5	45.9	52.1	44.0	54.0	61.2	–	56.4
Michigan	3,290	47.5	48.2	49.9	45.0	46.9	49.2	46.7	48.3	41.8	46.8	53.4	–	–	28.1
Minnesota	2,615	49.1	54.9	49.0	45.9	55.9	49.6	44.7	48.4	55.9	48.4	55.1	–	–	–
Mississippi	3,296	57.3	57.6	58.7	52.8	57.3	60.1	54.8	56.4	60.9	55.5	61.3	–	–	51.5
Missouri	2,448	50.3	47.7	47.6	51.6	48.6	53.0	49.8	51.3	43.5	48.8	64.7	–	–	–
Montana	2,895	39.5	42.5	39.8	34.8	38.2	42.2	38.6	38.1	45.3	39.4	–	–	48.4	29.9
Nebraska	5,540	46.2	52.0	45.2	41.7	50.9	41.3	46.0	46.0	47.6	45.7	–	–	–	51.4
Nevada	2,040	47.6	51.1	48.0	44.2	51.2	45.4	45.6	47.2	49.2	46.3	–	–	–	52.8
New Hampshire	2,982	45.1	47.4	48.8	41.7	49.3	43.6	43.2	45.5	41.9	44.8	–	–	–	44.7
New Jersey	3,153	49.8	58.7	50.6	46.2	53.9	51.5	46.7	48.0	61.8	45.0	54.8	69.9	–	57.3
New Mexico	3,093	44.4	50.3	39.4	40.5	51.5	41.3	39.4	42.7	49.9	40.6	–	–	44.2	47.7
New York	3,107	48.0	51.3	49.3	44.8	51.9	45.6	46.6	47.4	52.0	44.1	51.6	61.3	–	59.2

[a] Physical inactivity is defined as not meeting the Centers for Disease Control and Prevention physical activity guideline of at least 5 days per week for 30 minutes a day of moderate-intensity activity or at least 3 days per week for 20 minutes a day of vigorous-intensity activity.
[b] We restricted the prevalence estimates to the categories in which there were 50 or more respondents; blank cells indicate fewer than 50 respondents in this category. Confidence intervals are available from the authors on request.
[c] The total number of employed respondents in the 2007 BRFSS data stratified by 50 states and Washington, DC (excluding respondents missing physical inactivity data).

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Table 2. (continued) Prevalence of Physical Inactivity[a] by State Among Workers Aged 18 to 64 Years, 2007 Behavioral Risk Factor Surveillance System (BRFSS)

State	No. of Respon-dents[c]	Prevalence of Physical Inactivity[b], %													
		Overall	Annual Household Income, $			Educational Attainment			Health Insurance Status		Race/Ethnicity				
			<35,000	35,000-74,999	≥75,000	High School Graduate or Less	Some College	College Graduate	Any	None	White	African American	Asian/ Hawaiian/ Pacific Islander	American Indian/ Alaska Native	Hispanic
North Carolina	6,560	53.5	58.2	53.8	47.9	59.7	52.2	48.4	53.0	56.2	50.7	58.1	54.2	50.4	70.3
North Dakota	2,579	45.6	45.2	46.0	42.1	47.4	45.4	44.2	45.4	45.1	45.9	—	—	46.4	—
Ohio	5,013	48.1	51.3	48.0	45.7	48.3	49.8	46.7	48.2	46.5	47.5	52.4	—	—	69.0
Oklahoma	3,091	52.0	55.0	52.3	47.6	54.4	53.8	47.7	52.2	51.1	51.3	44.2	—	54.5	57.0
Oregon	2,237	43.0	47.1	44.4	38.0	47.8	43.7	39.0	42.4	45.5	42.3	—	—	—	52.0
Pennsyl-vania	5,735	45.7	47.6	47.4	43.0	48.7	46.1	42.9	46.3	40.0	46.6	48.1	40.1	—	39.7
Rhode Island	2,098	47.1	55.5	49.3	43.2	52.5	49.3	42.2	47.4	45.4	45.8	50.5	—	—	58.5
South Carolina	4,586	51.0	55.6	49.5	48.6	53.0	51.2	48.7	50.3	54.3	49.7	56.8	—	—	41.2
South Dakota	3,498	49.8	54.6	52.0	41.6	56.8	49.1	43.9	49.7	50.8	49.6	—	—	54.1	—
Tennessee	2,030	57.9	68.7	55.5	47.2	60.8	58.4	53.2	56.8	65.7	58.5	60.6	—	—	—
Texas	7,287	52.0	55.6	52.4	48.2	54.0	52.2	49.6	52.1	52.0	49.0	53.8	66.8	43.0	54.7
Utah	2,733	43.7	50.2	43.2	37.8	49.6	42.2	38.9	43.5	44.3	42.3	—	—	—	49.2
Vermont	3,724	40.3	45.3	40.4	37.9	46.9	42.9	34.1	41.3	33.9	40.0	—	—	—	55.7
Virginia	2,893	49.3	54.5	46.7	47.2	51.9	50.4	47.5	48.8	53.7	47.9	51.2	62.4	—	58.7
Washington	11,957	45.4	49.9	45.8	43.1	46.9	45.7	44.1	45.1	47.8	44.4	32.3	50.8	43.3	58.7
West Virginia	1,888	50.4	49.3	51.6	49.7	48.8	50.3	53.2	52.1	42.1	50.7	—	—	—	—
Wisconsin	3,867	42.7	46.1	43.8	39.1	41.7	46.5	40.4	42.7	42.5	42.8	44.9	—	—	31.2
Wyoming	3,229	41.5	44.7	41.3	39.0	42.9	43.7	37.5	41.9	40.6	40.9	—	—	—	49.0
United States	196,169	49.2	54.3	49.8	45.0	52.5	49.5	46.3	48.9	51.0	46.8	54.3	63.1	44.3	55.6

[a] Physical inactivity is defined as not meeting the Centers for Disease Control and Prevention physical activity guideline of at least 5 days per week for 30 minutes a day of moderate-intensity activity or at least 3 days per week for 20 minutes a day of vigorous-intensity activity.
[b] We restricted the prevalence estimates to the categories in which there were 50 or more respondents; blank cells indicate fewer than 50 respondents in this category. Confidence intervals are available from the authors on request.
[c] The total number of employed respondents in the 2007 BRFSS data stratified by 50 states and Washington, DC (excluding respondents missing physical inactivity data).

Table 3. Prevalence of Smoking[a] by State Among Workers Aged 18 to 64 Years, 2008 Behavioral Risk Factor Surveillance System (BRFSS)

		Prevalence of Smoking[b], %													
			Annual Household Income, $			Educational Attainment			Health Insurance Status		Race/Ethnicity				
State	No. of Respon-dents[c]	Overall	<35,000	35,000-74,999	≥75,000	High School Graduate or Less	Some College	College Graduate	Any	None	White	African American	Asian/Hawaiian/Pacific Islander	American Indian/Alaska Native	Hispanic
Alabama	2,659	22.9	29.7	22.3	13.5	32.9	20.1	13.6	20.1	38.7	23.3	22.6	—	—	—
Alaska	1,658	20.1	32.8	17.2	14.4	33.8	16.9	7.9	17.8	30.5	16.7	—	—	35.1	15.0
Arizona	2,330	17.4	25.8	20.4	9.7	28.1	18.8	6.4	14.8	29.6	17.8	—	—	10.9	18.0
Arkansas	2,474	23.0	36.9	21.6	11.4	34.0	24.3	8.7	19.4	38.9	22.0	26.1	—	—	29.5
California	5,391	14.9	20.6	15.9	9.7	19.3	20.5	6.9	13.4	21.2	15.3	22.4	6.9	—	14.9
Colorado	6,157	17.9	28.3	21.8	10.2	29.6	21.6	7.6	15.7	29.5	16.5	21.4	12.9	—	21.7
Connecticut	3,006	17.5	29.3	22.0	12.2	28.8	23.3	9.6	16.2	31.1	17.4	16.5	12.0	—	20.0
Delaware	2,015	19.4	35.6	23.3	11.9	35.0	19.5	9.4	18.4	32.0	19.9	17.3	—	—	17.9
District of Columbia	2,241	14.6	24.5	19.7	8.5	27.5	22.2	9.0	13.3	28.6	10.3	20.7	—	—	11.7
Florida	4,515	19.3	29.2	18.3	11.7	25.5	23.6	11.1	16.3	32.9	22.2	9.8	—	—	17.1
Georgia	2,719	19.4	27.3	21.1	15.0	31.3	20.3	10.5	16.9	34.1	20.5	15.4	—	—	16.1
Hawaii	3,506	17.1	28.2	19.2	11.8	27.1	16.5	9.9	16.2	29.9	15.4	—	13.5	—	16.4
Idaho	2,513	18.1	28.5	16.7	8.8	30.3	16.1	6.9	14.7	32.2	18.0	—	—	—	17.8
Illinois	2,581	21.4	33.0	22.6	15.4	34.8	23.7	10.3	19.3	34.0	21.2	22.5	11.9	—	24.2
Indiana	2,380	27.6	45.6	26.6	17.4	41.1	30.1	10.7	22.7	54.9	25.5	32.5	—	—	52.7
Iowa	3,244	20.9	37.9	20.4	11.5	35.2	20.3	7.4	18.2	47.6	20.4	—	—	—	24.4
Kansas	4,499	19.1	31.5	19.5	10.8	32.6	20.9	8.2	16.6	37.8	18.4	22.3	—	—	22.0
Kentucky	3,325	24.7	41.5	24.8	14.5	37.3	28.3	9.5	21.0	48.2	24.7	28.9	—	—	—
Louisiana	2,889	20.2	26.4	23.0	14.7	26.3	25.3	11.1	16.7	35.5	22.2	16.8	—	—	23.9
Maine	3,367	18.7	33.4	18.2	9.8	29.0	22.0	8.5	17.1	29.8	18.6	—	—	—	—
Maryland	4,941	14.9	23.9	19.5	10.0	25.2	19.6	7.3	13.3	27.0	16.4	15.1	4.3	—	8.9
Massachu-setts	10,643	15.7	24.7	17.9	11.8	27.7	20.1	7.6	15.1	29.0	16.3	17.4	6.2	—	11.0
Michigan	4,091	20.1	32.8	20.1	13.0	33.6	20.1	10.2	18.1	37.2	19.4	18.5	—	—	33.2
Minnesota	2,355	18.1	31.8	20.4	9.2	30.2	21.5	9.6	16.2	39.9	17.5	21.5	—	—	—
Mississippi	3,259	22.0	28.0	21.9	13.4	29.6	23.1	11.8	18.9	35.4	23.6	19.1	—	—	24.1
Missouri	2,382	25.5	42.9	24.6	15.3	38.6	24.4	12.9	21.9	47.0	25.8	18.9	—	—	—
Montana	3,308	19.5	34.2	16.2	9.4	31.1	21.8	8.2	15.4	36.6	18.4	—	—	37.3	23.6
Nebraska	8,558	20.1	32.7	21.5	10.6	33.3	20.6	9.7	17.2	39.5	20.2	19.6	—	—	21.2
Nevada	2,339	22.1	32.7	22.6	16.8	26.5	26.5	12.5	20.4	29.4	21.7	16.4	21.2	—	22.6
New Hampshire	3,610	18.3	32.0	23.2	11.1	31.8	22.8	8.7	15.7	41.1	18.4	—	1.5	—	—
New Jersey	6,002	16.1	21.2	20.9	11.4	25.1	20.1	8.5	15.3	21.6	17.4	17.7	9.8	—	12.7
New Mexico	2,987	20.5	29.5	17.6	14.2	28.6	22.8	10.4	17.5	32.3	21.0	—	—	11.7	21.9
New York	3,796	17.7	24.5	22.7	10.5	28.5	21.3	8.8	15.9	30.8	18.7	20.1	14.1	—	14.1

[a] Tobacco use is defined as ever having smoked at least 100 cigarettes and currently smoking every day or some days.
[b] We restricted the prevalence estimates to the categories in which there were 50 or more respondents; blank cells indicate fewer than 50 respondents in this category. Confidence intervals are available from the authors on request.
[c] The total number of employed respondents in the 2008 BRFSS data stratified by 50 states and Washington, DC (excluding respondents missing smoking data).

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Table 3. (continued) Prevalence of Smoking[a] by State Among Workers Aged 18 to 64 Years, 2008 Behavioral Risk Factor Surveillance System (BRFSS)

State	No. of Respon-dents[c]	Prevalence of Smoking[b], %													
		Overall	Annual Household Income, $			Educational Attainment			Health Insurance Status		Race/Ethnicity				
			<35,000	35,000-74,999	≥75,000	High School Graduate or Less	Some College	College Graduate	Any	None	White	African American	Asian/Hawaiian/Pacific Islander	American Indian/Alaska Native	Hispanic
North Carolina	7,331	22.0	32.4	21.2	13.8	33.5	21.3	10.1	19.5	33.9	22.8	21.0	22.0	40.3	16.3
North Dakota	2,765	20.4	31.5	19.8	14.3	29.0	25.0	8.8	17.9	39.7	19.2	–	–	53.1	–
Ohio	5,991	20.9	38.1	22.0	9.9	35.7	22.3	7.0	17.7	45.3	20.0	22.7	8.9	–	41.0
Oklahoma	3,398	25.0	37.3	25.1	12.8	34.5	28.2	10.8	21.9	38.0	23.7	28.1	–	31.2	24.4
Oregon	2,218	16.3	23.4	17.1	9.3	29.0	16.3	6.0	13.6	30.6	16.1	–	–	–	11.6
Pennsyl-vania	5,892	22.8	37.9	24.9	13.6	32.8	25.3	10.9	21.3	34.0	22.4	22.6	22.5	–	24.5
Rhode Island	2,317	18.0	25.5	24.3	11.4	28.7	23.8	8.1	16.2	31.2	18.6	19.7	–	–	11.3
South Carolina	4,388	19.9	28.7	19.8	14.7	29.9	19.6	10.7	16.7	36.2	21.5	15.9	–	–	16.6
South Dakota	3,627	18.7	28.2	17.1	13.6	27.8	20.0	9.9	16.7	33.7	18.0	–	–	37.0	–
Tennessee	1,990	20.7	34.1	17.3	11.8	31.6	18.5	9.9	18.1	35.6	22.8	17.3	–	–	–
Texas	4,767	20.1	26.1	21.4	12.6	28.9	21.3	10.6	16.7	30.5	20.4	19.4	11.9	–	20.6
Utah	2,912	9.8	15.3	13.1	4.4	17.6	8.1	3.4	9.0	13.8	9.5	–	–	–	14.6
Vermont	3,829	16.8	32.7	15.4	7.7	29.2	16.1	8.1	14.6	32.6	16.6	–	–	–	–
Virginia	2,484	16.2	31.9	18.7	9.8	26.0	20.7	8.6	13.6	39.7	16.6	18.1	10.0	–	15.3
Washington	10,576	15.7	26.1	18.7	8.8	28.3	17.4	6.2	13.6	29.9	15.6	20.8	7.1	31.7	16.1
West Virginia	1,794	26.7	40.1	25.4	14.1	37.9	24.2	13.0	22.4	47.6	26.3	–	–	–	–
Wisconsin	3,843	21.5	31.0	20.4	16.8	32.1	22.6	10.9	19.1	43.5	20.7	28.7	–	38.1	37.5
Wyoming	4,295	21.6	39.3	22.4	12.4	33.1	23.9	7.0	17.9	38.9	20.6	–	–	35.7	29.5
United States	196,157	19.2	28.9	20.6	11.9	29.3	21.6	9.2	16.8	32.5	19.7	18.7	10.8	27.8	17.9

[a] Tobacco use is defined as ever having smoked at least 100 cigarettes and currently smoking every day or some days.
[b] We restricted the prevalence estimates to the categories in which there were 50 or more respondents; blank cells indicate fewer than 50 respondents in this category. Confidence intervals are available from the authors on request.
[c] The total number of employed respondents in the 2008 BRFSS data stratified by 50 states and Washington, DC (excluding respondents missing smoking data).

Table 4. Prevalence of No Influenza Vaccination by State Among Workers Aged 50 to 64 Years, 2008 Behavioral Risk Factor Surveillance System (BRFSS)

		Prevalence of No Influenza Vaccination[a], %													
			Annual Household Income, $			Educational Attainment			Health Insurance Status		Race/Ethnicity				
State	No. of Respon-dents[b]	Overall	<35,000	35,000-74,999	≥75,000	High School Graduate or Less	Some College	College Graduate	Any	None	White	African American	Asian/Hawaiian/Pacific Islander	American Indian/Alaska Native	Hispanic
Alabama	1,047	59.9	74.5	57.1	50.6	67.6	62.2	49.7	58.5	73.3	56.3	71.2	–	–	–
Alaska	614	58.2	64.6	61.3	51.2	64.8	58.5	53.2	55.7	73.6	59.6	–	–	46.4	–
Arizona	991	65.0	59.5	66.0	64.5	64.3	69.3	62.2	65.2	63.5	65.4	–	–	–	74.3
Arkansas	1,052	56.2	57.2	56.6	53.5	61.2	54.3	51.8	53.9	72.6	55.6	67.9	–	–	–
California	2,056	63.4	73.9	65.7	57.7	71.6	63.5	58.4	60.3	87.7	58.5	70.2	68.3	–	70.6
Colorado	2,474	53.3	64.6	54.6	49.8	61.1	55.9	48.2	50.9	75.9	52.5	–	–	–	57.4
Connecticut	1,254	54.1	63.6	54.1	51.5	56.3	56.0	52.4	52.9	75.7	52.5	61.9	–	–	70.0
Delaware	769	53.2	66.0	50.2	49.9	67.0	49.6	47.4	52.2	78.4	52.0	59.2	–	–	–
District of Columbia	866	55.5	63.7	58.8	50.6	58.7	61.4	53.0	54.5	68.4	44.7	65.0	–	–	–
Florida	1,911	70.2	77.7	71.1	64.0	78.6	74.4	62.3	67.9	86.2	66.2	74.4	–	–	83.9
Georgia	1,045	62.2	66.5	64.1	58.4	64.5	65.5	58.3	60.7	73.0	60.0	66.4	–	–	–
Hawaii	1,480	53.9	58.4	53.8	52.0	59.2	56.8	49.9	52.6	87.5	58.6	–	45.9	–	50.9
Idaho	1,022	63.8	72.3	68.4	52.8	75.8	63.5	53.9	60.3	86.7	63.5	–	–	–	–
Illinois	1,000	63.7	78.8	65.1	57.8	69.4	64.9	59.1	63.0	73.3	62.8	69.5	–	–	–
Indiana	986	62.6	75.3	61.3	57.6	66.5	61.2	60.0	60.5	90.2	61.7	65.2	–	–	–
Iowa	1,315	52.3	64.2	51.3	47.6	59.0	51.4	44.9	51.7	59.5	52.0	–	–	–	–
Kansas	1,984	57.0	64.7	57.6	53.0	65.9	59.4	50.1	55.3	81.8	56.6	50.5	–	–	62.3
Kentucky	1,362	56.4	69.4	57.5	49.0	66.4	57.6	46.0	54.1	78.1	56.6	–	–	–	–
Louisiana	1,099	56.4	65.5	53.2	52.5	57.7	61.4	52.1	53.7	72.5	55.4	62.3	–	–	–
Maine	1,535	55.2	64.7	57.4	49.3	61.7	52.0	53.1	52.8	76.3	55.2	–	–	–	–
Maryland	1,991	54.6	61.7	59.3	51.6	67.7	53.4	49.1	53.7	68.2	51.3	61.9	–	–	–
Massachu-setts	4,210	55.4	66.5	57.2	51.5	60.8	60.5	50.9	55.0	66.3	55.1	65.9	–	–	51.5
Michigan	1,735	60.9	72.1	61.5	56.1	68.9	64.1	53.6	59.6	75.5	59.5	69.8	–	–	–
Minnesota	995	50.4	64.5	51.3	44.4	57.6	51.7	45.4	48.4	88.0	50.0	–	–	–	–
Mississippi	1,360	63.2	71.6	63.1	55.8	68.5	62.0	58.1	60.2	80.5	59.4	70.6	–	–	–
Missouri	1,012	55.8	67.0	56.6	50.7	67.0	56.0	46.4	53.9	76.9	54.2	73.6	–	–	–
Montana	1,550	61.5	71.0	62.3	52.0	71.9	60.2	55.3	58.4	78.6	61.3	–	–	60.7	–
Nebraska	3,794	49.7	59.3	52.5	43.3	57.7	50.4	42.4	47.9	69.0	50.0	–	–	–	58.5
Nevada	922	71.4	83.3	74.7	65.7	82.0	70.7	64.2	69.3	87.8	67.4	–	–	–	84.3
New Hampshire	1,571	52.8	57.8	56.4	50.4	62.9	55.3	47.0	51.2	72.0	52.6	–	–	–	–
New Jersey	2,396	60.7	66.8	66.0	56.7	67.1	61.7	56.3	59.4	74.2	60.2	64.7	–	–	62.3
New Mexico	1,265	62.0	68.5	60.4	57.9	70.2	59.5	58.4	59.4	77.4	60.6	–	–	49.8	65.9
New York	1,614	58.1	69.1	59.5	54.2	65.9	61.1	51.7	55.5	83.3	56.4	70.9	–	–	59.9

[a] We restricted the prevalence estimates to the categories in which there were 50 or more respondents; blank cells indicate fewer than 50 respondents in this category. Confidence intervals are available from the authors on request.
[b] The total number of employed respondents in the 2008 BRFSS data stratified by 50 states and Washington, DC (excluding respondents missing influenza vaccination data).

(Continued on next page)

Table 4. (continued) Prevalence of No Influenza Vaccination by State Among Workers Aged 50 to 64 Years, 2008 Behavioral Risk Factor Surveillance System (BRFSS)

State	No. of Respondents[b]	Prevalence of No Influenza Vaccination[a], %													
		Overall	Annual Household Income, $			Educational Attainment			Health Insurance Status		Race/Ethnicity				
			<35,000	35,000-74,999	≥75,000	High School Graduate or Less	Some College	College Graduate	Any	None	White	African American	Asian/Hawaiian/Pacific Islander	American Indian/Alaska Native	Hispanic
North Carolina	2,906	55.0	65.3	55.7	48.6	60.5	55.0	49.6	52.6	74.5	52.9	61.0	—	69.9	60.4
North Dakota	1,202	56.0	55.7	58.0	54.8	62.2	55.5	51.3	54.7	69.2	55.7	—	—	—	—
Ohio	2,749	58.8	61.7	59.9	55.6	64.6	64.2	50.4	57.1	78.4	58.2	61.9	—	—	—
Oklahoma	1,361	49.9	63.6	46.3	43.7	58.6	48.9	41.8	46.5	70.5	50.5	49.4	—	42.7	—
Oregon	1,031	57.9	65.7	62.3	49.9	63.8	59.0	53.3	56.1	75.6	57.3	—	—	—	—
Pennsylvania	2,462	59.2	69.6	57.4	58.0	65.1	60.5	52.3	57.8	77.3	59.1	50.5	—	—	—
Rhode Island	1,008	50.4	54.8	50.5	49.7	55.7	55.1	45.5	49.3	65.7	49.8	—	—	—	—
South Carolina	1,845	59.5	68.8	62.4	51.5	70.5	63.0	47.9	57.5	75.9	58.0	63.7	—	—	—
South Dakota	1,636	47.1	54.0	46.1	43.9	51.6	48.9	41.5	44.6	74.6	47.0	—	—	46.6	—
Tennessee	851	60.7	66.2	59.9	52.5	68.2	60.0	51.9	59.1	71.9	57.6	69.3	—	—	—
Texas	1,883	58.6	66.5	61.8	51.5	67.8	59.9	50.3	56.5	67.8	54.7	71.6	—	—	64.5
Utah	1,004	51.2	67.2	53.0	45.5	58.5	56.1	43.1	49.1	79.4	50.9	—	—	—	—
Vermont	1,759	56.2	62.4	57.3	53.0	63.6	56.3	51.9	54.3	77.8	55.7	—	—	—	—
Virginia	1,043	54.5	49.0	54.7	53.6	59.7	52.4	52.5	53.4	68.7	54.9	67.2	—	—	—
Washington	4,829	56.8	66.8	60.2	51.6	67.2	58.5	51.0	55.0	80.1	57.0	—	43.2	55.3	55.9
West Virginia	754	54.3	68.1	52.5	50.1	64.8	48.6	45.6	52.0	73.2	53.4	—	—	—	—
Wisconsin	1,575	57.2	62.8	59.3	51.9	63.7	58.8	49.9	55.4	76.2	56.7	—	—	—	—
Wyoming	1,896	56.9	64.3	59.1	52.7	63.5	59.0	49.3	54.5	75.7	56.8	—	—	—	54.0
United States	82,071	59.3	68.6	60.5	54.4	66.3	61.0	53.3	57.4	77.1	57.4	66.8	60.3	56.3	67.1

[a] We restricted the prevalence estimates to the categories in which there were 50 or more respondents; blank cells indicate fewer than 50 respondents in this category. Confidence intervals are available from the authors on request.
[b] The total number of employed respondents in the 2008 BRFSS data stratified by 50 states and Washington, DC (excluding respondents missing influenza vaccination data).

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ORIGINAL RESEARCH

Health-Related Quality of Life Among Adults With Multiple Chronic Conditions in the United States, Behavioral Risk Factor Surveillance System, 2007

Han-Yang Chen, MS; Dennis J. Baumgardner, MD; Jessica P. Rice, MPH

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PEER REVIEWED

Abstract

Introduction

Little is known about health-related quality of life (HRQOL) among people with multiple chronic conditions. We examined the association between the number of chronic conditions and self-reported HRQOL outcomes among adults in the United States.

Methods

We used data from the Behavioral Risk Factor Surveillance System (BRFSS) in 2007 (n = 430,912) to compare 4 HRQOL measures for people with any of 8 chronic conditions. We also assessed the frequency of self-reported physical and mental distress and the number of days activity was limited because of chronic conditions. We estimated prevalence and adjusted odds ratios (AORs) and 95% confidence intervals (CIs) by using survey logistic regression analyses.

Results

People with 3 or more chronic conditions had the highest risk of reporting fair or poor health compared with respondents with no chronic conditions (AOR, 8.7; 95% CI, 8.0-9.4). People with cardiovascular conditions or diabetes had higher risk of reporting poor HRQOL outcomes than those with other chronic conditions. The odds ratios for frequent physical distress were consistently higher than those for frequent mental distress and frequent activity limitations for all conditions.

Conclusion

Strategies that help clinicians to manage their patients' chronic conditions may contribute to improved HRQOL among adults. Our findings may help to inform these strategies.

Introduction

As disease prevention and management improve and the population ages, the prevalence of chronic conditions is accelerating in the United States. Nearly half of adults have at least 1 chronic condition (1), which can result in extended pain and suffering and impaired quality of life.

The growing number of Americans living with chronic illness has shifted the focus of research from treatment and quantity of life to improvement of the quality of life. One of the major goals of *Healthy People 2010* (2) was improving the quality and number of years of healthy life. During the past decade, the research community has increasingly focused on measuring the patient's perspective when evaluating the effect of chronic illness and the benefit of treatment. Self-assessments of health-related quality of life (HRQOL) are rapidly gaining acceptance and are widely used for tracking health status. The Centers for Disease Control and Prevention (CDC) developed a surveillance definition of HRQOL as "perceived physical and mental health over time" (3). Others characterize HRQOL as a subjective assessment of well-being and physical, mental, and social functioning. Thus, HRQOL is recognized as a health-oriented subset of the broader concept of overall quality of life, including aspects of life satisfaction and happiness (4).

The high prevalence of chronic disease in the United States does not tell the whole story. A more specific concern is that many people, especially those in the Medicare population, have multiple chronic conditions (5). Whether HRQOL varies by number of conditions has not been established, despite the research finding that multiple chronic diseases have a substantial negative effect on quality of life, not only how people feel about their lives but also the extent of their psychological distress (6). Some chronic conditions have a stronger relationship with functional impairment than others, but people with more chronic conditions experience more functional impairment and experience it sooner than people with fewer chronic conditions (7).

Our primary objective was to examine the association between the number of chronic conditions and HRQOL outcomes. Our secondary objective was to describe the prevalence of common chronic conditions among the US adult population.

Methods

We analyzed data from the 2007 Behavioral Risk Factor Surveillance System (BRFSS). BRFSS collects data from ongoing random-digit–dial telephone surveys administered to noninstitutionalized US adults aged 18 years or older on health risk behaviors, preventive health practices, and access to and use of health care services primarily related to chronic conditions. BRFSS data are directly weighted for the probability of selection of a telephone number, the number of adults in a household, and the number of telephones in a household. A final poststratification adjustment is made for nonresponse and noncoverage of households without telephones. The weights for each relevant factor are multiplied to get a final weight (8). In 2007, BRFSS was administered to 430,912 (weighted N = 230,172,178) respondents. The median response rate was 51%, and the median cooperation rate was 72%. A detailed description of the survey design and random sampling procedures is available elsewhere (8). The health sciences institutional review board at the University of Wisconsin-Madison approved this study.

In our analysis, the outcomes of interest were 4 measures of HRQOL from the CDC Healthy Days Core Module (CDC HRQOL-4): general health, mental distress, physical distress, and activity limitations. The CDC HRQOL measures have acceptable content, construct and criterion validity, and test-retest reliability (3,9-12).

In the CDC HRQOL-4, the first question asks respondents to rate their general health on a scale from excellent to poor. We dichotomized these responses as either "fair/poor" or "good/very good/excellent." The other 3 questions ask about respondents' assessment of their health in the previous 30 days: "How many days was your physical health, which includes physical illness or injury, not good?" (physical distress), "How many days was your mental health, which includes stress, depression, and problems with emotions, not good?" (mental distress), and "How many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?" (activity limitations). We dichotomized these 3 HRQOL variables in terms of their frequency in the previous 30 days (≥14 being frequent or <14 being infrequent). We used the 14-day minimum period because clinicians and clinical researchers often use this period as a marker for clinical depression and anxiety disorders, and longer duration of symptoms is associated with a higher level of activity limitation (13). In addition, most studies based on the BRFSS HRQOL indicators used the same dichotomized criteria as we did (13-16). Thus, our results can be compared with those of previous studies. Moreover, our outcomes of interest were not normally distributed; by dichotomizing the outcomes, we were able to conduct logistic regression analyses without violating the linearity assumption.

We examined respondents by 8 chronic conditions: asthma, arthritis, 3 cardiovascular diseases (heart attack, angina, stroke), diabetes, and hypertension, based on diagnosis of the condition by a health professional, and obesity, defined as a body mass index of at least 30 kg/m^2, based on self-reported height and weight.

We estimated the prevalence of each chronic condition among adults in the United States. We estimated adjusted odds ratios (AORs) and 95% confidence intervals (CIs) by comparing having each chronic condition with having no condition. To account for potential confounding effects, we controlled for respondents' age, sex, race/ethnicity, education level, income level, employment status, marital status, and health insurance coverage status. In addition, we adjusted for 3 health behavior risk factors: current smoking (defined as ever having smoked at least 100 cigarettes and now smoking every day or some days), current heavy drinking (defined as having more than 2 alcoholic drinks per day for men and having more than 1 alcoholic drink per day for women during the previous 30 days), and no physical activity (defined as not participating in any physical activity during the previous 30 days). To account for complex survey design and produce unbiased estimates of standard errors, we used multivariate survey logistic regression models to estimate AORs and 95% CIs. We conducted all analyses using SAS version 9.2 (SAS Institute, Inc, Cary, North Carolina).

Results

Approximately 19% of respondents were smokers, 5% were heavy drinkers, and 9% did not participate in any physical activity (Table 1). Among all survey respondents, 57% reported at least 1 chronic condition. The most prevalent chronic conditions were arthritis (27%), obesity (26%), and hypertension (28%). Among people with cardiovascular diseases, more than 90% of them had 2 or more chronic conditions (Table 2).

The most common conditions for which fair or poor health were reported were cardiovascular diseases (53% for each one) or diabetes (48%) (Table 3). People with 1 or no chronic condition had a higher prevalence of frequent mental distress than frequent physical distress. In contrast, people with 2 or more conditions had a higher prevalence of frequent physical distress than mental distress. Respondents with cardiovascular diseases or diabetes were approximately 7 to 8 times as likely to report fair or poor health as respondents with no chronic condition (Table 4). People with 3 or more chronic conditions were more likely to report poor HRQOL outcomes than those with 1 or 2 conditions. In the population of adults with at least 1 chronic illness, the odds ratios of frequent physical distress varied more widely than those for frequent mental distress and frequent activity limitations across conditions.

Discussion

Our findings that respondents with multiple chronic conditions reported worse HRQOL than those with 1 or no chronic condition and that frequent physical distress was more common than frequent mental distress were consistent with previous studies in disease-specific populations, such as those of adults with asthma (15), obesity (16), stroke (17), diabetes (18), and arthritis (19).

We found that people without any chronic condition reported a higher prevalence of frequent mental distress than frequent physical distress. However, as the number of chronic conditions increased, frequent physical distress outpaced frequent mental distress. Although our results were consistent with previous findings that the burden of chronic illness is primarily carried in terms of physical health (20), the observation that mental distress is less frequent than physical distress does not imply that mental distress is an unimportant consideration in managing chronic conditions. People with chronic illness may have lived with their conditions for years and feel that they are able to manage their illness and therefore report less mental distress. For example, diabetes patients often rate their well-being positively despite the presence of diabetes-related complications or poor glycemic control (21). These findings suggest that in addition to medical care, the mental health quality of life of the chronically ill population may benefit from social support and be mitigated by socioeconomic status, personality characteristics, and styles of coping with illness.

We found that cardiovascular diseases and diabetes are frequently associated with other surveyed diseases; they may also be associated with many other unmeasured comorbidities. Because our statistical analysis did not adjust for the number of comorbidities, our finding that physical distress is higher in participants with cardiovascular diseases and diabetes may be due to unmeasured comorbidities. In addition, cardiovascular diseases are the primary causes of illness and death among people with diabetes (22) and have a negative effect on quality of life (23).

Our finding of more frequent activity limitations among respondents with at least 1 chronic condition may be a consequence of impaired physical health among the chronically ill population. Physical pain, fatigue, or other limitations may prohibit chronically ill people from engaging in exercise or physical activities. Engaging in such health promotion behaviors, however, and being able to make choices that reflect personal needs and goals are positive characteristics related to quality of life among older adults (24). Thus, applying motivational interviewing techniques (25) to help patients identify their problems and adopt a health-promoting lifestyle early in a disease course, combined with customized medication or treatment that empowers patients to manage their conditions, may improve their quality of life.

Various disease-specific quality-of-life scales have been developed and validated (26-29). Although disease-specific measures provide additional valuable information, they could be more time-consuming than a simple general health questionnaire for respondents to complete. In a general health survey such as BRFSS, a short, valid, generic scale that is applicable across conditions and groups is practical and preferable (30). The CDC HRQOL-4 measures used in BRFSS reflect general HRQOL and compare well against other HRQOL measures, such as the Medical Outcomes Study 36-Item Short-Form Health Survey and the Quality of Well-Being Scale (12,31-33).

Managing chronic illness, especially for people with multiple conditions, presents substantial challenges to professionals in all arenas of health care. Health professionals seek not only to develop better strategies to manage chronic disorders and prevent complications but also to maintain or enhance the functional abilities of people who are chronically ill. Clinician awareness of patients' needs early in their care may reduce the effect of chronic comorbidities on HRQOL. By targeting outcomes that patients seem to value most, clinicians could provide customized treatment plans that patients are more motivated to follow. Thus, a better understanding of HRQOL related to chronic conditions may lead to more effective preventive education and improved care of patients with chronic illness.

Our study had several limitations. First, BRFSS does not survey people who are hospitalized or institutionalized. People with severe conditions might not have been able to answer the telephone or be interviewed. For example, stroke survivors interviewed through BRFSS may have less severe disabilities than the total population of stroke survivors. BRFSS also excludes people with no telephones or people who use only cellular telephones. People who use only cellular telephones tend to be younger and may have fewer chronic conditions (34), whereas people with no telephones are usually from a lower socioeconomic group, which is associated with poor HRQOL (35). Thus, BRFSS may either underestimate or overestimate the prevalence of people with impaired physical or mental health. Second, the analyses were based on self-reported data, which may be influenced by reporting bias. However, results from previous validation studies showed substantial agreement between self-reported disease status and disease status as documented in medical records (36). Third, since BRFSS did not include questions about the severity of impairment resulting from conditions or comorbidities, we were unable to assess the association between severity of impairment and HRQOL. It is possible that people who report better physical health or fewer activity limitations had a less severe impairment from their conditions than those who reported worse HRQOL. However, in our analyses, we were able to categorize respondents by the number of conditions they had and to assess the association with self-reported HRQOL. Finally, the cross-sectional study design allowed us to demonstrate only an association. Future studies using a longitudinal design are necessary to assess the temporal sequence of the onset of the chronic conditions and the change in HRQOL.

Despite these potential limitations, our findings suggest that HRQOL varies substantially by the category and number of chronic conditions. The prevalence and AORs of frequent physical distress vary more widely across the chronic conditions and appear to be higher than those of frequent mental distress; HRQOL consistently decreases as the number of conditions increases. Strategies by individual clinicians and teams providing customized medication or treatment to improve the HRQOL of their patients should focus on preventing sequelae and comorbidities of the patient's chronic disease and targeting the areas that the patient values most, such as the ability to perform daily activities, a desired recreational activity, or playing with grandchildren. Motivating patients to take charge of their disease management and adopt healthy lifestyles that improve physical health may improve their HRQOL. On a broad scale, health care organizations could focus care management resources on enhancing communication with patients and guiding them in making choices to improve their health and HRQOL.

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Author Information

Corresponding Author: Han-Yang Chen, MS, Center for Urban Population Health, University of Wisconsin School of Medicine and Public Health, 1020 N 12th St, Suite 4180, Milwaukee, WI 53233. Telephone: 414-219-5181. E-mail: chen25@wisc.edu.

Author Affiliations: Dennis J. Baumgardner, Jessica P. Rice, Center for Urban Population Health, University of Wisconsin School of Medicine and Public Health, Milwaukee, Wisconsin. Dr Baumgardner is also affiliated with the Aurora UW Medical Group, Milwaukee, Wisconsin.

References

1. Chronic diseases: the power to prevent, the call to control: at a glance 2009. Centers for Disease Control and Prevention. http://www.cdc.gov/nccdphp/publications/AAG/chronic.htm#aag. Accessed November 1, 2009.
2. US Department of Health and Human Services. Healthy people 2010. 2nd edition. With understanding and improving health and objectives for improving health. 2 vols. Washington (DC): US Government Printing Office; 2000.
3. Moriarty DG, Kobau R, Zack MM, Zahran HS. Tracking healthy days — a window on the health of older adults. Prev Chronic Dis 2005;2(3). http://www.cdc.gov/pcd/issues/2005/jul/05_0023.htm. Accessed August 31, 2010.
4. Measuring healthy days: population assessment of health-related quality of life. Centers for Disease Control and Prevention; 2000. http://www.cdc.gov/hrqol/pdfs/mhd.pdf. Accessed August 31, 2010.
5. Thorpe KE, Howard DH. The rise in spending among Medicare beneficiaries: the role of chronic disease prevalence and changes in treatment intensity. Health Aff (Millwood) 2006;25(5):w378-88.
6. Walker AE. Multiple chronic diseases and quality of life: patterns emerging from a large national sample, Australia. Chronic Illn 2007;3(3):202-18.
7. Vogeli C, Shields AE, Lee TA, Gibson TB, Marder WD, Weiss KB, et al. Multiple chronic conditions: prevalence, health consequences, and implications for quality, care management, and costs. J Gen Intern Med 2007;22 Suppl 3:391-5.
8. Behavioral Risk Factor Surveillance System survey data. Centers for Disease Control and Prevention; 2007. http://www.cdc.gov/brfss/technical_infodata/surveydata/2007.htm. Accessed August 31, 2010.
9. Hennessy CH, Moriarty DG, Zack MM, Scherr PA, Brackbill R. Measuring health-related quality of life for public health surveillance. Public Health Rep 1994;109(5):665-72.
10. Andresen EM, Catlin TK, Wyrwich KW, Jackson-Thompson J. Retest reliability of surveillance questions on health related quality of life. J Epidemiol Community Health 2003;57(5):339-43.
11. Bombard JM, Powell KE, Martin LM, Helmick CG, Wilson WH. Validity and reliability of self-reported arthritis: Georgia senior centers, 2000-2001. Am J Prev Med 2005;28(3):251-8.
12. Measuring healthy days: population assessment of health-related quality of life. Atlanta (GA): Centers for Disease Control and Prevention; 2000. http://www.cdc.gov/hrqol/pdfs/mhd.pdf. Accessed August 31, 2010.
13. Jiang Y, Hesser JE. Associations between health-related quality of life and demographics and health risks. Results from Rhode Island's 2002 behavioral risk factor survey. Health Qual Life Outcomes 2006;4:14.
14. Strine TW, Okoro CA, Chapman DP, Balluz LS, Ford ES, Ajani UA, et al. Health-related quality of life and health risk behaviors among smokers. Am J Prev Med 2005;28(2):182-7.
15. Ford ES, Mannino DM, Homa DM, Gwynn C, Redd SC, Moriarty DG, et al. Self-reported asthma and health-related quality of life: findings from the Behavioral Risk Factor Surveillance System. Chest 2003;123(1):119-27.
16. Heo M, Allison DB, Faith MS, Zhu SK, Fontaine KR. Obesity and quality of life: mediating effects of pain and comorbidities. Obes Res 2003;11(2):209-16.
17. Greenlund KJ, Giles WH, Keenan NL, Croft JB, Mensah GA. Physician advice, patient actions, and health-related quality of life in secondary prevention of stroke through diet and exercise. Stroke 2002;33(2):565-71.
18. Valdmanis V, Smith DW, Page MR. Productivity and economic burden associated with diabetes. Am J Public Health 2001;91(1):129-30.
19. Dominick KL, Ahern FM, Gold CH, Heller DA. Health-

related quality of life among older adults with arthritis. Health Qual Life Outcomes 2004;2:5.
20. Bethell C, Lansky D, Fiorillo J. A portrait of the chronically ill in America, 2001. A report from the Robert Wood Johnson Foundation National Strategic Indicator Surveys. Portland (OR): Foundation for Accountability; 2001.
21. Snoek FJ. Quality of life: a closer look at measuring patients' well-being. Diabetes Spectr 2000;13:24-8.
22. Engelgau MM, Geiss LS, Saaddine JB, Boyle JP, Benjamin SM, Gregg EW, et al. The evolving diabetes burden in the United States. Ann Intern Med 2004;140(11):945-50.
23. de Visser CL, Bilo HJ, Groenier KH, de Visser W, Jong Meyboom-de B. The influence of cardiovascular disease on quality of life in type 2 diabetics. Qual Life Res 2002;11(3):249-61.
24. Mowad L. Correlates of quality of life in older adult veterans. West J Nurs Res 2004;26(3):293-306.
25. Miller WR, Rollnick S. Motivational interviewing: preparing people to change. New York (NY): Guilford Press; 2002.
26. Williams LS, Weinberger M, Harris LE, Clark SO, Biller J. Development of a stroke-specific quality of life scale. Stroke 1999;30(7):1362-9.
27. Polonsky WH, Anderson BJ, Lohrer PA, Welch G, Jacobson AM, Aponte JE, et al. Assessment of diabetes-related distress. Diabetes Care 1995;18(6):754-60.
28. Juniper EF, Guyatt GH, Epstein RS, Ferrie PJ, Jaeschke R, Hiller TK. Evaluation of impairment of health related quality of life in asthma: development of a questionnaire for use in clinical trials. Thorax 1992;47(2):76-83.
29. Thompson DR, Jenkinson C, Roebuck A, Lewin RJP, Boyle RM, Chandola T. Development and validation of a short measure of health status for individuals with acute myocardial infarction: the myocardial infarction dimensional assessment scale (MIDAS). Qual Life Res 2002;11(6):535-43.
30. Verbrugge LM, Merrill SS, Liu X. Measuring disability with parsimony. Disabil Rehabil 1999;21(5-6):295-306.
31. Newschaffer CJ. Validation of Behavioral Risk Factor Surveillance System (BRFSS) HRQOL measures in a statewide sample. Atlanta (GA): Centers for Disease Control and Prevention; 1998.
32. Schecter S, Beatty P, Willis GB. Asking survey respondents about health status: judgment and response issues. In: Schwarz N, Park DC, Knäuper B, Sudman S, editors. Cognition, aging, and self-reports. Philadelphia (PA): Psychology Press; 1999.
33. Andresen EM, Fouts BS, Romeis JC, Brownson CA. Performance of health-related quality-of-life instruments in a spinal cord injured population. Arch Phys Med Rehabil 1999;80(8):877-84.
34. The cell phone challenge to survey research. Pew Research Center for the People and the Press; 2006. http://people-press.org/report/276/. Accessed September 1, 2010.
35. Robert SA, Cherepanov D, Palta M, Dunham NC, Feeny D, Fryback DG. Socioeconomic status and age variations in health-related quality of life: results from the National Health Measurement Study. J Gerontol B Psychol Sci Soc Sci 2009;64(3):378-89.
36. Brownson RC, Jackson-Thompson J, Wilkerson JC, Kiani F. Reliability of information on chronic disease risk factors collected in the Missouri Behavioral Risk Factor Surveillance System. Epidemiology 1994;5(5):545-9.

Tables

Table 1. Sample Characteristics, Behavioral Risk Factor Surveillance System (n = 430,912), United States, 2007

Characteristic	Weighted %[a]
Age, y	
18-44	50
45-64	33
≥65	17
Sex	
Men	49
Women	51
Race/ethnicity	
Non-Hispanic white	69
Non-Hispanic black	10
Hispanic	15
Other	6
Education	
Less than high school	12
High school diploma	29
More than high school	60
Annual household income, $	
<25,000	22
25,000-49,999	23
50,000-74,999	15
≥75,000	27
Don't know/not sure/refused	13
Employment status	
Employed	61
Unemployed	5
Homemaker/student	13
Retired	16
Unable to work	5
Health insurance coverage	
No	15
Yes	85
Marital status	
Married	61
Single, previously married	18
Single, never married	18
Member of an unmarried couple	4
Smoking behavior	
Current smoking[b]	19
No current smoking	81
Drinking behavior	
Heavy drinking[c]	5
No heavy drinking	95
Physical activity behavior	
No physical activity[d]	9
Some physical activity	91

[a] Weighted N = 230,172,178.
[b] Current smoking defined as ever having smoked at least 100 cigarettes and now smoking every day or some days.
[c] Heavy drinking defined as more than 2 alcoholic drinks per day for men and more than 1 alcoholic drink per day for women during the previous 30 days.
[d] No physical activity defined as not participating in any physical activity during the previous 30 days.

Table 2. Prevalence of Chronic Conditions, Behavioral Risk Factor Surveillance System (n = 430,912), United States, 2007

Condition[a]	Overall, %	1 Condition, %	2 Conditions, %	≥3 Conditions, %
Any	57	50	27	23
Asthma	8	33	28	39
Arthritis	27	30	31	39
Cardiovascular disease				
Myocardial infarction	4	6	16	78
Angina	4	6	15	78
Stroke	3	9	19	73
Diabetes	9	11	23	67
Obesity	26	37	29	34
Hypertension	28	25	34	41

[a] Respondents were categorized as having a condition if they had ever been diagnosed with it by a health professional or, in the case of obesity, if their body mass index (calculated from self-reported weight and height) was ≥30 kg/m^2.

Table 3. Prevalence of Health-Related Quality of Life Outcomes, by Chronic Conditions, Behavioral Risk Factor Surveillance System (n = 430,912), United States, 2007

Condition[a]	Fair or Poor Health, %	Frequent Physical Distress,[b] %	Frequent Mental Distress,[b] %	Frequent Activity Limitations,[b] %
Asthma	30	23	19	15
Arthritis	31	23	15	14
Cardiovascular disease				
Myocardial infarction	53	34	17	21
Angina	53	35	18	22
Stroke	53	38	20	24
Diabetes	48	28	16	17
Obesity	25	16	13	10
Hypertension	31	20	13	12
Number of conditions				
0	7	4	7	3
1	14	9	10	6
2	24	16	13	10
≥3	47	32	18	20

[a] Respondents were categorized as having a condition if they had ever been diagnosed with it by a health professional or, in the case of obesity, if their body mass index (calculated from self-reported weight and height) was ≥30 kg/m^2.
[b] On ≥14 days of the preceding 30 days.

Table 4. Health-Related Quality of Life Outcomes, by Chronic Conditions, Behavioral Risk Factor Surveillance System (n = 430,912), United States, 2007[a]

Condition[b]	Fair or Poor Health, AOR (95% CI)	Physical Distress,[c] AOR (95% CI)	Mental Distress,[c] AOR (95% CI)	Activity Limitations,[c] AOR (95% CI)
No condition	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Asthma	4.7 (4.3-5.1)	3.9 (3.6-4.3)	2.3 (2.2-2.6)	3.1 (2.8-3.5)
Arthritis	4.5 (4.2-4.8)	4.0 (3.7-4.3)	2.5 (2.3-2.6)	3.3 (3.0-3.6)
Cardiovascular disease				
Myocardial infarction	8.3 (7.6-9.2)	4.8 (4.4-5.3)	2.5 (2.3-2.8)	3.9 (3.5-4.4)
Angina	9.2 (8.4-10.0)	5.4 (4.9-6.0)	2.8 (2.5-3.1)	4.2 (3.8-4.7)
Stroke	6.9 (6.2-7.7)	4.8 (4.3-5.4)	2.5 (2.2-2.9)	3.7 (3.3-4.2)
Diabetes	7.6 (7.0-8.3)	4.2 (3.8-4.5)	2.3 (2.1-2.5)	3.1 (2.8-3.4)
Obesity	3.5 (3.3-3.8)	2.7 (2.5-2.9)	1.8 (1.7-2.0)	2.4 (2.2-2.6)
Hypertension	4.3 (4.0-4.6)	3.1 (2.8-3.3)	2.0 (1.9-2.2)	2.7 (2.4-2.9)
Number of conditions				
1	2.1 (1.9-2.3)	1.9 (1.7–2.0)	1.5 (1.4-1.6)	1.7 (1.6-1.9)
2	3.7 (3.4-4.0)	3.0 (2.8-3.3)	2.1 (1.9-2.2)	2.5 (2.3-2.8)
≥3	8.7 (8.0-9.4)	5.5 (5.1-5.9)	2.9 (2.7-3.1)	4.1 (3.8-4.5)

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.
[a] Adjusted by age, sex, race/ethnicity, education, income, employment, health insurance coverage status, marital status, and 3 risk behaviors: smoking, heavy drinking, and no physical activity. All AORs are significant at $P < .001$.
[b] Respondents were categorized as having a condition if they had ever been diagnosed with it by a health professional or, in the case of obesity, if their body mass index (calculated from self-reported weight and height) was ≥30 kg/m^2.
[c] On ≥14 days of the preceding 30 days.

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ORIGINAL RESEARCH

Actions to Control Hypertension Among Adults in Oklahoma

Jennifer L. Han, PhD

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PEER REVIEWED

Abstract

Introduction

Hypertension is a chronic condition that can be managed with self-monitoring, lifestyle changes, and medication. The purpose of this study was to describe receipt of physician's treatment advice and use of treatments to manage hypertension among Oklahoma's adult population.

Methods

A random-digit–dialed telephone survey was administered to noninstitutionalized adult residents of Oklahoma (n = 7,463) in 2007. Respondents who indicated that they had ever had hypertension (n = 2,937) were asked whether a doctor had advised them on each of 5 general management techniques and whether they used these techniques to manage their condition. Data were weighted and a descriptive analysis of the age-adjusted rates was performed.

Results

Of all hypertensive adults, 91% had received advice from a physician regarding treatment options, and medication was the most commonly recommended therapy (80%). Almost all hypertensive adults were managing their hypertension through use of medication or lifestyle modification, and reducing salt intake was the most common treatment used (74%). Physician advice and individual treatment choices varied by demographic characteristics, although respondents more commonly used a treatment method that was advised by a physician.

Conclusion

Doctors should advise hypertensive patients of treatment options because patients may be more likely to use 1 or more physician-advised options to manage their condition. Efforts should be made to enhance physicians' ability to educate patients about the effects of hypertension and ways in which hypertension can be treated, in addition to enhancing the patients' knowledge of prevention and treatment strategies.

Introduction

Hypertension is a major risk factor for cardiovascular and kidney disease and a major contributor to premature deaths (1). In 2005-2006, almost 30% of US adults lived with hypertension (systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg), and another 28% of US adults had prehypertension (systolic pressure of 120-139 mm Hg or diastolic pressure of 80-89 mm Hg), a condition that puts them at increased risk of developing hypertension (2). Hypertension is a silent disease; as many as 20% of people with hypertension are not aware that they have the condition (2). Irreversible damage can occur in people who are unaware that they have hypertension for years before a diagnosis is made. In people who are aware that they have the disease, complications arise for several reasons: not obtaining physician assistance, not being adequately educated about treatment options (3-5), having uncontrolled blood pressure (1,2,6,7), and failing to adhere to prescribed treatment (8-11).

Prevalence of hypertension and cardiovascular disease, as well as death rates due to cardiovascular and kidney disease, is higher in Oklahoma compared with the rest of the nation (12,13). Furthermore, demographic differences in disease prevalence and mortality exist (2,12,13). Among Oklahoma's adult population, hypertension is more common among those who are older, black, obese, poorer, and less educated (14). Although almost 32% of Oklahoma adults have hypertension (14), how they manage their condition is unknown. Early detection of hypertension and treatment with medication and lifestyle modification may reduce the burden of illness and premature death in Oklahoma (1).

This study was conducted to ascertain how Oklahoma adults who have hypertension control their disease. Hypertensive adults who received treatment advice from a physician were analyzed to determine which treatment methods they used. Treatment options that physicians advised and the actions taken by patients were assessed to determine whether disparities existed among demographic groups.

Methods

The Behavioral Risk Factor Surveillance System (BRFSS) is the largest ongoing state- and territory-based telephone survey of health behaviors and disease prevalence in the United States. In Oklahoma, BRFSS is coordinated by the Oklahoma State Department of Health, whose in-house call center uses computer-assisted telephone interviewing software to administer the questionnaire to Oklahoma residents aged 18 years or older living in a noninstitutionalized setting. Participants were selected by random-digit-dialing of phone numbers stratified across 6 regions of the state. Only those telephone numbers associated with landlines in residences were considered valid numbers. The BRFSS protocol has exempt status from the institutional review board of the Human Research Protection Office, Department of Health and Human Services under 45 CFR 46.101(b)(2).

Interviewers asked respondents, "Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?" If respondents answered yes, interviewers then asked respondents a series of questions regarding how they managed their blood pressure and whether a doctor had advised them of the various treatment options available to manage blood pressure (Appendix). Treatment options included taking medication, modifying diet, reducing salt intake and alcohol consumption, and participating in physical activity.

From January to December 2007, the call center completed interviews with 7,463 noninstitutionalized Oklahoma residents aged 18 years or older. The overall response rate ranged from 49% to 52% per month (15). Data were sent to the Centers for Disease Control and Prevention (CDC) for processing and were returned to the state for analysis. CDC weighted the data, adjusting for noncoverage, nonresponse, and the number of adults and telephones in the household (16).

The researcher analyzed blood pressure management items and physician advice for the 2,937 respondents who indicated that they had hypertension. Mutually exclusive racial and ethnic categories were created (white, black, American Indian not of Hispanic origin, Hispanic, and other); however, in-depth analyses by individual race or ethnicity were not possible, given the small sample sizes in the nonwhite categories. Body mass index was grouped into 3 categories: underweight/normal weight (<25.0 kg/m^2), overweight (25.0-29.9 kg/m^2), and obese (≥30.0 kg/m^2). Respondents who were nonconsumers of salt and alcoholic beverages were excluded from analysis of demographic differences in reducing salt and alcohol consumption, respectively. Records with missing data were excluded from summary analyses specific to the variable to which the missing data pertained.

The researcher age-adjusted the data to the 2000 US standard population (17) and used SAS version 9.2 (SAS Institute, Inc, Cary, North Carolina) and SAS-callable SUDAAN version 10.0 (RTI International, Research Triangle Park, North Carolina) to account for the survey's complex sampling design. Descriptive statistics were determined and pairwise comparisons in age-adjusted rates among groups were evaluated by comparing the 95% confidence intervals. Differences in taking action between respondents who received a physician's advice and those who did not were assessed via *t* tests. Significance was set at $\alpha = .05$.

Results

Characteristics of Oklahoma's hypertensive population

In 2007, 31.5% of Oklahoma adults (n = 2,937) had been told by a health professional that they had hypertension.

Most respondents with hypertension were aged 45 years or older and were overweight or obese (Table 1). Almost two-thirds of respondents with hypertension were married, and more than half had lower levels of education (high school diploma/general educational development certification completion or less).

Doctor's advice to manage blood pressure

Almost 91% of hypertensive adults had received physician counseling regarding treatment options for their condition. Seventeen percent were advised of all treatment options inquired about by BRFSS, and 13.5% were advised of only 1 of the 5 options. Taking medication was the treatment most commonly advised by doctors (Table 2). Almost 10% of hypertensive adults did not receive treatment advice from their doctor.

Differences in age-adjusted rates of treatment advice were evident by sex and age (Table 2). The sole sex-based discrepancy in treatment advice was that doctors more often counseled women than they did men to take medication. Doctors also recommended medication more often as patients' age increased. Doctors more commonly advised patients aged 45 to 64 years to change their diet and exercise, and less frequently advised seniors aged 65 years or older to limit alcohol consumption. There were few socioeconomic differences for type of treatment advice received.

Individual actions taken to manage blood pressure

Most respondents with hypertension (94.6%) were taking action to manage their condition, and approximately 84% were using more than one type of treatment. Reducing salt intake was the most common treatment being followed (Table 3). Only 5.4% of respondents were not managing their hypertension by using any of the methods inquired about by the BRFSS.

Demographic differences were apparent with respect to methods commonly used to manage blood pressure (Table 3). For example, more women than men took medication as a means of managing blood pressure. Use of medication increased with age, and respondents aged 45 to 64 years were more likely to have modified their diet and reduced alcohol consumption than older adults. A small percentage of obese adults were exercising, and college graduates and respondents with a household income of at least $50,000 were less often reducing alcohol intake than were respondents at lower levels of education and income levels, respectively.

Following doctor's advice to manage blood pressure

A large proportion of residents who were advised by their doctors to take specific action to manage their blood pressure indicated that they were doing so (Table 4). For instance, 80% of respondents who were advised to take medication used some form of medication, and more than 80% of respondents who were counseled to modify their diet and reduce salt or alcohol intake were following their doctors' advice. Some residents engaged in behaviors to improve their blood pressure without being told to do so by a physician. Reducing salt intake was the most frequent modification made by such people. Of the 10% of people who were not counseled by a physician, approximately one-third were not managing their blood pressure via any method inquired about in the survey.

Discussion

Of the 31.5% of Oklahoma adults who had hypertension, almost 91% had received advice from a physician regarding how to manage their condition, and approximately 95% were managing their hypertension through using medication, modifying their diet, reducing salt or alcohol intake, or exercising. Medication was the most common treatment advised by a physician, irrespective of demographic, and reducing salt intake was the most common treatment used by the population as a whole. Although demographic differences existed with respect to advice given and treatment used, patterns were not consistent. In general, respondents more often used a specific type of treatment when it was advised by a physician.

The primary reason for managing blood pressure is to reduce illness and death related to heart disease, stroke, and kidney disease (1,2). Medication is the primary treatment for hypertension, and several classes of medications can be taken to assist with lowering blood pressure. Most people require more than 1 medication to control their condition (1) and may use different medications before finding the most effective one. Because medications are key to reducing hypertension and its associated risk of stroke and other debilitating events and taking medication may be simpler to accomplish than incorporating several lifestyle changes (11), it was not surprising that medication was the most commonly advised treatment among Oklahomans. It was also the most commonly used treatment for adults aged 45 years or older, perhaps because of its effectiveness at reducing risk of chronic diseases associated with hypertension and because older adults may have difficulty managing their condition (18,19). However, the BRFSS survey did not include questions about type and number of medications being used, adherence to prescribed treatment, and whether blood pressure was under control.

Lifestyle modifications are necessary to prevent and manage hypertension. Such modifications include dietary changes (ie, adopting the DASH [Dietary Approaches to Stop Hypertension] eating plan, which involves eating more fruits, vegetables, and low-fat dairy products and fewer saturated fats), reducing sodium and alcohol consumption, engaging in regular physical activity, and maintaining a healthy weight (1). Of the lifestyle treatments inquired about by BRFSS, exercising and reducing salt intake were most commonly advised for Oklahoma adults, followed by making dietary modifications. Although these lifestyle treatments enable modest reductions in blood pressure, weight loss and weight control can have a greater effect on blood pressure (1) and may lower the risk of developing hypertension for people who do not already have the condition (1,20,21). Studies have demonstrated that weight loss and weight control are prominent treatments advised by physicians to their patients (3,4), yet questions regarding weight control as a treatment for hypertension were not included in the BRFSS survey. Modifying the diet and engaging in physical activity are actions that may lead to weight loss, however, and should be recommended to people who are overweight and obese. Both of these lifestyle treatments were advised more commonly for hypertensive Oklahomans who were obese, a finding similar to that of Mellen et al (5), although results from the Oklahoma BRFSS were not significant.

In general, people more often used a treatment that was recommended by a physician. This observation underscores the importance of supplying people who have been diagnosed with hypertension with enough information to make informed decisions, including strategies to assist them in making key lifestyle changes. Overall, 10% of hypertensive Oklahomans received no physician advice, and almost one-third of these people were not managing their blood pressure via using medication, making dietary changes, reducing salt and alcohol intake, or exercising, which puts them at higher risk of developing cardiovascular and kidney diseases (2). Of respondents who received advice from a physician, few were informed of all available treatment options inquired about in the BRFSS survey, although advice rates for lifestyle modifications were much higher than those observed in other studies (3,5).

There are several possible reasons why patients were not advised of all treatment options, including having a less severe condition or lack of other risk factors. Perhaps some physicians did not have sufficient time to spend with patients (22), underestimated their risk (23), or believed that patients do not listen or understand the problem (22). Physicians may be less likely to provide lifestyle recommendations and intensive counseling because they lack the training in lifestyle counseling to do so (3,5). Also, patients may not remember having received information regarding a specific treatment and thus would not have responded positively to the BRFSS survey questions regarding treatment advice. Regardless, not fully educating patients on all available treatments may affect their ability to make well-informed decisions and inhibits the ability to experiment with various treatments to find the single treatment or combination of treatments that is most successful. Even considering differences in patients' health histories and disease severity, lifestyle modifications alone would benefit patients' overall health, particularly their cardiovascular health.

Managing hypertension is difficult, and as many as 65% of people in the United States do not have good control over their condition, meaning their blood pressure is not maintained below 140/90 mm Hg (7). Physicians should educate patients on treatment options and the consequences of leaving hypertension untreated, and patients should adhere to their doctors' advice. Adherence, sometimes referred to as compliance, is estimated to be 50% for medication use and even lower for behavior modifications (11). Although a large percentage of respondents were estimated to have followed their physicians' treatment advice, adherence rates could not be determined with the BRFSS survey. Fewer people were likely actually adhering to their physicians' recommendations than was estimated.

Recommendations for improving patient adherence to treatment have been published (1). Advice from a physician may act as a primer for forthcoming information, improve recall, improve the sharing of information with others, and perhaps effect behavior change (24).

Physicians should discuss the consequences of allowing hypertension to go untreated, as they sometimes do not (3). Advice is not enough to effect compliance and long-term adherence, however. The consensus is that patients must be motivated to adhere to a regimen, and although patients should take personal responsibility for their actions, they also require education, reinforcement, individualized programs, monitoring, and other types of assistance from health care professionals to ensure successful treatment (1,18,20,25). Health promotion efforts that target physicians in an effort to improve their rates of providing advice, introduce novel ways of educating their patients, and assist them in increasing adherence would benefit both the physician and patient.

There are several strengths to this study. The sample was a stratified random sample of Oklahoma's noninstitutionalized adult population. Data were weighted to reduce bias and to provide a more accurate representation of the population from which the sample was drawn. Statistical analysis used methods most appropriate for weighted data.

There are also some limitations to this study. Households without landline telephones were not included in the 2007 survey, and people who live in cell-phone-only households may have different health risks and behaviors than people who live in households with landline service. Respondents may have provided answers to questions that they thought would be more appropriate, potentially introducing social desirability bias to the data, which tends to overreport good behavior and underreport bad behavior. Because BRFSS surveys a cross-section of the population, associations rather than cause-and-effect relationships were assessed. Comorbidities were not evaluated, and the survey did not include questions about when the respondents' last blood pressure screening occurred, whether they currently had high blood pressure, whether they were truly compliant with their physicians' advice, and whether their blood pressure was under control.

In summary, almost 91% of Oklahoma adults with hypertension had received advice from a physician regarding how to manage their condition, and approximately 95% were managing their hypertension through some combination of using medication, modifying diet, reducing salt or alcohol intake, or exercising. Respondents who received advice from a doctor about a specific type of treatment had higher rates of using that type of treatment. Therefore, efforts should be made to enhance physicians' ability to educate patients about the effects of hypertension and ways in which hypertension can be treated.

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Author Information

Jennifer L. Han, PhD, Staff Analyst, Health Care Information, Oklahoma State Department of Health, 1000 NE 10th St, Oklahoma City, OK 73117-1299. Telephone: 405-271-6225. E-mail: jenniferlh@health.ok.gov.

References

1. National High Blood Pressure Education Program. The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Bethesda (MD): National Institutes of Health; 2003. http://www.nhlbi.nih.gov/guidelines/hypertension/jnc7full.pdf. Accessed May 27, 2009.
2. Ostchega Y, Yoon SS, Hughes J, Louis T. Hypertension awareness, treatment, and control — continued disparities in adults: United States, 2005-2006. NCHS data brief no. 3. Hyattsville (MD): National Center for Health Statistics; 2008. http://www.cdc.gov/nchs/data/databriefs/db03.pdf. Accessed May 27, 2009.
3. Bell RA, Kravitz RL. Physician counseling for hypertension: what do doctors really do? Patient Educ Couns 2008;72(1):115-21.
4. Frijling BD, Lobo CM, Hulscher ME, van Drenth BB, Braspenning JC, Prins A, et al. Provision of information and advice in cardiovascular care: clinical performance of general practitioners. Patient Educ Couns 2002;48(2):131-7.
5. Mellen PB, Palla SL, Goff DC Jr, Bonds DE. Prevalence of nutrition and exercise counseling for patients with hypertension. United States, 1999 to 2000. J Gen Intern Med 2004;19(9):917-24.
6. Wolf-Maier K, Cooper RS, Kramer H, Banegas JR, Giampaoli S, Joffres MR, et al. Hypertension treatment and control in five European countries, Canada,

and the United States. Hypertension 2004;43(1):10-7.
7. Cutler JA, Sorlie PD, Wolz M, Thom T, Fields LE, Roccella EJ. Trends in hypertension prevalence, awareness, treatment, and control rates in United States adults between 1988-1994 and 1999-2004. Hypertension 2008;52(5):818-27.
8. Krousel-Wood M, Thomas S, Muntner P, Morisky D. Medication adherence: a key factor in achieving blood pressure control and good clinical outcomes in hypertensive patients. Curr Opin Cardiol 2004;19(4):357-62.
9. Ockene IS, Hayman LL, Pasternak RC, Schron E, Dunbar-Jacob J. Task Force #4 — adherence issues and behavior changes: achieving a long-term solution. 33rd Bethesda Conference. J Am Coll Cardiol 2002;40(4):630-40.
10. Harmon G, Lefante J, Krousel-Wood M. Overcoming barriers: the role of providers in improving patient adherence to antihypertensive medications. Curr Opin Cardiol 2006;21(4):310-5.
11. Haynes RB, McDonald HP, Garg AX. Helping patients follow prescribed treatment: clinical applications. JAMA 2002;288(22):2880-3.
12. Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System survey data. Atlanta (GA): US Department of Health and Human Services; 2007. http://apps.nccd.cdc.gov/brfss/. Accessed February 23, 2009.
13. Centers for Disease Control and Prevention, National Center for Health Statistics. Compressed Mortality File 1999-2005. CDC WONDER On-line database, compiled from Compressed Mortality File 1999-2005 Series 20 No. 2K, 2008. http://wonder.cdc.gov/cmf-icd10.html. Accessed May 28, 2009.
14. Health Care Information. Behavioral Risk Factor Surveillance System Survey Data, 2007. Oklahoma City (OK): Oklahoma State Department of Health, Center for Health Statistics; 2007.
15. Centers for Disease Control and Prevention. 2007 Data quality report for Oklahoma, Behavioral Risk Factor Surveillance System. Atlanta (GA): US Department of Health and Human Services; March 3, 2008.
16. Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System operational and user's guide, version 3.0. Atlanta (GA): US Department of Health and Human Services. ftp://ftp.cdc.gov/pub/Data/Brfss/userguide.pdf. Accessed November 4, 2009.
17. Klein RJ, Schoenborn CA. Age adjustment using the 2000 projected US population. Healthy people statistical notes, no. 20. Hyattsville (MD): National Center for Health Statistics; January 2001.
18. King DE, Ellis TM, Everett CJ, Mainous AG. Medication use for diabetes, hypertension, and hypercholesterolemia from 1988-1994 to 2001-2006. South Med J 2009;102(11):1127-32.
19. Lloyd-Jones DM, Evans JC, Levy D. Hypertension in adults across the age spectrum. JAMA 2005;294(4):466-72.
20. The Trials of Hypertension Prevention Collaborative Research Group A. Effects of weight loss and sodium reduction interventions on blood pressure and hypertension incidence in overweight people with high-normal blood pressure: The Trials of Hypertension Prevention, phase II. Arch Intern Med 1997;157(6):657-67.
21. He J, Whelton PK, Appel LJ, Charleston J, Klag MJ. Long-term effects of weight loss and dietary sodium reduction on incidence of hypertension. Hypertension 2000;35(2):544-9.
22. Hobbs FD, Erhardt L. Acceptance of guideline recommendations and perceived implementation of coronary heart disease prevention among primary care physicians in five European countries: The Reassessing European Attitudes about Cardiovascular Treatment (REACT) survey. Fam Pract 2002;19(6):596-604.
23. Wexler R, Elton T, Taylor CA, Pleister A, Feldman D. Physician reported perception in the treatment of high blood pressure does not correspond to practice. BMC Fam Pract 2009;10:23.
24. Kreuter MW, Chheda SG, Bull FC. How does physician advice influence patient behavior? Arch Fam Med 2000;9(5):426-33.
25. Roumie CL, Elasy TA, Greevy R, Griffin MR, Liu X, Stone WJ, et al. Improving blood pressure control through provider education, provider alerts, and patient education. Ann Intern Med 2006;145(3):165-75.

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Tables

Table 1. Demographic Characteristics of Survey Respondents Who Have Hypertension (N = 2,937), Behavioral Risk Factor Surveillance System, Oklahoma, 2007

Characteristics	Sample Size[a] (N = 2,937)	Weighted %[b] (95% CI)
Sex		
Male	1,035	50.2 (47.9-52.5)
Female	1,902	49.8 (47.5-52.1)
Age, y		
18-44	320	21.2 (18.8-23.6)
45-64	1,174	43.7 (41.4-46.0)
≥65	1,443	35.1 (33.2-37.1)
Body mass index, kg/m^2		
<25.0	701	21.1 (19.3-23.0)
25.0-29.9	1,034	37.3 (35.0-39.6)
≥30.0	1,075	41.6 (39.2-43.9)
Race/ethnicity		
White	2,253	70.7 (68.5-73.0)
Black	202	8.3 (6.9-9.6)
American Indian	186	9.3 (7.6-10.9)
Hispanic	80	4.3 (3.2-5.4)
Other	208	7.4 (6.2-8.6)
Marital status		
Married	1,572	65.7 (63.5-67.8)
Unmarried	1,359	34.3 (32.2-36.5)
Education		
High school diploma or less	1,518	51.1 (48.8-53.4)
Some college/technical school	817	28.1 (26.0-30.1)
College graduate	597	20.8 (19.0-22.6)
Household income, $		
<25,000	1,097	38.2 (35.8-40.6)
25,000-49,999	734	29.3 (27.1-31.5)
≥50,000	680	32.5 (30.1-34.8)

Abbreviation: CI, confidence interval.
[a] Some cells may not add to 2,937 because of missing data. Records with missing data were excluded from summary analyses specific to the variable to which the missing data pertained.
[b] Data were weighted and adjusted for noncoverage, nonresponse, and the number of adults and telephones in the household.

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Table 2. Frequencies of Survey Respondents and Age-Adjusted Estimates of Hypertensive Adults Who Were Advised by a Doctor of Treatments, Behavioral Risk Factor Surveillance System, Oklahoma, 2007

Characteristic	Treatment Advised, Weighted %[a] (95% Confidence Interval)				
	Take Medication	Modify Diet	Reduce Salt Intake[b]	Reduce Alcohol Intake[c]	Exercise
Total (n = 2,937)	80.1 (75.9-83.7)	59.8 (55.7-63.7)	69.4 (65.5-73.0)	33.0 (29.2-37.0)	68.2 (64.1-72.0)
Sex					
Male (n = 1,035)	75.9 (69.8-81.1)	60.0 (54.1-65.6)	68.4 (62.7-73.7)	37.4 (31.9-43.2)	67.0 (61.0-72.4)
Female (n = 1,902)	86.6 (82.1-90.1)	61.3 (56.6-65.9)	70.8 (66.1-75.0)	27.8 (23.4-32.8)	71.3 (66.8-75.5)
Age, y					
18-44 (n = 320)	66.7 (59.1-73.6)	58.6 (51.1-65.7)	67.2 (60.1-73.6)	39.7 (32.9-47.0)	64.3 (56.8-71.2)
45-64 (n = 1,174)	94.0 (92.2-95.4)	67.5 (64.3-70.6)	73.2 (70.1-76.1)	31.0 (27.8-34.3)	75.7 (72.8-78.5)
≥65 (n = 1,443)	97.5 (96.4-98.3)	49.7 (46.7-52.8)	69.4 (66.5-72.1)	15.5 (13.3-17.9)	66.9 (64.1-69.6)
BMI, kg/m^2					
<25.0 (n = 701)	—[d]	—	—	—	—
25.0-29.9 (n = 1,034)	79.1 (71.9-84.9)	55.8 (49.0-62.4)	69.9 (63.4-75.6)	30.1 (24.1-37.0)	64.7 (57.7-71.2)
≥30.0 (n = 1,075)	82.3 (75.9-87.3)	67.2 (60.9-72.9)	70.0 (64.2-75.3)	34.7 (29.0-40.9)	74.3 (68.4-79.5)
Education					
High school diploma or less (n = 1,518)	78.7 (72.4-83.9)	56.3 (50.3-62.1)	69.6 (63.6-74.9)	34.2 (28.6-40.2)	64.0 (58.0-69.5)
Some college/technical school (n = 817)	83.5 (76.3-88.8)	67.6 (60.8-73.7)	68.2 (61.2-74.4)	35.7 (29.0-43.0)	75.3 (68.7-81.0)
College graduate (n = 597)	79.6 (70.2-86.6)	59.0 (50.6-66.9)	70.2 (63.3-76.3)	26.2 (20.2-33.2)	70.1 (61.0-77.9)
Annual income, $					
<25,000 (n = 1,097)	79.9 (72.4-85.7)	59.9 (53.0-66.5)	74.5 (68.3-79.9)	35.8 (29.4-42.8)	68.5 (62.0-74.3)
25,000-49,999 (n = 734)	82.0 (73.3-83.4)	60.4 (52.0-68.2)	70.5 (62.4-77.5)	39.4 (31.6-47.7)	68.8 (60.1-76.4)
≥50,000 (n = 680)	81.6 (74.4-87.2)	62.4 (55.5-68.9)	67.6 (61.2-73.4)	28.9 (23.6-34.9)	74.7 (67.6-80.6)

Abbreviation: BMI, body mass index.
[a] Data were weighted and adjusted for noncoverage, nonresponse, and the number of adults and telephones in the household.
[b] Weighted percentages include only participants who used salt (n = 2,843).
[c] Weighted percentages include only participants who consumed alcohol (n = 1,634).
[d] Records with missing data were excluded from summary analyses specific to the variable to which the missing data pertained. A dash (—) indicates an unstable rate, with standard error >5.0.

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Table 3. Frequencies of Survey Respondents and Age-Adjusted Estimates of Hypertensive Adults Who Took Action to Manage Their Blood Pressure, Behavioral Risk Factor Surveillance System, Oklahoma, 2007

Characteristic	Treatment Advised, Weighted %[a] (95% Confidence Interval)				
	Took Medication	Modified Diet	Reduced Salt Intake[b]	Reduced Alcohol Intake[c]	Exercised
Total (n = 2,937)	66.1 (62.3-69.6)	66.4 (62.4-70.2)	74.2 (70.2-77.8)	59.8 (54.6-64.8)	63.5 (59.8-67.1)
Sex					
Male (n = 1,035)	61.9 (56.9-66.7)	65.8 (60.0-71.2)	73.0 (67.4-78.3)	59.6 (52.5-66.2)	66.1 (60.6-71.2)
Female (n = 1,902)	73.0 (68.1-77.4)	67.1 (62.3-71.6)	75.6 (70.9-79.7)	61.2 (54.6-67.4)	60.5 (55.7-65.1)
Age, y					
18-44 (n = 320)	46.3 (39.7-53.1)	63.8 (56.5-70.5)	70.7 (63.4-77.2)	58.0 (48.8-66.8)	67.0 (60.1-73.3)
45-64 (n = 1,174)	84.2 (81.6-86.4)	73.5 (70.4-76.3)	78.5 (75.4-81.2)	68.6 (63.8-73.0)	60.5 (57.1-63.8)
≥65 (n = 1,443)	95.8 (94.4-96.8)	62.2 (59.2-65.1)	77.3 (74.5-79.8)	49.8 (44.2-55.4)	58.1 (55.1-61.0)
BMI, kg/m²					
<25.0 (n = 701)	59.8 (51.1-67.9)	—[d]	—	—	—
25.0-29.9 (n = 1,034)	63.0 (56.8-68.7)	68.4 (61.9-74.2)	74.1 (67.5-79.8)	53.0 (44.5-61.3)	71.6 (66.1-76.6)
≥30.0 (n = 1,075)	70.2 (64.3-75.5)	66.1 (60.1-71.6)	75.2 (69.1-80.4)	66.4 (58.9-73.2)	56.6 (50.8-62.3)
Education					
High school diploma or less (n = 1,518)	62.3 (57.0-67.3)	63.2 (57.3-68.7)	74.8 (68.6-80.2)	64.6 (57.0-71.6)	59.9 (54.2-65.3)
Some college/technical school (n = 817)	68.1 (61.2-74.4)	69.3 (62.3-75.4)	72.6 (65.3-78.9)	66.4 (57.7-74.1)	65.8 (59.2-71.9)
College graduate (n = 597)	73.2 (64.8-80.2)	70.8 (62.7-77.8)	74.5 (67.7-80.2)	43.6 (34.4-53.3)	69.4 (62.4-75.6)
Annual income, $					
<25,000 (n = 1,097)	61.9 (55.7-67.7)	66.6 (59.9-72.7)	80.7 (74.2-85.9)	72.8 (64.1-80.1)	61.4 (55.2-67.3)
25,000-49,999 (n = 734)	70.7 (62.5-77.7)	68.8 (60.5-76.0)	74.9 (66.5-81.8)	66.2 (56.7-74.5)	61.8 (53.4-69.6)
≥50,000 (n = 680)	69.3 (62.7-75.2)	67.7 (61.1-73.7)	70.9 (64.4-76.6)	47.6 (39.7-55.6)	69.5 (63.5-74.9)

Abbreviation: BMI, body mass index.
[a] Data were weighted and adjusted for noncoverage, nonresponse, and the number of adults and telephones in the household.
[b] Weighted percentages include only those who used salt (n = 2,685).
[c] Weighted percentages include only those who consumed alcohol (n = 1,230).
[d] Records with missing data were excluded from summary analyses specific to the variable to which the missing data pertained. A dash (—) indicates an unstable rate, with standard error > 5.0.

Table 4. Frequencies of Survey Respondents and Age-Adjusted Estimates of Oklahoma's Hypertensive Residents Who Followed a Doctor's Advice or Managed Blood Pressure On Their Own, Behavioral Risk Factor Surveillance System, Oklahoma, 2007[a]

Treatment	Advised by Doctor		Not Advised by Doctor		*P* Value
	Sample Size[b] n/N	Weighted %[c] (95% CI)	Sample Size[b] n/N	Weighted %[c] (95% CI)	
Took medication	2,399/2,614	80.3 (76.0-83.9)	25/174	11.8 (8.1-16.9)	<.05
Modified diet	1,238/1,544	80.4 (76.3-84.0)	584/1,211	46.2 (39.4-53.1)	<.05
Reduced salt intake[d]	1,396/1,602	84.8 (79.9-88.6)	515/886	57.1 (50.3-63.6)	<.05
Reduced alcohol intake[e]	273/324	81.3 (73.1-87.4)	307/674	47.8 (41.2-54.6)	<.05
Exercised	1,256/1,880	71.3 (67.3-75.0)	373/875	47.6 (40.3-55.0)	<.05

Abbreviation: CI, confidence interval.
[a] Records with missing data were excluded from summary analyses specific to the variable to which the missing data pertained.
[b] Sample size refers to the number of respondents who engaged in the action (n)/number of respondents who were advised of the treatment method (N).
[c] Data were weighted and adjusted for noncoverage, nonresponse, and the number of adults and telephones in the household.
[d] Weighted percentages include only those who used salt (n = 2,685).
[e] Weighted percentages include only those who consumed alcohol (n = 1,230).

Appendix. Questions From the Core Survey and Optional Module, Behavioral Risk Factor Surveillance System, Oklahoma, 2007

Respondents who answered yes when asked, "Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?," were asked the questions listed below. Possible responses for each item were yes, no, "don't know/not sure," and "refused." The items pertaining to salt and alcohol also included the responses "do not use salt" and "do not drink," respectively.

From the Core Survey

Question: Are you currently taking medicine for your high blood pressure?

From the Optional Module

Preface: Are you now doing any of the following to help lower or control your high blood pressure?

Question: [Are you] changing your eating habits (to help lower or control your high blood pressure)?

Question: [Are you] cutting down on salt (to help lower or control your high blood pressure)?

Question: [Are you] reducing alcohol use (to help lower or control your high blood pressure)?

Question: [Are you] exercising (to help lower or control your high blood pressure)?

Preface: Has a doctor or other health professional ever advised you to do any of the following to help lower or control your high blood pressure?

Question: [Ever advised you to] change your eating habits (to help lower or control your high blood pressure)?

Question: [Ever advised you to] cut down on salt (to help lower or control your high blood pressure)?

Question: [Ever advised you to] reduce alcohol use (to help lower or control your high blood pressure)?

Question: [Ever advised you to] exercise (to help lower or control your high blood pressure)?

Question: [Ever advised you to] take medication (to help lower or control your high blood pressure)?

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ORIGINAL RESEARCH

Commute Times, Food Retail Gaps, and Body Mass Index in North Carolina Counties

Stephanie B. Jilcott, PhD; Haiyong Liu, PhD; Justin B. Moore, PhD, MS; Jeffrey W. Bethel, PhD; James Wilson, PhD; Alice S. Ammerman, DrPH, RD

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PEER REVIEWED

Abstract

Introduction

The prevalence of obesity is higher in rural than in urban areas of the United States, for reasons that are not well understood. We examined correlations between percentage of rural residents, commute times, food retail gap per capita, and body mass index (BMI) among North Carolina residents.

Methods

We used 2000 census data to determine each county's percentage of rural residents and 1990 and 2000 census data to obtain mean county-level commute times. We obtained county-level food retail gap per capita, defined as the difference between county-level food demand and county-level food sales in 2008, from the North Carolina Department of Commerce, and BMI data from the 2007 North Carolina Behavioral Risk Factor Surveillance System. To examine county-level associations between BMI and percentage of rural residents, commute times, and food retail gap per capita, we used Pearson correlation coefficients. To examine cross-sectional associations between individual-level BMI (n = 9,375) and county-level commute times and food retail gap per capita, we used multilevel regression models.

Results

The percentage of rural residents was positively correlated with commute times, food retail gaps, and county-level BMI. Individual-level BMI was positively associated with county-level commute times and food retail gaps.

Conclusions

Longer commute times and greater retail gaps may contribute to the rural obesity disparity. Future research should examine these relationships longitudinally and should test community-level obesity prevention strategies.

Introduction

In the United States, the prevalence of obesity is higher in rural than in urban populations (1-5). Area-level factors that contribute to this disparity are not well understood, but one underlying mechanism may be the food environment. Obesity prevalence is lower in census tracts containing a supermarket (6), and rural areas have few supermarkets, which generally have a healthier mix of low-cost food items compared with local convenience stores (7). Accessibility to healthy food is also difficult in rural areas because convenience stores are more common than supermarkets (8-10).

Rural residents may regularly travel to urban areas in neighboring counties to shop for food because of convenience along the route to work, better prices, wider selection, or one-stop shopping offered at discount "supercenters" (eg, Walmart) (11,12). This pattern of food shopping among rural residents may create a retail shortfall or "gap" for food venues in rural areas, causing rural food venues to have a decreased share of the market. A large food retail gap may exacerbate rural food deserts (13), or areas where residents have limited access to affordable, healthy food (14), when smaller food venues in underserved areas close as business is lost to nearby discount supercenters (13,15). Rural residents' prolonged travel time to larger supermarkets or supercenters not only increases the retail gap in the rural county but decreases the frequency of food shopping. In turn, diet quality may decrease as rural residents purchase less fresh produce and more processed foods (16,17).

Another hypothesized mechanism underlying the rural-urban obesity disparity is that rural residents may spend more time traveling to work or to obtain goods and services than do their urban counterparts. Obesity is associated with urban sprawl (18-20), time spent in cars (21), and vehicle miles traveled per day (22). One Los Angeles-based study found that distance traveled to the nearest supermarket was positively associated with higher body mass index (BMI) (23). To our knowledge, no studies have examined the associations between distance to food shopping location, commute times, and BMI among rural and urban residents.

To better understand associations between area-level factors and obesity, we conducted ecologic analyses of associations between the percentage of rural-dwelling residents, commute times, food retail gaps, and BMI for all 100 North Carolina counties. We hypothesized that 1) the percentage of rural residents per county is positively correlated with commute time and food retail gap per capita, 2) county-level commute time is positively correlated with food retail gap per capita, and 3) both commute time and food retail gap per capita are positively correlated with county-level mean BMI. In separate individual-level, contextual analyses, we examined individual-level BMI as the dependent variable and county-level commute time and food retail gap per capita as independent variables. We hypothesized that longer commute times and greater food retail gaps per capita would be positively correlated with individual-level BMI.

Methods

Percentage of rural residents

We calculated the percentage of rural residents for all North Carolina counties by dividing the number of county residents who lived in a rural area according to 2000 census criteria (24) by the county population. The percentage of rural residents ranged from 4% to 100%.

Commute times

We generated reports for county-level commute times for 1990 and 2000 from US census data from the North Carolina Department of Commerce Economic Development Intelligence System. Census data were derived from answers to the census long-form questionnaire. Respondents who worked outside the home estimated the number of minutes it took to get from home to work each day, and commute time was derived by dividing the total number of minutes by the number of workers aged 16 years or older who did not work at home. We examined associations by using the 1990 and 2000 commute times and the difference in commute times between 1990 and 2000. The difference in 1990 and 2000 commute times describes broad shifts in county-level commuting over 10 years.

Food retail gap

We defined the food retail gap as the difference between county-level demand for food and county-level sales of food. We obtained the food retail gap for each North Carolina county from the North Carolina Department of Commerce Economic Development Intelligence System. The Environmental Systems Research Institute (ESRI) calculated retail gaps by subtracting county-level retail sales (supply) of products for a particular industry category in 2008 from county-level demand for products in that industry category in 2008. ESRI estimated demand using data on consumer expenditures from the Bureau of Labor Statistics and InfoUSA, a commercial database marketing system.

ESRI calculates the food retail gap for North American Industry Classification System (NAICS) codes 445 (representing food and beverage stores) and 722 (representing the food services and drinking places) separately. For these analyses, we used food retail gaps calculated from individual and combined NAICS codes 445 and 722. Venues included in the food and beverage stores subsector (NAICS code 445) sell food and beverages from fixed point-of-sale locations, such as supermarkets, grocery stores, convenience stores, meat markets, produce markets, and specialty food stores. Venues included in the food services and drinking places subsector (NAICS code 722) prepare meals, snacks, and beverages to customer order for consumption on and off the premises, such as full-service restaurants, limited-service eating places (fast-food restaurants), special food services, and drinking places. To control for population density, we calculated the food retail gap per capita by dividing the ESRI-estimated food retail gap by the 2007 county population estimate provided by the US census. A negative retail gap indicated that county-level sales were greater than county-level demand; a positive retail gap indicated that county demand was greater than county sales. For example, if County X has 1 chain supermarket and neighboring County Y has a large discount supercenter, residents of County X may begin grocery shopping at the supercenter, creating a positive food retail gap in County X and a negative food retail gap in County Y as residents' food dollars are spent in the neighboring county. This could result in closing of the 1 chain supermarket in County X, making travel to the discount supercenter a necessity for obtaining groceries.

Body mass index

We estimated county-level mean BMI using self-reported height and weight for respondents to the North Carolina Behavioral Risk Factor Surveillance System (BRFSS); responses were aggregated over 5 years (2003-2007). The 5-year aggregate provided an adequate number of responses for reliable estimates for counties with low population densities (single-year estimates for rural counties are unstable). We calculated mean weighted BMI using SUDAAN version 10.1 (Research Triangle Institute, Research Triangle Park, North Carolina), which accounts for BRFSS oversampling of minorities. The mean (standard deviation) county-level BMI was 27.7 (0.85) kg/m^2. The median (interquartile range) was 27.6 (25.9-30.1) kg/m^2.

We conducted individual-level, contextual analyses using data from the 2007 North Carolina BRFSS for respondents aged 18 to 65 years with valid county identifiers. Because of confidentiality concerns, BRFSS does not provide county identifiers for residents of counties with fewer than 50 respondents. We excluded those counties. The individual-level sample consisted of 9,375 respondents from 64 counties. The mean population of the 64 counties included was 123,968, and the mean population of the 36 counties excluded was 25,322. The individual-level mean (SD) BMI was 28.1 (6.4) kg/m^2.

County-level census data

To control for economic interdependence of adjacent counties, we examined the Rural to Urban Continuum Codes (RUCC) as a covariate. The RUCC is a 9-level ordinal scale used by the Economic Research Service to classify counties according to adjacency to metropolitan areas (24). We included a diversity index as a potential covariate in analyses because of associations between racial/ethnic mix and availability of food venues (eg, supermarkets [25], fast-food restaurants [26]) and to account for North Carolina counties' varied race/ethnicity distributions (27). The diversity index represents the percentage of times 2 randomly selected people in each county would differ by race/ethnicity (27). The index is calculated by squaring the proportions of residents in each racial/ethnic group, summing the squares, and subtracting the result from 1. We determined both the county-level diversity index and the percentage of residents who lived below the poverty level using 2000 census data. We calculated the percentage of residents who lived below the poverty level by dividing the number of residents below the poverty level in 1999 by the estimated 1999 county population. North Carolina is divided into 3 regions (Coastal Plain/Eastern, Appalachian Mountain/Western, and Piedmont Plateau) with distinct demographic and socioeconomic characteristics. Thus, we also examined the variable "region" as a potential covariate.

Statistical analyses

For county-level ecological analyses, we used SAS version 9.2 (SAS Institute, Inc, Cary, North Carolina) to calculate correlation coefficients for percentage of rural residents, food retail gap per capita, commute time, and BMI for all 100 North Carolina counties. We used backward selection to construct linear regression models to examine the associations among county-level independent variables of commute times and food retail gap per capita, using county-level mean BMI as the dependent variable. Percentage of rural residents, diversity index, percentage below poverty, and region were potential covariates and were eliminated from the model in successive steps if the P value for the parameter estimate was .05 or higher. We examined the potential multicollinearity among covariates by computing their corresponding tolerance values. The tolerance is the proportion of variance in a given independent variable that is not explained by all of the other covariates; we found a tolerance value for all of greater than 0.1, which has been widely used as the threshold for multicollinearity in linear regressions (28).

For individual-level, contextual analyses, we constructed multilevel linear regression models; the dependent variable was individual-level BMI from 2007 BRFSS respondents (n = 9,375). County-level independent variables were food retail gap per capita, commute time in 2000, and difference in commute times between 2000 and 1990. Sex, age, race/ethnicity, and education were individual-level covariates, and the RUCC was a county-level covariate. Region was added as a third level.

Multilevel regression analyses allowed us to assess associations between individual-level BMI and area-level factors, accounting for the fact that people who reside in the same county are not independent observations (29). We examined the association between individual-level BMI and the 5 county-level variables of interest (commute time in 2000, difference between 1990 and 2000 commute times, retail gap per capita for NAICS code 445 [food and beverage stores], retail gap per capita for NAICS code 722 [restaurants and drinking places], and combined retail gap per capita) in separate models. The first 3 models to examine the association between BMI and county-level variables of interest were 2-level random intercept models. Model 4 included additional regional dummy variables to account for fixed effects from region. We used SAS version 9.2 for individual-level, contextual analyses, with estimates weighted to adjust for BRFSS oversampling.

Results

Summary statistics for the individual-level data among 2007 BRFSS respondents by region are reported in Table 1.

County-level analyses

Percentage of rural residents was significantly correlated with both the commute times in 1990 and 2000 and the difference in commute times between the 2 years, food retail gap per capita for restaurants and drinking places, overall food retail gap per capita, and BMI (Table 2).

We found significant positive correlations between commute time and retail gap per capita (Table 3). There were significant positive correlations between total food retail gap per capita and BMI and between the difference in commute times from 1990 to 2000 and BMI.

In linear regression analyses adjusted for county-level diversity index and the percentage of residents below the poverty level, a positive association was found between commute time in 2000 and BMI (parameter estimate, 5.24; standard error, 1.86; $P = .006$). We also found a significant positive association between food retail gap per capita and BMI when controlling for region and population percentage below poverty (parameter estimate, 0.024; standard error, 0.006; $P < .001$).

In linear regression models with county-level mean BMI as the dependent variable and difference in commute times from 1990 to 2000 and retail gap per capita as independent variables, the most parsimonious model included the covariates population percentage below poverty and regional fixed effects and explained 43% of variance in county-level BMI. When 2000 commute time and food retail gap per capita were included as independent variables, controlling for diversity index and percentage below the poverty level, the model explained 40% of variance in county-level BMI.

Individual-level analyses

The point estimates for each of the county-level variables of interest (commute time and retail gap per capita) are presented for 4 model specifications (Table 4). In Model 1, we did not include any additional covariates. Individual covariates were added in models 2 and 3. In model 4, regional fixed effects were added. All 5 measures of county-level commute time and food retail gap per capita were positively associated with individual-level BMI. These effects were significant in the unadjusted model (model 1), and the significance remained when individual-level and regional covariates were included in models 2, 3, and 4, with the exception of average commute time increase in model 4. When 2000 commute time and retail gap per capita were both included in the same model with individual-level and regional covariates, the parameter estimates for the county-level variables of interest were no longer significant.

Discussion

Our results demonstrate a positive correlation between percentage of rural residents and 1) commute times and 2) food retail gap per capita, suggesting that counties with a higher percentage of rural residents have longer commute times and greater retail shortfalls, and thus residents may generally spend food dollars outside their county of residence. Previous studies have found positive associations between BMI and travel distance to grocery stores (23) and time spent in cars (21,22).

We found significant cross-sectional correlations between individual-level and county-level BMI and 1) commute times and 2) food retail gap per capita, but significance did not remain when both were included in the individual-level model. This attenuation could be due to model over-adjustment if commute time and retail gap are both on the causal pathway explaining the relationship between rural residence and BMI.

These analyses support strategies presented in *Recommended Community Strategies and Measurements to Prevent Obesity in the United States* (30) to improve geographic availability of supermarkets in underserved areas and provide incentives to food retailers to offer healthier food and beverage choices in underserved areas. If implemented, these strategies would decrease travel times necessary for accessing healthy, affordable foods among low-income and rural residents. When combined with health education efforts and mass media campaigns encouraging healthy food choices, more accessible and affordable healthy foods may lead to healthier food consumption patterns and to lower obesity prevalence in these groups.

In a qualitative study of rural Georgia adults, participants identified several barriers to obtaining healthy foods, including poor selection, limited time, fuel prices, and the distance (15-45 miles) to larger communities with bigger stores and better selection (31). Another study found that longer distance traveled to the primary grocery store was associated with higher BMI (23). This previous work, taken together with our results, supports the notion that rural residents who travel farther to shop for food may purchase less healthful food. However, we did not measure the distance to the locations where people shopped and assumed that a positive food retail gap indicated a general trend for rural residents to shop for food outside their county of residence. Future work should assess the relationship between commute times and the locations where they purchase food. Future work should also include mediational analyses to examine the relationships between commute time, food shopping frequency and location, diet quality, and BMI.

This study has several limitations. Foremost is the ecological design, which used several different data sources. The inconsistent timing of data collection for commute times (1990, 2000), food retail gaps (2008), and BMI (2003-2007) is an additional limitation. However, we used the most recent data available, and average commute time is a proxy for distance between place of employment and residence (32). A related limitation is the exclusion of people in the 36 counties where BRFSS did not provide county-level identifiers, pointing to the need for more work to examine rural populations. An additional caveat is that we used self-reported height and weight from BRFSS to calculate BMI, potentially biasing results toward the null if hypothesized relationships between commute times, food retail gaps, and BMI truly exist, because of potential underestimation of weight status. The use of a commercial business database (InfoUSA) to obtain sales data is also a limitation, because such databases may contain errors (33). Finally, in these analyses, we assumed commute time referred to time spent driving. Some people may walk or bike to work instead of drive; however, few Americans actively commute (34).

This study is the first to examine correlations between commute times, food retail gap per capita, and mean BMI in counties in North Carolina. We present an approach to studying the association between BMI and variables related to the built and economic environments, providing support for the notion that economic and built environment factors are related to obesity.

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Author Information

Corresponding Author: Stephanie B. Jilcott, PhD, Department of Public Health, East Carolina University, 600 Moye Blvd, MS 660, Greenville, NC 27834. Telephone: 252-744-4034. E-mail: jilcotts@ecu.edu.

Author Affiliations: Haiyong Liu, Justin B. Moore, Jeffrey W. Bethel, East Carolina University, Greenville, North Carolina; James Wilson, Northern Illinois University, DeKalb, Illinois; Alice S. Ammerman, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

References

1. Lee SK, Sobal J, Frongillo EA, Olson CM, Wolfe WS. Parity and body weight in the United States: differences by race and size of place of residence. Obes Res 2005;13(7):1263-9.
2. Dalbey M. Implementing smart growth strategies in rural America: development patterns that support public health goals. J Public Health Manag Pract 2008;14(3):238-43.
3. McMurray RG, Harrell JS, Bangdiwala SI, Deng S. Cardiovascular disease risk factors and obesity of rural and urban elementary school children. J Rural Health 1999;15(4):365-74.
4. Blankenau J. Nutrition, physical activity, and obesity in rural America: a series examining health care issues in rural America. Wayne State College Center for Rural Affairs; 2009. http://files.cfra.org/pdf/Nutrition-Physical-Activity-and-Obesity-in-Rural-America.pdf. Accessed April 26, 2010.
5. Jackson JE, Doescher MP, Jerant AF, Hart LG. A national study of obesity prevalence and trends by type of rural county. J Rural Health 2005;21(2):140-8.
6. Morland K, Diez Roux AV, Wing S. Supermarkets, other food stores, and obesity: the Atherosclerosis Risk in Communities study. Am J Prev Med 2006;30(4):333-9.
7. Bustillos B, Sharkey JR, Anding J, McIntosh A. Availability of more healthful food alternatives in traditional, convenience, and nontraditional types of food stores in two rural Texas counties. J Am Diet Assoc 2009;109(5):883-9.
8. Kaufman P. Rural poor have less access to supermarkets, large grocery stores. Rural Development Perspectives 1999;13(3):19-26.
9. Liese AD, Weis KE, Pluto D, Smith E, Lawson A. Food store types, availability, and cost of foods in a rural environment. J Am Diet Assoc 2007;107(11):1916-23.
10. Sharkey JR, Horel S. Neighborhood socioeconomic deprivation and minority composition are associated with better potential spatial access to the ground-truthed food environment in a large rural area. J Nutr 2008;138(3):620-7.
11. Jilcott SB, Laraia BL, Evenson KR, Ammerman AS. Perceptions of the community food environment and related influences on food choice: a qualitative analysis. Women Health 2009;49(2-3):164-80.
12. Robinson NC, Caraher M, Lang T. Access to shops: the views of low-income shoppers. Health Education J 2000;59(2):121-36.
13. Guy C, Clarke G, Eyre H. Food retail change and the growth of food deserts: a case study of Cardiff. International Journal of Retail and Distribution Management 2004;32(2):72-88.
14. Furey S, Strugnell C, McIlveen H. An investigation of the potential existence of 'food deserts' in rural and urban areas of Northern Ireland. Agriculture and Human Values 2001;18(4):447-57.
15. Hallsworth A, Worthington S. Local resistance to larger retailers: the example of market towns and the food superstore in the UK. International Journal of Retail and Distribution Management 2000;28(4-5):207-16.
16. Yoo S, Baranowski T, Missaghian M, Baranowski J, Cullen K, Fisher JO, et al. Food-purchasing patterns for home: a grocery store-intercept survey. Public Health Nutr 2006;9(3):384-93.
17. Bhargava A. Socio-economic and behavioural factors are predictors of food use in the National Food Stamp Program Survey. Br J Nutr 2004;92(3):497-506.
18. Lopez R. Urban sprawl and risk for being overweight or obese. Am J Public Health 2004;94(9):1574-9.
19. Lee IM, Ewing R, Sesso HD. The built environment and physical activity levels: the Harvard Alumni Health Study. Am J Prev Med 2009;37(4):293-8.
20. Pendola R, Gen S. BMI, auto use, and the urban environment in San Francisco. Health Place 2007;13(2):551-6.
21. Frank LD, Andresen MA, Schmid TL. Obesity relationships with community design, physical activity, and time spent in cars. Am J Prev Med 2004;27(2):87-96.
22. Lopez-Zetina J, Lee H, Friis R. The link between obesity and the built environment. Evidence from an ecological analysis of obesity and vehicle miles of travel in

California. Health Place 2006;12(4):656-64.
23. Inagami S, Cohen DA, Finch BK, Asch SM. You are where you shop: grocery store locations, weight, and neighborhoods. Am J Prev Med 2006;31(1):10-17.
24. Hall SA, Kaufman JS, Ricketts TC. Defining urban and rural areas in US epidemiologic studies. J Urban Health 2006;83(2):162-75.
25. Morland K, Wing S, Diez Roux A, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. Am J Prev Med 2002;22(2):23-9.
26. Block JP, Scribner RA, DeSalvo KB. Fast food, race/ethnicity, and income: a geographic analysis. Am J Prev Med 2004;27(3):211-7.
27. Hero R, Tolbert C. A racial/ethnic diversity interpretation of politics and policy in the states of the U.S. American Journal of Political Science 1996;40(3):851-71.
28. Lin FQ. Solving multicollinearity in the process of fitting regression model using the nested estimate procedure. Quality and Quantity 2008;42:417-26.
29. Leyland AH, Groenewegen PP. Multilevel modelling and public health policy. Scand J Public Health 2003;31(4):267-74.
30. Centers for Disease Control and Prevention. Recommended community strategies and measurements to prevent obesity in the United States. MMWR Recomm Rep 2009;58(RR-7):1-26.
31. Kegler MC, Escoffery C, Alcantara I, Ballard D, Glanz K. A qualitative examination of home and neighborhood environments for obesity prevention in rural adults. Int J Behav Nutr Phys Act 2008;5:65.
32. Guiliano G, Small KA. Is the journey to work explained by urban structure? Urban Studies 1993;30(9):1485-500.
33. Jilcott SB, McGuirt J, Imai S, Evenson KR. Measuring the retail food environment in rural and urban North Carolina counties. J Public Health Manag Pract 2010. Forthcoming.
34. French SA, Story M, Jeffrey RW. Environmental influences on eating and physical activity. Annu Rev Public Health 2001;22:309-35.

Tables

Table 1. Characteristics of 9,375 Respondents by Region, North Carolina Behavioral Risk Factor Surveillance System, 2007[a]

Characteristic	Region[b]		
	Western n = 1,789	Eastern n = 3,190	Piedmont n = 4,837
BMI[c], kg/m^2	27.8 (6.1)	28.7 (6.6)	27.9 (6.3)
Age, y	47.6 (12.1)	46.3 (12.4)	46.0 (11.9)
Men, %	37.2 (48.3)	35.7 (47.9)	37.0 (48.3)
High school diploma, %	58.6 (49.3)	60.5 (48.9)	50.5 (50.0)
Non-Hispanic black, %	5.0 (21.8)	24.8 (43.2)	18.0 (38.4)
Non-Hispanic white, %	87.9 (32.6)	63.4 (48.2)	72.3 (44.7)
Hispanic, %	3.8 (19.1)	5.3 (22.5)	5.4 (22.5)
County-level percentage residing in rural areas	57.9 (22.6)	44.8 (24.2)	25.8 (20.9)
County-level diversity index × 100[d]	18.6 (7.1)	49.0 (12.1)	43.6 (10.3)
County-level percentage below the poverty level	12.1 (2.0)	15.5 (3.8)	9.8 (1.8)
County-level commute time in 1990, minutes	19.4 (1.4)	19.5 (2.3)	19.9 (1.7
County-level commute time in 2000, minutes	22.5 (2.0)	24.0 (3.3)	24.0 (2.2)
Commute time difference (2000 − 1990), minutes	3.2 (1.2)	4.4 (1.6)	4.1 (0.8)
Retail gap per capita (NAICS code 445)[e]	−251.2 (−353.3 to 124.2)	63.9 (−120.9 to 159	−44.3 (−279.7 to 373.9)
Retail gap per capita (NAICS code 722)[f]	150.7 (−362.2 to 228.6)	−116.5 (−211.5 to 358.1)	98.8 (−152.8 to 361.9)
Combined retail gap per capita (NAICS codes 445 + 722)	−6.5 (−668.8 to 334.4)	−147.6 (−455.7 to 457.9)	240.4 (−85.9 to 517.4)

Abbreviations: BMI, body mass index; NAICS, North American Industry Classification System.
[a] Respondents resided in 64 North Carolina counties with valid values for all covariates for regression analyses, weighted to population.
[b] All values are reported as mean (standard deviation), except those for retail gap per capita, which are reported as median (interquartile range).
[c] BMI was unavailable for 441 respondents: 73 for the Western region, 143 for the Eastern region, and 225 for the Piedmont region.
[d] Calculated by squaring the proportions of residents in each racial/ethnic group, summing the squares, and subtracting the result from 1 (27).
[e] Retail gap per capita calculated by subtracting county-level sales of products for a NAICS category in 2008 from county-level demand for products in that category in 2008. NAICS code 445 defined as stores that sell food and beverages from fixed point-of-sale locations, including supermarkets, grocery stores, convenience stores, meat markets, produce markets, and specialty food stores.
[f] NAICS code 722 defined as food services and drinking places that prepare meals, snacks, and beverages to customer order for consumption on and off the premises, including full-service restaurants, limited-service eating places (fast-food restaurants), special food services, and drinking places.

Table 2. Correlation Between Percentage of Rural Residents in 100 North Carolina Counties and Mean Commute Times, Food Retail Gap Per Capita, and BMI

Variable	Correlation With Percentage of Rural Residents[a]
Commute time 1990	0.56
Commute time 2000	0.59
Commute time difference (2000 − 1990)	0.25
Retail gap per capita (NAICS code 445)[b]	0.19
Retail gap per capita (NAICS code 722)[c]	0.43
Combined retail gap per capita (NAICS codes 445 + 722)	0.31
County-level BMI	0.21

Abbreviations: BMI, body mass index; NAICS, North American Industry Classification System.
[a] *P* values ranged from <.001 to .04 using a *t* test except except that for retail gap per capita (NAICS code 445) (*P* = .06).
[b] Retail gap per capita calculated by subtracting county-level sales of products for a NAICS category in 2008 from county-level demand for products in that category in 2008. NAICS code 445 defined as stores that sell food and beverages from fixed point-of-sale locations, including supermarkets, grocery stores, convenience stores, meat markets, produce markets, and specialty food stores.
[c] NAICS code 722 defined as food services and drinking places that prepare meals, snacks, and beverages to customer order for consumption on and off the premises, including full-service restaurants, limited-service eating places (fast-food restaurants), special food services, and drinking places.

Table 3. Correlation Between BMI and Mean Commute Times and Food Retail Gap per Capita in 100 North Carolina Counties

	Retail Gap per Capita[a]			
Variable	NAICS Code 445[b]	NAICS Code 722[c]	NAICS Codes 445 + 722	County-Level BMI
Commute time 1990	0.26	0.41	0.34	0.12
Commute time 2000	0.35	0.51	0.44	0.31
Commute time difference (2000 − 1990)	0.29	0.35	0.34	0.46
County-level BMI	0.37	0.24	0.34	1.00

Abbreviations: BMI, body mass index; NAICS, North American Industry Classification System.
[a] Retail gap per capita calculated by subtracting county-level sales of products for a NAICS category in 2008 from county-level demand for products in that category in 200. *P* values ranged from <.001 to .01 using a *t* test except that for commute time in 1990 and BMI (*P* = .22).
[b] NAICS code 445 defined as stores that sell food and beverages from fixed point-of-sale locations, including supermarkets, grocery stores, convenience stores, meat markets, produce markets, and specialty food stores.
[c] NAICS code 722 defined as food services and drinking places that prepare meals, snacks, and beverages to customer order for consumption on and off the premises, including full-service restaurants, limited-service eating places (fast-food restaurants), special food services, and drinking places.

Table 4. Correlation Between Individual-Level BMI and County-Level Variables, North Carolina[a]

County-Level Variable	Regression Model[b,c]			
	1	2	3	4
2000 Commute time	0.0847	0.0730	0.0733	0.0660
Commute time difference (2000 – 1990)	0.2719	0.1812	0.1791	0.1572
Retail gap per capita (NAICS code 445)[d]	0.0004	0.0002	0.0003	0.0002
Retail gap per capita (NAICS code 722)[e]	0.0004	0.0004	0.0004	0.0004
Combined retail gap per capita (NAICS codes 445 + 722)	0.0002	0.0002	0.0002	0.0002

Abbreviations: BMI, body mass index; NAICS, North American Industry Classification System.
[a] Individual-level BMI was the dependent variable and county-level commute times and food retail gap per capita were independent variables. Individual covariates were age, age squared, sex, education, and race/ethnicity.
[b] Model 1: no additional covariates; model 2: individual covariates only; model 3: individual covariates + Rural to Urban Continuum Codes (RUCC) (24); model 4: individual covariates + RUCC + regional dummy variables.
[c] *P* values ranged from <.001 to .048 using a *t* test, except those for Model 2 for retail gap per capita (NAICS code 445 [*P* = .08] and NAICS code 722 [*P* = .06]) and for Model 4 for for retail gap per capita (NAICS code 445 [*P* = .06]).
[d] Retail gap per capita calculated by subtracting county-level sales of products for a NAICS category in 2008 from county-level demand for products in that category in 2008. NAICS code 445 defined as stores that sell food and beverages from fixed point-of-sale locations, including supermarkets, grocery stores, convenience stores, meat markets, produce markets, and specialty food stores.
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ORIGINAL RESEARCH

Using Multiple Sources of Data to Assess the Prevalence of Diabetes at the Subcounty Level, Duval County, Florida, 2007

William C. Livingood, PhD; Luminita Razaila, MS; Elena Reuter, MPH; Rebecca Filipowicz, MPH; Ryan C. Butterfield, MPH; Katryne Lukens-Bull, MPH; Linda Edwards, MD; Carlos Palacio, MD, MPH; David L. Wood, MD, MPH

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PEER REVIEWED

Abstract

Introduction

Diabetes rates continue to grow in the United States. Effectively addressing the epidemic requires better understanding of the distribution of disease and the geographic clustering of factors that influence it. Variations in the prevalence of diabetes at the local level are largely unreported, making understanding the disparities associated with the disease more difficult. Diabetes death rates during the past 15 years in Duval County, Florida, have been disproportionately high compared with the rest of the state.

Methods

We analyzed multiple sources of secondary data related to diabetes illness and death in Duval County, including data on hospital discharge, emergency department (ED) use, and vital statistics. We accessed diabetes and diabetes-related ED use and hospitalization and death data by using codes from the International Classification of Diseases versions 9 and 10. We analyzed data from the Behavioral Risk Factor Surveillance System survey for Duval County and adapted Centers for Disease Control and Prevention weighting formulas for subcounty analysis. We used relative risk–type disease ratios and geographic information systems mapping to analyze data.

Results

The urban, mostly minority, low-socioeconomic area of Duval County had twice the rate of diabetes-related illness and death as other areas of the county, and the inner-city, poor area of the county had almost 3 times the rate of hospitalization and ED use for diabetes and diabetes-related conditions compared with the other areas of the county.

Conclusion

Our analyses show that diabetes-related disparities affect not only people and their families but also the community that absorbs the costs associated with the disproportionate health care use that results from these disparities. Analyzing data at the subcounty level has implications for health care planning and public health policy development at the local level.

Introduction

Diabetes is recognized as a growing national and international epidemic as prevalence rates for other major chronic diseases such as stroke and heart disease have decreased (1,2). The challenges of addressing the epidemic are exacerbated by the disparities in the prevalence of the disease. These disparities are complicated by quality-of-care issues and socioeconomic determinants (3-7), which may include local geographically clustered factors such as availability and access to health care, education and employment opportunity, and social capital and social cohesion. Furthermore, variations in the prevalence of diabetes at the local level are largely unreported, making understanding the disparities associated with the disease more difficult.

Duval County is a consolidated city/county government located on the northeast coast of Florida. It is a large (more than 840 square miles) and diverse area that has a population of more than 900,000 (8). The city/county contains areas that reflect urban, suburban, and rural areas. In 2007, Duval County, which encompasses Jacksonville, had an age-adjusted diabetes death rate of 32 per 100,000, compared with the 10 other largest counties in Florida (range, 14-29; median = 20) (9). In 2007, the total hospitalization costs for adult diabetes-related treatment in Duval County exceeded $714,000,000, and the cost for emergency department (ED) visits due to diabetes-related treatment was more than $57,000,000 (10). The growing disparity in diabetes deaths between Duval County and the state of Florida as a whole has been an alarming trend during the past 15 years (Figure 1).

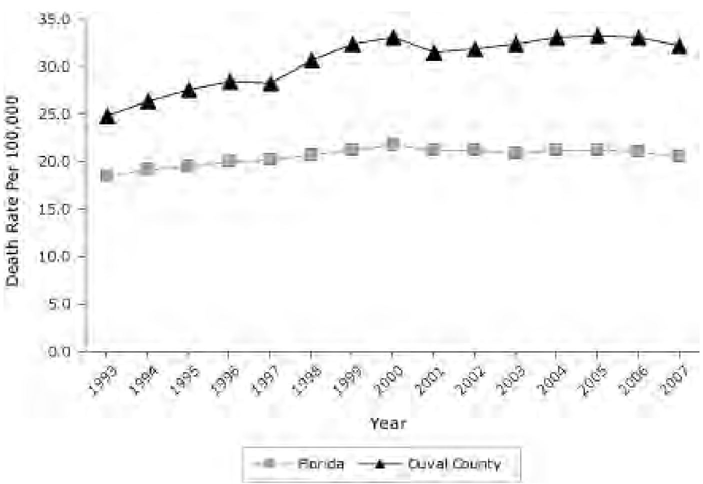

Figure 1. Yearly trend in age-adjusted diabetes 3-year death rate per 100,000. Three-year rate is calculated by summing the 3 years of deaths and dividing by 3 to obtain the annual average of events, followed by calculating the age-specific rates for each year. Data source: Florida Department of Health, Bureau of Vital Statistics, 1998-2008.

We used several methods to study the local prevalence of diabetes, including the use of administrative data for the number of hospital and physician visits for diabetes (11,12) and Behavioral Risk Factor Surveillance System (BRFSS) survey self-reported data (13). Both methods rely on health system diagnosis, either documented through administrative records or communicated to patients. We used a method of weighting prevalence rates to adjust for undiagnosed cases (14). Diabetes death rates and various measures of diabetes prevalence capture different forms of observable characteristics or effects of the disease. We assessed the comparable sensitivity of these measures, particularly as the measures relate to geographic distribution of ethnicity and social determinants, and analyzed diabetes-related disparities at the local level by using different sources of data to provide implications for public health and health care policy.

Methods

We used a secondary data analysis research design that included multiple sources to assess the prevalence and effect of diabetes in Duval County. Data sources were ED and hospital discharge data for the year 2007 reported to the Florida Agency for Health Care Administration (AHCA), vital statistics data for the year 2007 reported to the Florida Department of Health, 2007 BRFSS data collected by the Florida Department of Health, population data collected by the US Census Bureau and census estimates generated by the Florida Office of Economic and Demographic Research and Nielsen Claritas, and previously created geographically defined areas, identified as *health zones*.

Data sources and management

ED and hospital discharge data. Hospitals in Florida are required to report ED and hospitalization data quarterly to the AHCA, using a standardized format based on codes from the International Classification of Diseases (ICD) version 9. The most current complete data file available at the time of the analysis was 2007. Using hospital discharge data for all people aged 18 years or older, we identified the ICD-9 codes for diabetes (all diseases and conditions coded as 250) as the primary cause of hospitalization or ED use. Then, we counted diabetes-related cases as admissions for which the primary diagnosis was diabetes or for which diabetes was coded as a contributing condition. Finally, we calculated the rates by dividing the frequencies for diabetes or diabetes-related cases by the population and multiplying by 100,000.

Vital statistics death file data. First, we used ICD-10 codes to identify diabetes deaths from the primary cause of death and diabetes-related deaths from all contributing causes of death in addition to the primary cause of death, as recorded on the death certificate. Next, we calculated rates by dividing the number of cases in people aged 18 years or older by the population in each geographic area or demographic group and multiplying by 100,000.

BRFSS data. The Florida Department of Health conducted the 2007 BRFSS survey in the state of Florida. The Duval County Health Department obtained a larger sample from the county population so that we could conduct analyses at the subcounty level. The larger sample was purchased through the Florida Department of Health using noncategorical discretionary funds available to the county health department. Approximately 1,800 residents aged 18 years or older responded to the BRFSS in Duval County. The responses were weighted by using BRFSS weighting methods that account not only for the sampling plan of the telephone survey but also for the distribution of demographic groups within the county (see Appendix for description of weighting). The variable of interest from the BRFSS data file was DIABETE2, which contained the answer to the survey question, "Have you ever been told by a doctor that you have diabetes?" We counted the numbers of affirmative responses on both the raw data file and weighted data file and used them to calculate the weighted and unweighted BRFSS prevalence rates for diabetes, using SPSS software (SPSS, Inc, Chicago, Illinois). We calculated undiagnosed cases as a proportion of diagnosed cases (14).

Population data. We obtained the population estimates used for county-level rates from the Florida Office of Economic and Demographic Research via the Florida Department of Health, Office of Health Statistics and Assessment (CHARTS) (15). Population estimates for the subcounty level rates were obtained from Nielsen Claritas, a demographic data vendor that provided 2000 census–based demographic projections by zip code. The Florida Office of Economic and Demographic Research provides official state estimates for the county, but Nielsen Claritas was needed for the subcounty estimates.

Subcounty divisions. Because the zip code areas of Duval County were statistically unreliable for many health issues, we used multi–zip code health zones (Figure 2) that were created by the Duval County Health Department Institute for Health, Policy, and Evaluation Research to provide reliable and consistent data for subcounty analysis (16). Data generated on the basis of health zones also overcome Health Insurance Portability and Accountability Act (HIPAA) issues concerning protection of personal identifiers associated with geographic areas with small populations. The private and public heath and social services sectors of the county use these health zones extensively for community assessment and planning. The health zones have different demographic characteristics. For example, health zone 1 is more than 80% African American, whereas health zones 3 and 6 are less than 20% African American. Health zone 1 has many health disparities compared with the other health zones (16).

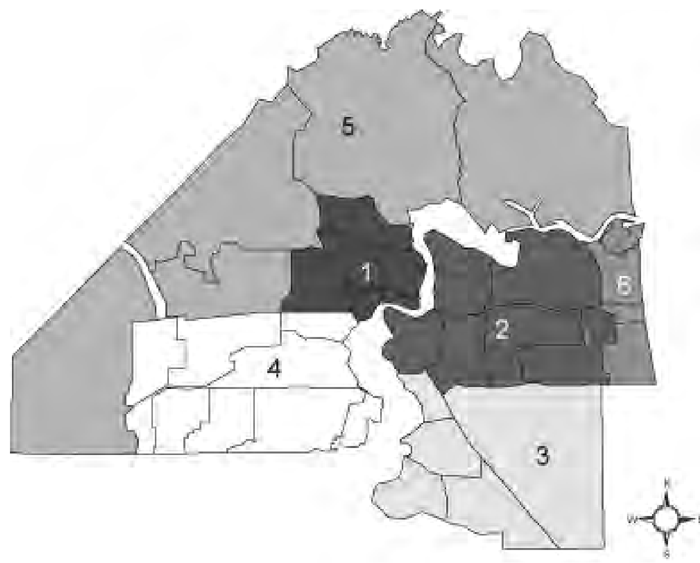

Figure 2. Health zones, Duval County, Florida. Prepared by the Duval County Health Department, Institute for Health, Policy, and Evaluation Research, August 2008.

Analysis

Comparison of rates from the different data sources involved several steps: calculation of rates using a standard format; comparison of rates for each of the subcounty zones to the overall county rate, using graphic and mapping analytic techniques; calculation of the disease ratios (relative risk and prevalence ratio) for the urban core zone (health zone 1) compared with the rest of the county; and calculation of odds ratios for comparison of each health zone to one another. Disease ratios such as relative risk (typically associated with incidence) and prevalence ratios use the same formulas for calculation. The relative risk and corresponding confidence interval calculations were computed by using Epi Info (Centers for Disease Control and Prevention, Atlanta, Georgia).

GIS mapping. We used geographical information systems (GIS) mapping to interpret and visualize patterns of diabetes illness and death and hospitalization and ED data across Duval County health zones. We used ArcMap (Environmental Systems Research Institute, Inc, Redlands, California) for spatial analysis. Specifically, we developed thematic maps using percentages and rates of disease by health zone.

Disease ratios (relative risk and prevalence ratio). We compared illness and death rates by dividing the rate for health zone 1 by the rate for the rest of Duval County for each diabetes measure. The prevalence rate was based on the BRFSS weighted sample. We constructed a graph to compare the diabetes rates in health zone 1 (the urban core) with the rest of the county in the rank order of diabetes measures derived from the rates per 100,000. We then calculated confidence intervals for the disease ratios (prevalence ratios and relative risks), comparing health zone 1 against the other health zones for each diabetes measure.

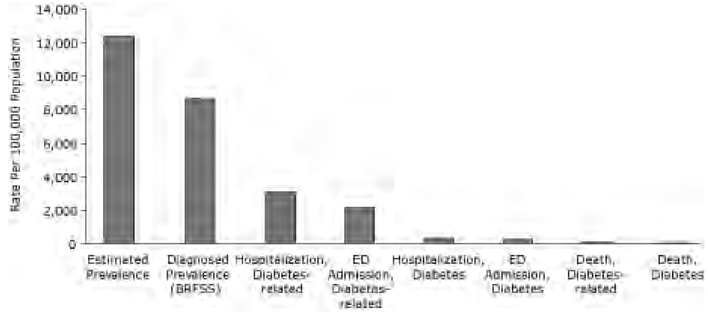

Figure 3. Rates for diabetes measures in Duval County, Florida, 2007. Rates are presented in descending order, on the basis of number of cases per 100,000 population. Abbreviations: BRFSS, Behavioral Risk Factor Surveillance System; ED, emergency department. Data sources: BRFSS, Duval County, 2007; Florida Agency for Healthcare Administration, in-patient and ED data, 2007; Florida Department of Health, Office of Vital Statistics, 2007 death files.

Results

Diabetes rates vary extensively in Duval County, depending on the source of data and the type of measure. Figure 3 shows the relationship of these measures in descending order, ranging from an estimated diabetes prevalence of 12,371, per 100,000 population to a death rate of 40 per 100,000.

Overall, residents from health zone 1 are less educated and poorer than residents from the other health zones, and health zone 1 has a higher African American population than the other health zones (Table 1).The extensive local variations for these different measures are illustrated in Table 2, which shows major disparities in the county. Health zone 1, the urban core, had an age-adjusted death rate of 93.5 compared with the lowest rates in the county, health zones 2, 3, and 6 with rates of 30.5, 31.0, and 31.6, respectively. These 3 rates were lower than the county rate of 39.9 and the state rate of 34.9. The other health zones (4 and 5) had rates that were less than half of the urban core rate. The rate of age-adjusted diabetes death for adults varied dramatically by health zone. Health zone 1 had more than double the rate of health zone 5, which had the next highest rate, and more than triple the 2 lowest rates (health zones 2 and 3).

Rates for hospitalization and ED visits revealed even more profound disparities in terms of location. The hospitalization rate for the urban core (health zone 1) was 747 compared with 148 for the health zone with the lowest rate (health zone 3). The urban core hospitalization rate was more than double that of all other health zones but 1. The distribution of diabetes rates for ED use was similar in that the rate of health zone 1 far exceeded those of the other health zones. Health zone 1 had an unusually high ED visit rate (692) compared with health zone 3, which had the lowest rate (105) and had more than twice the rate of the other health zones. Health zone 1, which had a rate of self-reported diagnosed diabetes of 14,251, exceeded the county rate, but this is the only measure for which another health zone (health zone 5, rate of 15,446) exceeded the urban core (ie, health zone 1) (Table 2).

The ratios of prevalence and relative risk in health zone 1 compared with the rest of the county for each diabetes measure complemented the GIS analysis, providing markers of significance for the disparities in the county (Table 3). Significant differences between health zone 1 and the rest of the county (health zones 2-6) were established for each of the diabetes measures. The largest difference in ratios was for diabetes ED use, followed by diabetes-related ED use. The health zone 1 ratio for hospitalization for diabetes and diabetes-related illness were also high compared with the other zones. The ratios for diabetes deaths and diabetes-related deaths were also comparatively high for health zone 1. The ratio of prevalence of diabetes for health zone 1 compared with the other health zones was the lowest ratio.

Discussion

The results of our study show that the diabetes prevalence ratios within the high-minority, low-socioeconomic area of Duval County were statistically different when compared with the other parts of the county. Understanding the effect of the disease and the distribution of that disease in the community has implications for policy development and resource allocation. The costs associated with hospitalization and ED use are much higher in the high-minority, low-socioeconomic part of the county. The cost per capita of diabetes-related hospitalizations in health zone 1 in 2007 was $2,010, which was nearly double the cost per capita for the county ($1,059). The charity cost per capita of diabetes-related hospitalizations in health zone 1 in 2007 was $1,053, which was more than double the cost per capita for the county ($465). The reasons for the acute disparities identified by this study deserve considerably more discussion than is feasible here, but they include a range of socioeconomic and health care disparities (17-29).

The results of this study provide insights about the distribution of diabetes in specific areas of the county, insights that get lost in data aggregated at the metropolitan level. An unexpected result of our study was the low rate of diagnosed cases of diabetes, which were inferred from BRFSS data. This could be due to a lack of access to prevention and primary care for people in health zone 1, resulting in poorer outcomes related to delayed care, which are reflected in the other measures such as higher rates of hospitalization and death, as previously discussed. However, it may also reflect flaws in BRFSS methods related to low participation of African Americans in the BRFSS telephone surveys, which is exacerbated by declining land-line use. Although weighting is used to compensate for underrepresentation, it may not adequately address disproportionate underrepresentation of the highest-risk patients among African Americans.

Our study has limitations that are associated with most efforts to measure disease, illness, and death. The accuracy of the data is dependent on the people observing and recording the data and may be affected by the data collection process. Another limitation is that BRFSS data use sampling frames and telephone interviews that have inherent issues with sampling bias, particularly when refusals and land-line issues are considered. However, examining multiple sources of data is beneficial because together these sources provide a more accurate picture of disease effect, similar to the concept of triangulation found with qualitative research.

Currently allocated resources may be insufficient or inappropriate to adequately deal with diabetes and its complications in the areas of highest need. Health zone 1 is the urban core, which has the lowest socioeconomic levels. Areas with the highest prevalence of diabetes contain the patients who have the fewest resources to deal effectively with the disease. This disparity may account for the disproportionate number of hospital and ED visits, which drive up the cost of health care for the poorest because of a lack of adequate preventive resources.

Our analyses revealed that diabetes disproportionately affects the geographic part of the community that has the highest minority population and the lowest socioeconomic status. The most sensitive measures of the effects of diabetes at the local level were hospitalization data and ED use, and the least sensitive measure was prevalence, determined from BRFSS data. Our analyses show that diabetes-related disparities affect not only people and their families, but also the community that absorbs the costs associated with the disproportionate health care use that results from these disparities. Analyzing data at the subcounty level has implications for health care planning and public health policy development at the local level.

Author Information

Corresponding Author: William C. Livingood, PhD, Duval County Health Department and University of Florida College of Medicine, Jacksonville, 900 N University Blvd, Jacksonville, FL 32211. Telephone: 904-253-2339. E-mail: William_Livingood@doh.state.fl.us.

Author Affiliations: Luminita Razaila, Elena Reuter, Rebecca Filipowicz, Ryan C. Butterfield, Duval County Health Department, Jacksonville, Florida; Katryne Lukens-Bull, Linda Edwards, Carlos Palacio, David L. Wood, University of Florida College of Medicine, Jacksonville, Jacksonville, Florida.

References

1. Mokdad AH, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales VS, et al. Prevalence of obesity, diabetes, and other obesity-related health risk factors, 2001. JAMA 2003;289(1):76-9.
2. Centers for Disease Control and Prevention. Decline in deaths from heart disease and stroke — United States, 1990-1999. MMWR Morb Mortal Wkly Rep 1999;48(30):649-56.
3. Jones RG, Trivedi AN, Ayanian JZ. Factors influencing the effectiveness of interventions to reduce racial and ethnic disparities in health care. Soc Sci Med 2010;70(3):337-41.
4. Duru OK, Gerzoff RB, Selby JV, Brown AF, Ackermann RT, Karter AJ, et al. Identifying risk factors for racial disparities in diabetes outcomes: the translating research into action for diabetes study. Med Care 2009;47(6):700-6.
5. McWilliams JM, Meara E, Zaslavsky AM, Ayanian JZ. Differences in control of cardiovascular disease and diabetes by race, ethnicity, and education: US trends from 1999 to 2006 and effects of Medicare coverage. Ann Intern Med 2009;150(8):505-15.
6. Miech RA, Kim J, McConnell C, Hamman RF. A growing disparity in diabetes-related mortality US trends, 1989-2005. Am J Prev Med 2009;36(2):126-32.
7. Link CL, McKinlay JB. Disparities in the prevalence of diabetes: is it race/ethnicity or socioeconomic status? Results from the Boston Area Community Health (BACH) survey. Ethn Dis 2009;19(3):288-92.
8. City of Jacksonville, Florida. About Jacksonville. http://www.coj.net/About+Jacksonville/Geography+and+Demography.htm. Accessed February 20, 2009.
9. Florida Department of Health, Office of Health Statistics and Assessment. Age-adjusted diabetes death rate. Florida CHARTS. http://www.floridacharts.com/charts/DisPlayHTML.aspx?Sid=5qfgl1ukrontfv2obuslwc455&ReportType=8. Accessed February 20, 2009.
10. Agency for Health Care Administration. In-patient and emergency department data, 2007. http://ahca.myflorida.com. Accessed February 20, 2009.
11. Green C, Hoppa RD, Young TK, Blanchard JF. Geographic analysis of diabetes prevalence in an urban area. Soc Sci Med 2003;57(3):551-60.
12. Blanchard JF, Ludwig S, Wajda A, Dean H, Anderson K, Kendall O, et al. Incidence and prevalence of diabetes in Manitoba, 1986-1991. Diabetes Care 1996;19(8):807-11.
13. Schlundt DG, Hargreaves MK, McClellan L. Geographic clustering of obesity, diabetes, and hypertension in Nashville, Tennessee. J Ambul Care Manage 2006;29(2):125-32.
14. Cowie CC, Rust KF, Byrd-Holt DD, Eberhardt MS, Flegal KM, Engelgau MM, et al. Prevalence of diabetes and impaired fasting glucose in adults in the US population: National Health and Nutrition Examination Survey 1999-2002. Diabetes Care 2006;29(6):1263-68.
15. Florida Department of Health, Office of Health Statistics and Assessment. Florida CHARTS. http://www.floridacharts.com/charts/PopQuery.aspx. Accessed February 20, 2009.
16. Center for Health Statistics. Place matters. Duval County Health Department, Institute for Health Policy and Evaluation Research; 2008. Vol 7. http://www.dchd.net/services/hper/new/Reports/Reports%20in%20PDF/Volume%207,%202008/place%20matters2.pdf. Accessed July 30, 2009.
17. Signorello LB, Schlundt DG, Cohen SS, Steinwandel MD, Buchowski MS, McLaughlin JK, et al. Comparing diabetes prevalence between African Americans and whites of similar socioeconomic status. Am J Public Health 2007;97(12):2260-7.
18. Carter JS, Pugh JA, Monterrosa A. Non-insulin-dependent diabetes mellitus in minorities in the United States. Ann Intern Med 1996;125(3):221-32.
19. Robbins JM, Vaccarino V, Zhang H, Kasl SV. Socioeconomic status and type 2 diabetes in African American and non-Hispanic white women and men: evidence from the Third National Health and Nutrition Examination Survey. Am J Public Health 2001;91(1):76-83.
20. Kumari M, Head J, Marmot M. Prospective study of social and other risk factors for incidence of type 2 diabetes in the Whitehall II Study. Arch Intern Med 2004;164(17):1873-80.
21. Rich-Edwards JW, Colditz GA, Stampfer MJ, Willett WC, Gillman MW, Hennekens CH, et al. Birthweight and the risk for type 2 diabetes mellitus in adult women. Ann Intern Med 1999;130(4 Pt 1):278-84.
22. Mooy JM, de Vries H, Grootenhuis PA, Bouter LM, Heine RJ. Major stressful life events in relation to prevalence of undetected type 2 diabetes: the Hoorn Study. Diabetes Care 2000;23(2):197-201.
23. Musselman DL, Betan E, Larsen H, Phillips LS. Relationship of depression to diabetes types 1 and 2: epidemiology, biology, and treatment. Biol Psychiatry

2003;54(3):317-29.
24. Winkleby MA, Kraemer HC, Ahn DK, Varady AN. Ethnic and socioeconomic differences in cardiovascular disease risk factors: findings for women from the Third National Health and Nutrition Examination Survey, 1988–1994. JAMA 1998;280(4):356-62.
25. Feinglass J, Abadin S, Thompson J, Pearce WH. A census-based analysis of racial disparities in lower extremity amputation rates in Northern Illinois, 1987-2004. J Vasc Surg 2008;47(5):1001-7.
26. Chin MH, Zhang JX, Merrell K. Diabetes in the African-American Medicare population. Morbidity, quality of care, and resource utilization. Diabetes Care 1998;21(7):1090-5.
27. Pickett KE, Kelly S, Brunner E, Lobstein T, Wilkinson RG. Wider income gaps, wider waistbands? An ecological study of obesity and income inequality. J Epidemiol Community Health 2005;59(8):670-4.
28. Cox M, Boyle PJ, Davey PG, Feng Z, Morris AD. Locality deprivation and type 2 diabetes incidence: a local test of relative inequalities. Soc Sci Med 2007;65(9):1953-64.
29. Hasnain-Wynia R, Baker DW, Nerenz D, Feinglass J, Beal AC, Landrum MB, et al. Disparities in health care are driven by where minority patients seek care: examination of the hospital quality alliance measures. Arch Intern Med 2007;167(12):1233-9.
30. Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion. Behavioral Risk Factor Surveillance System (BRFSS) annual survey data. http://www.cdc.gov/BRfss/technical_infodata/weighting.htm. Accessed February 20, 2009.

Tables

Table 1. Health Zone Comparisons for Selected Demographic Characteristics, Duval County, Florida, 2007[a]

Characteristic[b]	Health Zone 1	Health Zone 2	Health Zone 3	Health Zone 4	Health Zone 5	Health Zone 6	Duval County
Residents at or below federal poverty level	28.0	8.8	5.3	11.7	10.8	7.3	11.9
At least high-school education	63.7	87.2	92.5	82.6	75.7	89.6	82.9
Children aged <18 y at or below the federal poverty level	38.4	12.0	6.4	16.6	14.5	9.2	16.4
Average median household income, $	21,185	44,509	53,972	39,610	42,040	44,765	41,118
African American	79.2	19.8	9.3	21.4	27.7	10.8	27.8

[a] Data Source: US Census, 2000.
[b] All numbers are percentages unless otherwise indicated.

Table 2. Diabetes Rates by Health Zone, Duval County, Florida, 2007[a]

Health Zone	Measure			
	Deaths[b]	Hospitalizations[c]	ED Visits[c]	Diagnosed With Diabetes[d]
1	93.5	747	692	14,250
2	30.5	239	191	6,310
3	31.0	148	105	5,166
4	38.8	322	236	11,861
5	43.8	401	224	15,446
6	31.6	187	155	5,132

Abreviation: ED, emergency department.
[a] Rates are per 100,000 adult population.
[b] Age-adjusted. Source: Florida Department of Health, Office of Vital Statistics.
[c] Source: Florida Agency for Health Care Administration.
[d] Data obtained from the 2007 Behavioral Risk Factor Surveillance System and reflect participants who responded yes to the question, "Have you ever been told by a doctor that you have diabetes?"

Table 3. Ratio of Diabetes Illness and Death for Health Zone 1 vs Other Health Zones, Duval County, Florida, 2007

Data Source	Ratio (95% CI)
Diagnosed prevalence[a]	1.67 (1.64-1.70)
Hospitalization, diabetes-related	2.49 (2.41-2.56)
ED use, diabetes-related	3.37 (3.26-3.48)
Hospitalization, diabetes	2.94 (2.68-3.22)
ED use, diabetes	3.74 (3.38-4.13)
Death, diabetes-related	2.52 (2.12-3.00)
Death, diabetes	2.70 (2.08-3.51)

Abbreviations: CI, confidence interval; ED, emergency department.
[a] Data obtained from the 2007 Behavioral Risk Factor Surveillance System.
Data Sources: Behavioral Risk Factor Surveillance System, Duval County, 2007; Florida Agency for Healthcare Administration, in-patient and emergency department data, 2007; Florida Department of Health Office of Vital Statistics, 2007 death files.

Appendix. Method for Weighting Data

The weighting formula for the data was adapted from the Behavioral Risk Factor Surveillance System method for calculating "FINALWT" (www.cdc.gov/BRfss/technical_infodata/weighting.htm). A variable, "HZFINALWT," was created, which was the final weight assigned to each respondent. It was obtained by replacing "POSTSTRAT" with "ZONEPOSTRAT" in the formula of "FINALWT." It was calculated by multiplying 2 variables, "WT2" and "ZONEPOSTSTR." The variable "WT2" (equals STRWT × 1/NPH × NAD) is precomputed by CDC and takes into account the number of adults in the respondent's household, the inverse of the number of residential telephone numbers in the respondent's household, and the differences in the basic probability of selection among strata. The variable "ZONEPOSTSTR" was created to account for zone, age, race, and sex of the respondent and is equal to the number of people in a health zone-by-age-by-race-by-sex category divided by the sum of the products of the preceding weights for the respondents in that same health zone-by-age-by-race-by-sex category (30).

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ORIGINAL RESEARCH

Factors Associated With Cervical Cancer Screening in Puerto Rico

Ana P. Ortiz, PhD, MPH; Sarah Hebl; Ruby Serrano, MS, DrPH; María E. Fernandez, PhD; Erick Suárez, PhD; Guillermo Tortolero-Luna, MD, PhD

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PEER REVIEWED

Abstract

Introduction

Racial/ethnic disparities in cervical cancer screening exist in the United States; rates are lowest among women who live in Puerto Rico. We identified factors associated with cervical cancer screening among women aged 18 years or older living in Puerto Rico.

Methods

We included women who participated in the Puerto Rico Behavioral Risk Factor Surveillance System in 2006 who had not had a hysterectomy (n = 2,206). We calculated the weighted population prevalence estimates of Papanicolaou (Pap) test screening in the past 3 years and used logistic regression models to assess factors associated with screening.

Results

Most participants (71.9% [95% confidence interval (CI) = 69.4%-74.4%]) reported having had a Pap test in the preceding 3 years. Factors associated with screening in multivariate analysis included routine checkup in the past year and leisure-time physical activity. Compared with women with a household income less than $15,000, those with higher incomes were more likely to have had a Pap test. Similarly, divorced or separated women were more likely to have been screened (OR = 1.13; 95% CI = 1.12-1.15) than those who were married/living together. We did not find associations between screening behavior and education, health care coverage, body mass index, or smoking status.

Conclusion

The prevalence of cervical cancer screening in Puerto Rico is below the 90% recommendation established by *Healthy People 2010*. Our findings regarding factors associated with Pap screening behavior identified population subgroups who are underscreened and who may benefit from targeted interventions and screening programs.

Introduction

In the United States, the incidence of cervical cancer among Hispanics (14.2 per 100,000) is almost double that of non-Hispanic whites (7.3 per 100,000); the death rate for Hispanics (3.4 per 100,000) is also 50% higher than for non-Hispanic whites (2.3 per 100,000) (1). Despite the overall decline in cervical cancer incidence and deaths in the United States in the last few decades, Hispanic women are less likely to be diagnosed with localized disease and have poorer survival rates than non-Hispanic whites (1,2). Cervical cancer is the 6th most common cancer among Hispanic women and ranks only 13th among cancers for non-Hispanic whites (2). In Puerto Rico, cervical cancer is the fourth most commonly diagnosed cancer in women, accounting for 4% of all newly diagnosed cancers and 2% of all cancer-related deaths among women (3).

The use of the Papanicolaou (Pap) test has resulted in a substantial decline in cervical cancer illnesses and deaths over recent decades (2). In the United States, lack of cervical cancer screening is the most powerful predictor of cervical cancer; thus, disparities in Pap test coverage influence disparities in cervical cancer (4). Despite the accessibility of this screening method, racial/ethnic disparities exist in its use in the United States (5). For example, in 2004, women living in Puerto Rico had the lowest prevalence of having had a recent (last 3 years) Pap test (73%) when compared with non-Hispanic whites (87%), African Americans (89%), and Hispanics (87%) living in the United States (excluding US territories) (6). Among Hispanics and other racial/ethnic groups in the United States, sociodemographic factors such as older age, lower income, lower education level (particularly those who did not graduate from high school), and lack of health care coverage have been positively correlated with a lower rate of Pap screening (7,8). In addition to sociodemographic factors, psychosocial factors such as embarrassment, language barriers, fear, lack of knowledge, and perceived partner disapproval influence Hispanic women's use of Pap screening (9).

To the best of our knowledge, no study has explored the factors influencing Pap test use among women in Puerto Rico. The purpose of this study was to determine the factors associated with self-reported recent Pap test (within 3 years before the interview) among women aged 18 years or older living in Puerto Rico who participated in the Puerto Rico Behavioral Risk Factor Surveillance System (PR-BRFSS). The results of our study are needed to elucidate barriers to cervical cancer screening in the Hispanic population of Puerto Rico. Our objectives are in alignment with the National Breast and Cervical Cancer Early Detection Program's goal of reducing racial disparities in screening and early detection and with the *Healthy People 2010* goal of reducing health disparities (10). In addition, this study contributes to meeting the objective of the Puerto Rico Comprehensive Cancer Control Plan (11) of increasing the proportion of women aged 18 years or older who receive a Pap test consistent with current recommendations.

Methods

For this study, we used 2006 data from the PR-BRFSS (12). The PR-BRFSS is part of the national BRFSS, a state-based system of health surveys established in 1984 by the Centers for Disease Control and Prevention to collect information on health risk behaviors, preventive health practices, and health care access primarily related to chronic disease and injury. This cross-sectional survey is conducted annually among noninstitutionalized adults, aged 18 years or older, in all 50 states, the District of Columbia, Puerto Rico, the US Virgin Islands, and Guam. The institutional review board of the University of Puerto Rico Medical Sciences Campus approved this study.

The women eligible for this study had participated in the 2006 PR-BRFSS, were aged 18 years or older, had no history of hysterectomy, and had responded to the question of whether or not they had had a Pap test in the past 3 years before the interview. Among the 3,040 women aged 18 years or older who participated in the PR-BRFSS in 2006, we excluded 710 women who had had a hysterectomy and 124 women with missing information regarding age (n = 16), Pap test history (n = 38), time since last Pap test (n = 31), or hysterectomy status (n = 39), which left a final study sample of 2,206 women.

The outcome variable of interest for this analysis was the proportion of women who had had a Pap test in the 3 years before the interview. Factors of interest included demographic characteristics, such as age in years (18-20, 21-29, 30-39, 40-49, 50-64, ≥65), marital status (married/living together, divorced/separated, widowed, single), educational attainment (less than high school graduate, high school graduate/General Educational Development certification, some college/technical school, college graduate), household income (<$15,000, $15,000-$34,999, $35,000-$49,999, ≥$50,000), health care coverage (yes/no), employment status (currently employed, unemployed, homemaker or retired, unable to work, student), and number of children living in the household (0, 1, 2, ≥3). Clinical characteristics included body mass index (BMI, categorized as normal or underweight [18.5-24.9 kg/m^2], overweight [25.0-29.9 kg/m^2], or obese [≥30.0 kg/m^2]), routine checkup in the past year (yes/no), and perceived general health status (fair or poor, good or excellent). Lifestyle characteristics included current smoking status (yes/no), binge drinking (4 or more drinks on 1 occasion [yes/no]), and leisure-time physical activity in the past 30 days (yes/no).

We conducted the statistical analysis by using SAS version 9.2 (SAS Institute, Inc, Cary, North Carolina) and Stata version 10.0 (StataCorp LP, College Station, Texas). We first described the study sample according to demographic, clinical, and lifestyle characteristics by using the survey frequency function in SAS. We then assessed the relationship between cervical cancer screening behavior and the demographic, clinical, and lifestyle factors by using contingency tables and Pearson's χ^2 tests, which also required the use of the survey frequency function. To further assess these relationships, we used the generalized linear model procedure in Stata to construct simple and multivariable logistic regression models (13). We estimated the prevalence odds ratios and their 95% confidence intervals to determine the magnitude of the association between the specific factors and cervical cancer screening behavior. The variables significantly associated with cervical cancer screening ($P < .05$) in the age-adjusted logistic regression models were included in the multivariable logistic regression models; those with at least marginal significance ($P < .10$) in the multivariate model were retained in the model. All data were weighted according to the respondent's age and the inverse of her probability of selection by using the 2006 census population projections. Detailed information about BRFSS weighting procedures can be found in the BRFSS operational guide (14).

Results

Approximately half of the women were aged 39 years or younger and were married or living as a couple (Table 1). Most had a household income of less than $35,000 a year, and almost all reported having health care coverage. Two-thirds of women reported that they were in good to excellent general health; 81% had a routine checkup in the previous year, 82% had at least 1 Pap test in their lifetime, and 72% had a Pap test in the past 3 years.

In the bivariate analysis, Pap screening in the past 3 years was significantly associated ($P < .05$) with age, marital status, education level, household income, employment status, number of children in the household, BMI, routine physical examination in the past year, health status, and leisure-time physical activity. Lower rates of Pap screening were observed in younger women, single women, women with a household income less than $15,000, women with some college or technical school education, and students (Table 2). In addition, lower rates of Pap test screening were reported by underweight or normal-weight women, women who had not had a routine medical checkup in the prior year, and those who reported no leisure-time physical activity. Pap screening was not associated with smoking status, health care coverage, binge drinking, or heavy alcohol consumption.

We found no significant interactions in the multivariate model (likelihood ratio $\chi^2 = 70.13$, $P = .17$). Compared with younger women (aged 18-20 years), older women (aged ≥21 years) were 2 to 5 times as likely to have had a Pap test in the last 3 years (Table 3). In addition, compared with women with the lowest household income, women with larger household incomes were also more likely to have had a Pap test in the past 3 years. Single women (never married) and widows were less likely than married women to have had a Pap test in the past 3 years.

Discussion

In 2006, Puerto Rico fell short of meeting the *Healthy People 2010* goal of a 90% Pap test screening rate for women aged 18 years or older (15). Our study shows that younger (aged <30 years) and older (aged ≥65 years) Puerto Rican women reported lower rates of cervical cancer screening than women aged 30 to 64 years. These results are consistent with the overall screening patterns in the United States (16) and among Hispanic women in the rest of the United States (8). Of interest is the low prevalence of screening among women aged 18 to 20 years in Puerto Rico observed in our study (9%). This prevalence is consistent with the low rate of cervical cancer screening among women aged 18 to 24 years in Puerto Rico (41%) reported by the BRFSS for 2004, which in addition is much lower than the screening rate of their counterparts in the rest of the United States (median = 81%), a pattern that has been consistent since 1996 (6). In addition, women with a household income of at least $35,000 were 2 to 3 times as likely to have been screened as those with the lowest household income. Household income has been positively correlated with cervical cancer screening in multiple studies (10,16-17), an association that could be partially explained by improved access to care with increasing wealth.

In contrast to results in other populations, our study found no substantial positive effect of education, employment status, or health care coverage on screening practices (7,8,16,17). Although the reasons for the lack of association between screening behavior and education and employment are unknown, for health care coverage the lack of association may be explained by the high prevalence of women in our study who had health care coverage (94%). The health care reform legislation passed in Puerto Rico in 1993 made health insurance available for underserved populations in Puerto Rico at or below 200% of the poverty level.

Routine checkup in the past year increased the likelihood of having been screened, a result consistent with other studies (8,18). This finding is not surprising since cervical cancer screening is often recommended by the doctor during the clinical visit. Participating in leisure-time physical activity increased the likelihood of screening in our study by more than 60%, a result consistent with that of another recent study that found that exercise was positively associated with breast and cervical cancer screening (7). This previous study also found a positive association between nonsmoking and screening. Our research, however, did not observe this association. Although studies have consistently shown an inverse relationship between obesity and screening behavior (decreased cervical cancer screening with increasing body size) (19), we found no association between BMI and cervical cancer screening in multivariate analysis. While in some groups higher weight may be associated with less emphasis on health and thus less screening, our findings may reflect a cultural norm of acceptance of a larger body weight/body size in Puerto Rican women similar to that found is some populations of black women in the United States (20).

Our study is subject to limitations. First, because the BRFSS is a telephone-based survey, it includes data only from residents who have a working home telephone and, thus, is unable to survey those who reside in households without telephone access. Consequently, the above data may not be generalizable to the entire adult Puerto Rican female population. Evidence suggests that income is positively associated with a recent Pap test. Since women who do not have telephones are more likely to have lower incomes, they likely also have lower Pap screening rates than women who participated in the study (8). Nonetheless, response rates in the 2006 PR-BRFSS were much higher (74%) than the median reported for BRFSS surveys in all other states and territories of the United States for the same year (51%) (21). Finally, the prevalence estimates were based on self-reported information, which is subject to recall bias and social desirability bias.

Our study shows that the rates of cervical cancer screening in Puerto Rico are lower than those in the United States, and well below the 90% goal established by *Healthy People 2010*. We have identified factors associated with Pap test screening in Puerto Rico that help identify subgroups of the population who are underscreened and who would benefit from targeted interventions. Interventions should focus on increasing screening rates, particularly among young and low-income women. Future studies should also focus on other psychosocial correlates of screening, including attitudes, beliefs, and cultural norms regarding screening practices. Studies of the effect of social determinants of health, such as area of residence (rural vs urban) and migrant status, are warranted in this population, since these factors influence screening behavior (17,22). In addition, public health policy regarding universal mandatory cervical cancer screening coverage in Puerto Rico should be implemented.

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Author Information

Corresponding Author: Ana P. Ortiz, PhD, MPH, University of Puerto Rico Comprehensive Cancer Center and University of Puerto Rico Medical Sciences Campus, PMB 711, 89 De Diego Ave, Ste 105, San Juan, Puerto Rico 00927-6346. Telephone: 787-758-2525, ext 1471. E-mail: ana.ortiz7@upr.edu.

Author Affiliations: Sarah Hebl, Tufts University School of Medicine, Boston, Massachusetts; Ruby Serrano, Puerto Rico Behavioral Risk Factor Surveillance System, Puerto Rico Department of Health, San Juan, Puerto Rico; María E. Fernandez, University of Texas at Houston, Houston, Texas; Erick Suárez, University of Puerto Rico Medical Sciences Campus, San Juan, Puerto Rico; Guillermo Tortolero-Luna, University of Puerto Rico Comprehensive Cancer Center, San Juan, Puerto Rico.

References

1. Cancer facts and figures for Hispanics, 2006-2008.

Atlanta (GA): American Cancer Society; 2006. http://www.cancer.org/downloads/STT/CAFF2006HispPWSecured.pdf. Accessed June 18, 2009.
2. Howe HL, Wu X, Ries LA, Cokkinides V, Ahmed F, Jemal A, et al. Annual report to the nation on the status of cancer, 1975-2003, featuring cancer among U.S. Hispanic/Latino populations. Cancer 2006;107(8):1711-42.
3. Cancer of the cervix uteri stat fact sheet, Puerto Rico Central Cancer Registry. Puerto Rico Department of Health; 2003. http://www.salud.gov.pr/RCancer/Reports/Pages/default.aspx. Accessed June 18, 2009.
4. Akers AY, Newmann SJ, Smith JS. Factors underlying disparities in cervical cancer incidence, screening, and treatment in the United States. Curr Probl Cancer 2007;31(3):157-81.
5. Smith RA, Cokkinides V, Brawley OW. Cancer screening in the United States, 2009: a review of current American Cancer Society guidelines and issues in cancer screening. CA Cancer J Clin 2009;59(1):27-41.
6. Behavioral Risk Factor Surveillance System survey data. Atlanta (GA): US Department of Health and Human Services, Centers for Disease Control and Prevention. http://apps.nccd.cdc.gov/brfss/race_c.asp?cat=WH&qkey=4426&yr=2004&state=PR&bkey=20047230&qtype=C&yr_c=&state_c=UB&bkey_c=20049930&qtype_c=C&grouping=&resp=1. Accessed May 15, 2007.
7. Welch C, Miller CW, James NT. Sociodemographic and health-related determinants of breast and cervical cancer screening behavior, 2005. J Obstet Gynecol Neonatal Nurs 2008;37(1):51-7.
8. Coughlin SS, Uhler RJ. Breast and cervical cancer screening practices among Hispanic women in the United States and Puerto Rico, 1998-1999. Prev Med 2002;34(2):242-51.
9. Fernández ME, Gonzales A, Tortolero-Luna G, Williams J, Saavedra-Embesi M, Chan W, et al. Effectiveness of cultivando la salud: a breast and cervical cancer screening promotion program for low-income Hispanic women. Am J Public Health 2009;99(5):936-43.
10. Adams EK, Breen N, Joski PJ. Impact of the National Breast and Cervical Cancer Early Detection Program on mammography and Pap test utilization among white, Hispanic, and African American women: 1996-2000. Cancer 2007;109(2 Suppl):348-58.
11. Puerto Rico Comprehensive Cancer Control Plan, 2008-2012. San Juan (PR): Comprehensive Cancer Control Coalition; 2008.
12. Behavioral Risk Factor Surveillance System survey data. Atlanta (GA): US Department of Health and Human Services, Centers for Disease Control and Prevention. http://apps.nccd.cdc.gov/brfss/page.asp?cat=XX&yr=2006&state=PR#XX. Accessed February 18, 2010.
13. Hosmer D, Lemeshow S. Applied logistic regression. 2nd edition. New York (NY): John Wiley & Sons, Inc; 2000. p. 31-46.
14. Behavioral Risk Factor Surveillance System operational and user's guide, version 3.0. Atlanta (GA): US Department of Health and Human Services, Centers for Disease Control and Prevention. ftp://ftp.cdc.gov/pub/Data/Brfss/userguide.pdf. Accessed February 18, 2010.
15. Healthy people 2010. Volumes I and II. US Department of Health and Human Services; 2001. http://www.healthypeople.gov/Document/tableofcontents.htm#under. Accessed June 18, 2009.
16. Coughlin SS, Leadbetter S, Richards T, Sabatino SA. Contextual analysis of breast and cervical cancer screening and factors associated with health care access among United States women, 2002. Soc Sci Med 2008;66(2):260-75.
17. Coughlin SS, King J, Richards TB, Ekwueme DU. Cervical cancer screening among women in metropolitan areas of the United States by individual-level and area-based measures of socioeconomic status, 2000 to 2002. Cancer Epidemiol Biomarkers Prev 2006;15(11):2154-9.
18. Shah M, Zhu K, Wu H, Potter J. Hispanic acculturation and utilization of cervical cancer screening in the US. Prev Med 2006;42(2):146-9.
19. Cohen SS, Palmieri RT, Nyante SJ, Koralek DO, Kim S, Bradshaw P, et al. Obesity and screening for breast, cervical and colorectal cancer in women: a review. Cancer 2008;112(9):1892-904.
20. Anderson LA, Eyler AA, Galuska DA, Brown DR, Brownson RC. Relationship of satisfaction with body size and trying to lose weight in a national survey of overweight and obese women aged 40 and older, United States. Prev Med 2002;35(4):390-6.
21. Kilmer G, Roberts H, Hughes E, Li Y, Valluru B, Fan A, et al. Surveillance of certain behaviors and conditions among states and selected local areas — Behavioral Risk Factor Surveillance System (BRFSS), United States, 2006. MMWR Surveill Summ 2008;57(SS-7):1-10.
22. Coughlin SS, Wilson KM. Breast and cervical cancer screening among migrant and seasonal farmworkers: a review. Cancer Detect Prev 2002;26(3):203-9.

Tables

Table 1. Characteristics of 2,206 Adult Women With Data on Pap Testing, Puerto Rico Behavioral Risk Factor Surveillance System, 2006[a]

Characteristic	n[b]	% (95% CI)[c]
Age, y		
18-20	75	9 (6.6-10.5)
21-29	209	18 (15.3-20.0)
30-39	400	22 (20.1-24.3)
40-49	446	19 (17.2-20.8)
50-64	553	19 (17.4-20.8)
≥65	523	14 (12.2-14.8)
Marital status		
Married/living together	1,045	52 (49.0-54.1)
Divorced/separated	493	16 (14.7-17.9)
Widowed	343	9 (7.6-9.7)
Single	323	24 (20.9-26.0)
Education		
Less than high school graduate	632	22 (19.8-23.4)
High school graduate/GED	501	23 (21.0-25.3)
Some college/technical school	404	22 (19.6-24.0)
College graduate	668	33 (31.0-35.8)
Household income		
<$15,000	909	40 (37.3-42.4)
$15,000-34,999	683	41 (38.6-44.0)
$35,000-49,999	145	9 (7.5-10.7)
≥$50,000	150	10 (8.1-11.4)
Health care coverage		
Yes	2,093	94 (93.1-95.5)
No	110	6 (4.5-6.9)
Employment status		
Currently employed	803	41 (38.8-43.8)
Unemployed	103	5 (3.9-6.2)
Homemaker/retired	1,043	37 (34.8-39.4)
Unable to work	140	5 (3.9-5.6)
Student	116	12 (9.7-14.0)

Abbreviations: Pap, Papanicolaou; CI, confidence interval; GED, General Educational Development certificate; BMI, body mass index.
[a] Inclusion criteria included no prior hysterectomy and a yes or no response to the BRFSS question regarding having had a Pap test in the past 3 years. All other participants were excluded.
[b] Totals may vary as a result of missing responses, including don't know/not sure and refused.
[c] Weighted population estimates and percentages.

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Table 1. (continued) Characteristics of 2,206 Adult Women With Data on Pap Testing, Puerto Rico Behavioral Risk Factor Surveillance System, 2006[a]

Characteristic	n[b]	% (95% CI)[c]
No. of children in household		
0	1,327	54 (51.2-56.3)
1	354	20 (17.5-27.8)
2	345	17 (15.4-19.0)
≥3	180	9 (7.9-10.9)
BMI		
Underweight or normal weight (18.5-24.9 kg/m^2)	805	45 (42.0-47.3)
Overweight (25.0-29.9 kg/m^2)	695	32 (29.8-34.6)
Obese (≥30 kg/m^2)	525	23 (21.0-25.2)
Routine checkup in the past year		
Yes	1,755	81 (78.8-83.0)
No	372	19 (17.0-21.2)
General health status		
Good to excellent	1,298	67 (64.8-69.2)
Fair to poor	902	33 (30.8-35.2)
Ever had a Pap test		
Yes	1,957	82 (79.7-84.4)
No	249	18 (15.6-20.3)
Had Pap test in past 3 years		
Yes	1,695	72 (69.4-74.4)
No	511	28 (25.6-30.6)
Binge drinking		
Yes	117	7 (5.6-8.6)
No	2,042	93 (91.4-94.4)
Heavy alcohol consumption		
Yes	2,131	98 (96.8-98.5)
No	44	2 (1.5-3.2)
Current smoking status		
Yes	204	9 (7.8-10.7)
No	1,999	91 (89.3-92.2)
Leisure-time physical activity		
Yes	1,173	54 (51.0-56.0)
No	1,032	47 (44.0-49.0)

Abbreviations: Pap, Papanicolaou; CI, confidence interval; GED, General Educational Development certificate; BMI, body mass index.
[a] Inclusion criteria included no prior hysterectomy and a yes or no response to the BRFSS question regarding having had a Pap test in the past 3 years. All other participants were excluded.
[b] Totals may vary as a result of missing responses, including don't know/not sure and refused.
[c] Weighted population estimates and percentages.

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Table 2. Percentage of Adult Women Who Have Had a Pap Test in the Past 3 Years, Puerto Rico Behavioral Risk Factor Surveillance System, 2006[a]

Characteristic	n[b]	% (95% CI)[c]
Age (*P* < .001), y		
18-20	25	26 (16.0-35.6)
21-29	147	64 (56.4-71.3)
30-39	322	81 (76.0-84.9)
40-49	366	81 (77.1-85.2)
50-64	461	83 (79.4-86.4)
≥65	374	69 (64.2-73.3)
Marital status (*P* < .001)		
Married/living together	874	83 (80.6-85.9)
Divorced/separated	406	82 (77.3-85.9)
Widowed	245	68 (62.2-74.0)
Single	168	41 (35.0-47.7)
Education (*P* = .006)		
Less than high school graduate	457	71 (66.7-75.0)
High school graduate/GED	382	69 (62.9-74.2)
Some college/technical school	306	67 (61.1-73.1)
College graduate	549	78 (73.8-82.0)
Household income (*P* < .001)		
<$15,000	672	70 (66.2-73.7)
$15,000-34,999	546	73 (68.9-77.6)
$35,000-49,999	134	87 (79.2-95.3)
≥$50,000	128	84 (77.1-91.6)
Health care coverage (*P* = .25)		
Yes	1,621	72 (69.7-74.9)
No	72	66 (56.1-76.6)
Employment status (*P* < .001)		
Currently employed	661	79 (75.9-82.9)
Unemployed	85	76 (65.2-87.7)
Homemaker/retired	799	77 (73.6-79.6)
Unable to work	110	80 (72.4-87.0)
Student	39	26 (17.6-33.8)

Abbreviations: Pap, Papanicolaou; CI, confidence interval; GED, General Educational Development certificate; BMI, body mass index.
[a] Data exclude women who had had a hysterectomy.
[b] Totals may vary as a result of missing responses, including don't know/not sure and refused.
[c] Weighted population estimates; women who responded don't know/not sure, or who refused were excluded.

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Table 2. (continued) Percentage of Adult Women Who Have Had a Pap Test in the Past 3 Years, Puerto Rico Behavioral Risk Factor Surveillance System, 2006[a]

Characteristic	n[b]	% (95% CI)[c]
Number of children in household (*P* = .002)		
0	999	68 (64.3-71.3)
1	279	75 (69.6-80.7)
2	280	80 (75.3-84.9)
≥3	137	73 (65.1-81.2)
BMI (*P* < .001)		
Under or normal weight (18.5-24.9 kg/m^2)	608	68 (63.5-72.1)
Overweight (25.0-29.9 kg/m^2)	574	80 (75.9-83.6)
Obese (≥30 kg/m^2)	403	74 (69.2-78.7)
Routine checkup in the past year (*P* < .001)		
Yes	1,409	76 (73.0-78.5)
No	241	60 (53.6-65.9)
General health status (*P* = .045)		
Good to excellent	999	70 (67.0-73.6)
Fair to poor	692	75 (71.8-78.6)
Binge drinking (*P* = .29)		
Yes	87	66 (55.5-77.2)
No	1,572	72 (69.5-74.7)
Heavy alcohol consumption (*P* = .95)		
Yes	34	72 (55.8-88.9)
No	1,639	72 (69.4-74.4)
Current smoking status (*P* = .93)		
Yes	204	72 (69.3-74.6)
No	1,999	72 (64.9-79.6)
Leisure-time physical activity (*P* = .005)		
Yes	945	75 (72.0-78.5)
No	750	68 (64.3-71.8)

Abbreviations: Pap, Papanicolaou; CI, confidence interval; GED, General Educational Development certificate; BMI, body mass index.
[a] Data exclude women who had had a hysterectomy.
[b] Totals may vary as a result of missing responses, including don't know/not sure and refused.
[c] Weighted population estimates; women who responded don't know/not sure, or who refused were excluded.

Table 3. Multivariate Predictors of Having Had a Pap Test in the Past 3 Years Among Adult Women, Puerto Rico Behavioral Risk Factor Surveillance System, 2006[a]

Predictor Variable	Multivariate OR (95% CI)
Age group (*P* < .001), y	
18-20	1 [Reference]
21-29	3.54 (3.46-3.62)
30-39	4.61 (4.50-4.72)
40-49	3.88 (3.79-3.98)
50-64	4.26 (4.15-4.37)
≥65	2.38 (2.31-2.44)
Household income (*P* < .001)	
<$15,000	1 [Reference]
$15,000-34,999	1.29 (1.28-1.31)
$35,000-49,999	2.78 (2.71-2.84)
≥$50,000	2.45 (2.39-2.50)
Marital status (*P* < .001)	
Married/living together	1 [Reference]
Divorced/separated	1.14 (1.12-1.15)
Widowed	0.64 (0.62-0.65)
Single	0.19 (0.18-0.19)
Routine checkup in the past year (*P* < .001)	
Yes	2.52 (2.49-2.55)
No	1 [Reference]
Leisure-time physical activity (*P* < .001)	
Yes	1.41 (1.40-1.42)
No	1 [Reference]

Abbreviations: Pap, Papanicolaou; OR, odds ratio; CI, confidence interval.
[a] Data exclude women who had had a hysterectomy and those who responded don't know/not sure or who refused to answer.

This file was updated on August 15, 2010, to incorporate the corrections in Vol. 7, No. 5, at http://www.cdc.gov/pcd/issues/2010/sep/10_0138.htm.

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ORIGINAL RESEARCH

State-Level Medicaid Expenditures Attributable to Smoking

Brian S. Armour, PhD; Eric A. Finkelstein, PhD; Ian C. Fiebelkorn

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PEER REVIEWED

Abstract

Introduction

Medicaid recipients are disproportionately affected by tobacco-related disease because their smoking prevalence is approximately 53% greater than that of the overall US adult population. This study estimates state-level smoking-attributable Medicaid expenditures.

Methods

We used state-level and national data and a 4-part econometric model to estimate the fraction of each state's Medicaid expenditures attributable to smoking. These fractions were multiplied by state-level Medicaid expenditure estimates obtained from the Centers for Medicare and Medicaid Services to estimate smoking-attributable expenditures.

Results

The smoking-attributable fraction for all states was 11.0% (95% confidence interval, 0.4%-17.0%). Medicaid smoking-attributable expenditures ranged from $40 million (Wyoming) to $3.3 billion (New York) in 2004 and totaled $22 billion nationwide.

Conclusion

Cigarette smoking accounts for a sizeable share of annual state Medicaid expenditures. To reduce smoking prevalence among recipients and the growth rate in smoking-attributable Medicaid expenditures, state health departments and state health plans such as Medicaid are encouraged to provide free or low-cost access to smoking cessation counseling and medication.

Introduction

Medicaid is a means-tested entitlement program that provides health care coverage to approximately 58 million low-income Americans, many of whom would otherwise be uninsured (1,2). The Medicaid program is jointly financed by the federal and state governments. In 2005, depending on a state's average personal income level, the federal Medicaid matching rate ranged from 50% to 83% (1). The Congressional Budget Office estimates that federal Medicaid expenditures were $191 billion in 2007 (3). Assuming an average Medicaid matching rate of 57%, program expenditures for all 50 states and the District of Columbia are projected to have exceeded $144 billion in 2007 (4,5). By 2018, total federal Medicaid spending is projected to be $445 billion, and assuming a 57% matching rate, total state Medicaid spending is projected to exceed $335 billion (3).

As a percentage of state budgets, Medicaid expenditures increased from 8% in 1985 to 21.5% in 2006, surpassing elementary and secondary education as the largest single budget item (2,5). Medicaid expenditures are expected to consume an ever-increasing share of state budgets, and many states will have difficulty meeting their Medicaid commitments without cutting other state-funded programs (1,5,6). In response to growing concern among state governments, the chairman and vice-chairman of the National Governors Association, in testimony before the US Senate Finance Committee, recommended placing a greater emphasis on disease prevention as a means to contain rising Medicaid costs (6).

Tobacco-cessation programs are effective in lowering the prevalence of cigarette smoking and its consequent serious and costly medical conditions, including pregnancy-related complications, heart disease, respiratory illness, and several types of cancer (7-9). Tobacco-cessation programs should target Medicaid recipients because smoking prevalence in the adult Medicaid population is approximately 53% greater than that of the overall US adult population (34.5% vs 22.6% in 2006) (10).

We used data from the Medical Expenditure Panel Survey (MEPS) and the Behavioral Risk Factor Surveillance System (BRFSS) to update previous estimates of Medicaid smoking-attributable medical expenditures at the state level (11). These estimates might assist state health departments and Medicaid in formulating effective smoking-cessation polices to help reduce the high prevalence of cigarette use among their recipients.

Methods

Data

We used the 2001 and 2002 MEPS to develop a model that predicts smoking-attributable medical expenditures for the Medicaid population. MEPS is a nationally representative survey of the civilian, noninstitutionalized population that quantifies each participant's total annual medical spending, including expenditures from public- and private-sector health insurers and out-of-pocket payments. The data also include information about each participant's source of health insurance (eg, any evidence of Medicaid coverage during the year) and sociodemographic characteristics (such as race/ethnicity, sex, and education). Information about MEPS is available at www.meps.ahrq.gov/mepsweb/.

The MEPS sampling frame is drawn from participants in the National Health Interview Survey (NHIS). NHIS is a nationally representative survey that collects data on selected health topics. Although MEPS does not capture information on smoking, self-reported smoking variables are available for a subset of adult NHIS participants (the Adult Sample File) and can be merged with MEPS data. We used responses to the question "Have you smoked at least 100 cigarettes in your entire life?" to differentiate between ever smokers and nonsmokers. We excluded from the analysis sample respondents with missing data on smoking variables (≈1% of respondents aged ≥18 years and all respondents aged <18 at the time of the NHIS interview) and those who did not receive Medicaid coverage. Our final MEPS-NHIS population included 1,588 adults with weighting variables that allowed us to generate nationally representative estimates of the adult, civilian, noninstitutionalized Medicaid population (Table 1).

Before constructing our national model, we used the Medical Care component of the Consumer Price Index to inflate all MEPS annual medical spending data to 2004 dollars.

State-level representative data

The BRFSS is a state-based telephone survey of the adult (aged ≥18), noninstitutionalized population that tracks health risks in the United States. The most recent BRFSS surveys do not allow for stratifying participants by type of health insurance. This information was, however, available before 2001. Therefore, we used 1998-2000 BRFSS data to predict state-level medical expenditures for the Medicaid population. Information about BRFSS is available at www.cdc.gov/BRFSS/. Although BRFSS does not collect medical expenditure data, it includes information about each participant's smoking status, insurance status (before 2001), and sociodemographic characteristics (such as race/ethnicity, sex, and education). Because these variables match those from MEPS-NHIS, we were able to construct an expenditure prediction model with MEPS-NHIS data and use the results to generate expenditure estimates for smokers and nonsmokers on the basis of state-representative population characteristics of BRFSS participants.

As we did with our MEPS-NHIS restrictions, we excluded those with missing smoking data (≈1%) and those who did not receive Medicaid coverage. Our final BRFSS population included 16,201 adults with weighting variables that allowed us to generate state-representative estimates of the adult, noninstitutionalized Medicaid population (Table 1).

Estimating state-specific smoking-attributable medical expenditures for the Medicaid population involved 3 steps. First, we used MEPS-NHIS data to create a model that predicts annual medical expenditures for Medicaid recipients as a function of smoking status, body weight, and sociodemographic characteristics. Second, we used state-representative BRFSS data and results from our MEPS-NHIS national model to estimate the fraction of medical expenditures for Medicaid recipients that was attributable to smoking for each state. Third, we multiplied these fractions by previously published estimates of state-specific Medicaid expenditures to compute smoking-attributable Medicaid expenditures for each state. These steps are described in detail below.

MEPS-NHIS national model

We used a 4-part regression model to predict annual medical expenditures for each MEPS-NHIS Medicaid recipient. The 4-part regression approach was pioneered by authors of the RAND Health Insurance Experiment to control for several unique characteristics of the medical expenditures distribution and is now commonly applied to medical expenditures data (12,13). The model estimates predicted expenditures by using the following functional form: $EXP = Pr(C \times EXP_{IP} + [1 - C]EXP_{NIP})$, where EXP represents predicted annual expenditures; Pr represents the predicted probability of positive medical expenditures during the year and is estimated with a logistic regression model; C represents the conditional probability of positive inpatient expenditures, given positive expenditures, and is estimated with a logistic regression model; EXP_{IP} represents ordinary least squares (OLS)-predicted medical expenditures, given positive inpatient expenditures during the year; and EXP_{NIP} represents OLS-predicted medical expenditures, given positive expenditures but no inpatient expenditures.

All OLS regression models are estimated on the logged expenditure variable to adjust for the skewness in annual expenditures (mean annual expenditures are significantly greater than the median). Logged expenditures are converted back to expenditures by using the homoscedastic smearing factor (14).

Including dummy variables that indicate smoking status (ever smoked set equal to 1 and the referent group, never smoked, set equal to 0) in each regression model allowed us to quantify the effect of smoking on annual medical expenditures. In addition to smoking status, all regressions controlled for other variables assumed to influence annual medical expenditures, including self-reported body weight, sex, race/ethnicity, age, region of residence, education, and marital status. Regression models were estimated by using SUDAAN version 8 (RTI International, Research Triangle Park, North Carolina) to control for the complex survey design used in MEPS-NHIS. Table 2 presents results from the 4-part regression model.

BRFSS state-level estimates

We used the coefficient estimates from the MEPS-NHIS models to predict annual medical expenditures for each BRFSS Medicaid recipient. To do this, we multiplied each person's characteristics (the independent variables) by his respective coefficients generated from the 4 MEPS-NHIS regression models and combined the results with the equation above. Using the BRFSS weighting variables and each person's predicted medical expenditures, we computed total predicted medical expenditures for each state's Medicaid population.

We estimated smoking-attributable medical expenditures as the difference between predicted expenditures for ever smokers and predicted expenditures for nonsmokers, leaving all other variables unchanged. This method allowed us to isolate the effect of smoking while maintaining any other population characteristics that may contribute to higher annual medical expenditures among smokers.

For the Medicaid population in each state, the percentage of aggregate medical expenditures attributable to smoking was calculated by dividing aggregate predicted expenditures attributable to smoking by total predicted expenditures for adult Medicaid recipients in each state. Because BRFSS is limited to adults, our results should be interpreted as the fraction of adult medical expenditures that are attributable to smoking among adults in each state.

Estimating total and public-sector expenditures

For a variety of reasons, including the lack of data on institutionalized populations, MEPS national spending estimates (and state-level spending estimates based on MEPS) underestimate actual US health care spending (15). Therefore, to quantify annual adult smoking-attributable medical expenditures for each state, we multiplied our state-by-state smoking-attributable fractions by published estimates of 2001 state-specific Medicaid expenditures, available from the Centers for Medicare and Medicaid

Services (16). We used 2001 because it is the most recent year that annual, state-specific Medicaid expenditure estimates are available. To match our regression population, we limited Medicaid expenditures to those accrued by adult recipients (≥18 years). We then inflated medical expenditure estimates to 2004 by using a national adjustment factor (1.31). This adjustment factor, calculated as the ratio of 2004 projected expenditures (actual expenditures not yet available) to 2001 actual expenditures, was based on data from Centers for Medicare and Medicaid Services National Health Expenditure Accounts, generally considered the standard for measuring annual health care spending (17).

Results

State-specific estimates of smoking prevalence among Medicaid recipients vary considerably across states and range from 35% (Mississippi) to 80% (New Hampshire) (Table 3). Nationally, approximately 11% (95% confidence interval, 0.4%-17.0%) of adult Medicaid expenditures are attributable to smoking. At the state level, smoking-attributable fractions range from 6% (New Jersey) to 18% (Arizona and Washington).

Smoking-attributable medical expenditures in the adult Medicaid population total $22 billion. State-level smoking-attributable medical expenditures among adult Medicaid recipients range from $40 million (Wyoming) to $3.3 billion (New York) (Figure).

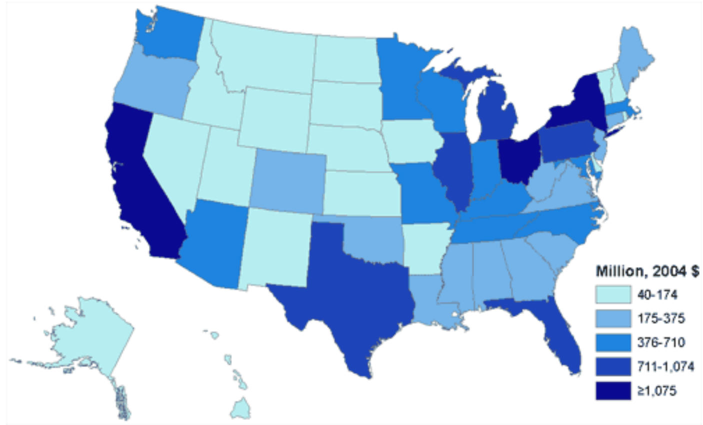

Figure. State-by-state distribution of Medicaid smoking-attributable medical expenditures.

Discussion

The 2000 Public Health Service (PHS) clinical practice guideline for treating tobacco dependence recommends individual, group, and telephone counseling, as well as 5 medications (18). Treating tobacco dependence is more cost-effective than commonly covered preventive services such as mammography or treatment of mild to moderate hypertension (19). In 2002, however, only 10 states reported using the 2000 PHS guideline to design treatment benefits and programs for Medicaid recipients or to train Medicaid health care providers. Moreover, only 5 states required providers or health plans to document tobacco use in patients' medical charts, and only 2 states offered all counseling and pharmacotherapy treatments recommended by the guideline to their Medicaid recipients (20).

The growth rate in Medicaid expenditures has led the National Governors Association to propose a bipartisan plan to reform the program. A key element of this plan is to make Medicaid more effective and efficient by developing policies that will "maintain or even [improve] health outcomes while potentially saving money for both the states and the federal government" (6). One way to improve the health of Medicaid recipients and potentially reduce the rate of growth in Medicaid program expenditures is by covering PHS-recommended treatments, including individual and group telephone counseling and approved drugs (9,21-24).

Strengths and limitations

The MEPS-NHIS national model that was used to calculate our state-level estimates is an improvement on a previous study that used data from the 1987 National Medical Expenditure Survey (NMES) to estimate smoking-attributable Medicaid expenditures (11). Results from the 1987 NMES are dated, and unlike NHIS, many of the key smoking variables that NMES used were imputed (25). Using recent data and actual, as opposed to imputed, smoking information in our calculations provides states with updated and accurate information that may better inform policy decisions. In addition, these differences may, in part, explain why the nationwide Medicaid smoking-attributable fraction of 11.0% is more conservative than the previous estimate of 14.5% generated for 1993 (11). Other changes that may account for the difference in our estimated smoking-attributable fraction include potential changes in the number of people treated for smoking-related illness from 1993 to 2002 and any change in treatment disposition from inpatient to outpatient care. Finally, our estimates differ from previous estimates, and probably understate Medicaid smoking-attributable expenditures, because they exclude expenditures for nursing home care, which are not available in the MEPS-NHIS model.

Despite these strengths, our study has several limitations. First, both the MEPS-NHIS and BRFSS are limited to noninstitutionalized populations, but we apply the resulting smoking-attributable fractions to expenditure estimates that include both institutionalized and noninstitutionalized populations. If these fractions are different for the institutionalized population, our expenditure estimates would be biased. Second, data limitations precluded us from quantifying smoking-attributable medical expenditures for smokers younger than 18 years and nonsmokers exposed to secondhand smoke. The effects of secondhand smoke on children's health are considerable (7). Secondhand smoke exposure can lead to acute lower respiratory infections, such as bronchitis and pneumonia in infants and young children, and can cause children who already have asthma to experience more frequent and severe attacks (26). Although health care expenditures attributable to secondhand smoke exposure may be high, quantifying these expenditures is difficult. As a consequence, our estimates understate smoking-attributable expenditures. Third, our analysis is limited to health care expenditures and therefore does not address other expenses (eg, disability, decreased productivity, absenteeism) that result from smoking (7). Finally, because our focus was not to test statistically whether smoking-attributable expenditures were larger in some states than others, we did not calculate standard errors at the state level.

Conclusions

An estimated 443,000 Americans die prematurely each year as a result of smoking or exposure to secondhand smoke (27). Medicaid recipients are disproportionately affected by tobacco-related disease because their smoking prevalence is approximately 53% greater than that of the overall US adult population (10). In addition to the individual health toll, the disproportionately higher smoking prevalence among Medicaid recipients imposes substantial costs on society. We estimate that smoking accounts for approximately 11% of Medicaid program expenditures. To improve the health of Medicaid recipients and potentially reduce the growth rate of expenditures, Medicaid programs in all 50 states and the District of Columbia are encouraged to follow the 2000 PHS guidelines and cover all recommended tobacco-dependence treatments and approved medications (18). The cost-effectiveness of these programs, combined with the high cost of smoking, suggests that such coverage may provide cost savings to the financially strapped Medicaid programs.

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Author Information

Corresponding Author: Brian S. Armour, PhD, Centers for Disease Control and Prevention, 1600 Clifton Rd NE, Mailstop E-88, Atlanta, GA 30329. Telephone: 404-498-3014. E-mail: barmour@cdc.gov.

Author Affiliations: Eric A. Finkelstein, Ian C. Fiebelkorn, RTI International, Research Triangle Park, North Carolina.

References

1. Smith VK, Moody G. Medicaid in 2005: principles and proposals for reform. A report prepared for the National Governors Association. Lansing (MI): Health Management Associates; 2005. http://www.healthmanagement.com/files/NGA-HMA-23Feb2005.pdf. Accessed June 4, 2008.
2. State expenditure report 2006. Washington (DC): National Association of State Budget Officers; 2007. http://www.nasbo.org/Publications/PDFs/fy2006er.pdf. Accessed June 4, 2008.
3. The budget and economic outlook: fiscal years 2008 to 2018. Washington (DC): Congressional Budget Office; 2008. http://www.cbo.gov/ftpdocs/89xx/doc8917/01-23-2008_BudgetOutlook.pdf. Accessed June 4, 2008.
4. Medicaid formula: differences in funding ability by states often are widened. A report to the Honorable

Dianne Feinstein, US Senate. Washington (DC): US General Accounting Office; 2003. http://www.gao.gov/new.items/d03620.pdf. Accessed June 4, 2008.
5. State expenditure report 2003. Washington (DC): National Association of State Budget Officers; 2004. http://www.nasbo.org/Publications/PDFs/2003ExpendReport.pdf. Accessed June 4, 2008.
6. Medicaid reform: statement of Governor Mark R. Warner, chairman, and Governor Mike Huckabee, vice chairman, before the Committee on Finance of the United States Senate. Washington (DC): National Governors Association; June 15, 2005.
7. The health consequences of smoking: a report of the Surgeon General. Atlanta (GA): Centers for Disease Control and Prevention, US Department of Health and Human Services; 2004.
8. Centers for Disease Control and Prevention. Annual smoking-attributable mortality, years of potential life lost, and productivity losses — United States, 1997-2001. MMWR Morb Mortal Wkly Rep 2005;54(25):625-28.
9. Issue brief: state employee wellness initiatives. Washington (DC): National Governors Association Center for Best Practices; 2005.
10. Pleis JR, Lethbridge-Çejku M. Summary health statistics for US adults: National Health Interview Survey, 2006. Vital Health Stat 10 2007;10(235):1-153.
11. Miller LS, Zhang X, Novotny T, Rice DP, Max W. State estimates of Medicaid expenditures attributable to cigarette smoking, fiscal year 1993. Public Health Rep 1998;113(2):140-51.
12. Manning W, Newhouse J, Duan N. Health insurance and the demand for medical care: evidence from a randomized experiment. Am Econ Rev 1987;77:251-77.
13. Finkelstein E, Fiebelkorn I, Wang G. National medical spending attributable to overweight and obesity: how much and who's paying? Health Aff Millwood 2003;(Suppl):W3-219-26.
14. Manning W. The logged dependent variable, heteroscedasticity, and the retransformation problem. J Health Econ 1998;17:283-95.
15. Seldon T. Reconciling medical expenditure estimates from MEPS and the NHA. Health Care Financ Rev 1996;23(1):161-78.
16. Centers for Medicare and Medicaid Services. FY 2001 Medicaid medical vendor payments by age group of beneficiaries. http://www.cms.hhs.gov/medicaid/msis/01_table19.pdf. Accessed June 4, 2008.
17. Centers for Medicare and Medicaid Services. National health care expenditures projections: 2004-2014. http://www.cms.hhs.gov/NationalHealthExpendData/downloads/nheprojections2004-2014.pdf. Accessed June 4, 2008.
18. Fiore MC, Bailey WC, Cohen SJ, Dorfman SF, Goldstein MG, Gritz ER, et al. Treating tobacco use and dependence: clinical practice guideline. Rockville (MD): Public Health Service, US Department of Health and Human Services; 2000.
19. Eddy DM. David Eddy ranks the tests. Harv Health Lett 1992;Suppl:10-11.
20. Centers for Disease Control and Prevention. State Medicaid coverage for tobacco-dependence treatments — United States, 1994-2002. MMWR Morb Mortal Wkly Rep 2004;53:54-7.
21. Warner KE. Smoking out the incentives for tobacco control in managed care settings. Tobacco Control 1998;7(Suppl):S50-4.
22. Partnership for Prevention. Priorities for America's health: capitalizing on life-saving, cost-effective preventive services. http://www.prevent.org/content/view/46/96/. Accessed June 4, 2008.
23. Hopkins DP, Husten CG, Fielding JE, Rosenquist JN, Westphal LL. Reviews of evidence regarding interventions to reduce tobacco use and exposure to environmental tobacco smoke. Am J Prev Med 2001;20(2 Suppl):67-87.
24. Solberg LI, Maciosek MV, Edwards NM, Khanchandani HS, Goodman MJ. Repeated tobacco-use screening and intervention in clinical practice: health impact and cost effectiveness. Am J Prev Med 2006;31(1):62-71.
25. Cutler DM, Epstein AM, Frank RG, Hartman R, King III C, Newhouse JP, et al. How good a deal was the tobacco settlement? Assessing payments to Massachusetts. NBER Working Paper. 2000; No. 7747.
26. The health consequences of involuntary exposure to tobacco smoke: a report of the Surgeon General. Atlanta (GA): Centers for Disease Control and Prevention, US Department of Health and Human Services; 2006.
27. Centers for Disease Control and Prevention. Smoking-attributable mortality, years of potential life lost, and productivity losses — United States, 2000-2004. MMWR Morb Mortal Wkly Rep 2008;57(45):1226-8.

Tables

Table 1. Characteristics of Adult MEPS-NHIS (2001 and 2002) and BRFSS (1998-2000) Medicaid Recipients With Data on Smoking Status[a]

Characteristic	MEPS-NHIS		BRFSS	
	Nonsmokers (n = 768)	Ever Smokers (n = 820)	Nonsmokers (n = 7,701)	Ever Smokers (n = 8,500)
Sex				
Male	21	33	23	32
Female	79	67	77	68
Race/ethnicity				
White	32	60	32	58
Black	34	23	28	21
Hispanic	26	12	35	17
Asian	6	2	3	1
Other	1	3	1	3
Mean age, y	36	40	36	38
Region of residence				
Northeast	20	19	36	29
Midwest	21	24	11	18
South	35	38	28	28
West	24	18	25	25
Weight category				
Underweight	2	3	3	3
Normal	24	31	33	37
Overweight	36	31	29	30
Obese	36	34	30	26
Missing data	2	1	6	3
Education				
Less than high school graduate	35	34	33	38
High school graduate	56	58	61	58
College graduate	9	8	6	4
Marital status				
Married	34	24	37	32
Widowed	4	3	5	4
Divorced/separated	24	35	18	27
Single	39	38	40	37

Abbreviations: MEPS, Medical Expenditure Panel Survey; NHIS, National Health Interview Survey; BRFSS, Behavioral Risk Factor Surveillance System.
[a] All data are percentages, except age.

Table 2. Four-Part Model Regression of the Effect of Smoking on Annual Medical Expenditures

Variable	Correlation (Standard Error)			
	Probability of Positive Expenditures	Probability of Positive Inpatient Expenditures	Logged Expenditures for Users of Inpatient Services	Logged Expenditures for Nonusers of Inpatient Services
Intercept	4.19 (1.62)	−1.51 (1.21)	9.39 (0.80)	5.41 (0.70)
Smoking status				
Nonsmoker	Reference	Reference	Reference	Reference
Ever smoker	0.06 (0.24)	0.22 (0.14)	0.13 (0.11)	0.05 (0.12)
Weight category				
Underweight	0.06 (0.89)	0.35 (0.56)	0.64 (0.51)	0.45 (0.38)
Normal weight	Reference	Reference	Reference	Reference
Overweight	−0.08 (0.27)	−0.24 (0.27)	−0.16 (0.20)	−0.04 (0.16)
Obese	0.28 (0.26)	0.34 (0.26)	−0.02 (0.20)	0.21 (0.13)
Missing data	−0.88 (0.48)	−1.71 (0.72)	0.62 (0.22)	0.79 (0.34)
Sex				
Male	Reference	Reference	Reference	Reference
Female	0.81 (0.24)	−0.29 (0.24)	0.01 (0.16)	0.33 (0.18)
Race/ethnicity				
White	Reference	Reference	Reference	Reference
Black	−0.79 (0.30)	−0.34 (0.22)	−0.26 (0.16)	−0.57 (0.18)
Hispanic	−0.85 (0.28)	−0.08 (0.26)	−0.19 (0.13)	−0.55 (0.17)
Asian	−1.17 (0.54)	−0.72 (0.63)	−0.76 (0.35)	−0.85 (0.39)
Other	−0.96 (0.70)	−0.26 (0.59)	0.59 (0.36)	0.62 (0.30)
Age	−0.22 (0.10)	−0.04 (0.06)	−0.01 (0.04)	0.01 (0.04)
Age squared	0.00 (0.00)	0.00 (0.00)	−0.00 (0.00)	0.00 (0.00)
Region of residence				
Northeast	Reference	Reference	Reference	Reference
Midwest	−0.22 (0.40)	0.17 (0.28)	0.23 (0.17)	0.14 (0.25)
South	−0.33 (0.33)	0.37 (0.24)	0.10 (0.15)	0.19 (0.20)
West	0.12 (0.31)	−0.17 (0.28)	0.20 (0.20)	0.09 (0.21)
Education				
Less than high school diploma	Reference	Reference	Reference	Reference
High school diploma	0.37 (0.22)	0.18 (0.19)	−0.03 (0.12)	0.15 (0.12)
College	0.87 (0.65)	0.06 (0.31)	−0.21 (0.24)	0.03 (0.25)

(Continued on next page)

Table 2. (continued) Four-Part Model Regression of the Effect of Smoking on Annual Medical Expenditures

Variable	Correlation (Standard Error)			
	Probability of Positive Expenditures	Probability of Positive Inpatient Expenditures	Logged Expenditures for Users of Inpatient Services	Logged Expenditures for Nonusers of Inpatient Services
Marital status				
Married	Reference	Reference	Reference	Reference
Widowed	0.44 (0.77)	0.28 (0.48)	0.24 (0.28)	0.71 (0.33)
Divorced/separated	1.30 (0.30)	−0.05 (0.21)	0.07 (0.16)	0.24 (0.13)
Single	0.35 (0.22)	−0.09 (0.21)	0.01 (0.14)	0.19 (0.14)
Pregnancy				
Not pregnant	Reference	Reference	Reference	Reference
Pregnant	3.67 (1.09)	3.77 (1.17)	−1.69 (0.59)	−0.64 (0.54)
R^2	0.10	0.13	0.21	0.17

Table 3. Smoking Prevalence and Estimated Fraction and Total Annual Medicaid Expenditure Attributable to Smoking, by State

State	Smoking Prevalence, %	SAF, %[a]	SAE, million, 2004 $
Alabama	52	9	285
Alaska	68	15	67
Arizona	49	18	377
Arkansas	54	11	167
California	45	11	2,254
Colorado	61	17	338
Connecticut	49	7	249
Delaware	58	10	55
District of Columbia	51	11	95
Florida	46	11	951
Georgia	42	10	372
Hawaii	62	11	69
Idaho	62	14	97
Illinois	58	11	905
Indiana	68	15	521
Iowa	61	10	166
Kansas	54	12	171

Abbreviations: SAF, smoking-attributable fraction; SAE, smoking-attributable expenditure.
[a] Estimates for states are based on Behavioral Risk Factor Surveillance System state-representative data and the Medical Expenditure Panel Survey and National Health Interview Survey (MEPS-NHIS) national model. The fraction for the United States as a whole is based solely on the MEPS-NHIS national model.

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Table 3. (continued) Smoking Prevalence and Estimated Fraction and Total Annual Medicaid Expenditure Attributable to Smoking, by State

State	Smoking Prevalence, %	SAF, %[a]	SAE, million, 2004 $
Kentucky	65	12	390
Louisiana	43	12	364
Maine	63	14	190
Maryland	51	12	386
Massachusetts	53	11	696
Michigan	64	13	727
Minnesota	54	11	423
Mississippi	35	9	197
Missouri	66	14	514
Montana	70	15	70
Nebraska	64	15	167
Nevada	62	11	66
New Hampshire	80	15	103
New Jersey	36	6	309
New Mexico	50	12	159
New York	54	11	3,343
North Carolina	63	11	622
North Dakota	63	12	53
Ohio	65	13	1,171
Oklahoma	58	12	233
Oregon	67	15	290
Pennsylvania	70	11	849
Rhode Island	48	8	94
South Carolina	41	11	336
South Dakota	69	16	68
Tennessee	58	11	443
Texas	43	11	987
Utah	54	14	149
Vermont	67	15	74
Virginia	58	11	294
Washington	67	18	464
West Virginia	67	11	180
Wisconsin	63	13	440
Wyoming	62	16	40
US total	51	11	21,951

Abbreviations: SAF, smoking-attributable fraction; SAE, smoking-attributable expenditure.
[a] Estimates for states are based on Behavioral Risk Factor Surveillance System state-representative data and the Medical Expenditure Panel Survey and National Health Interview Survey (MEPS-NHIS) national model. The fraction for the United States as a whole is based solely on the MEPS-NHIS national model.

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ORIGINAL RESEARCH

The Association Between Body Mass Index and Arthritis Among US Adults: CDC's Surveillance Case Definition

Jamie M. Zakkak, MPH, Diane B. Wilson, EdD, MS, RD, Jack O. Lanier, DrPH, MHA, FACHE

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PEER REVIEWED

Abstract

Introduction
The Centers for Disease Control and Prevention modified the surveillance case definition of arthritis to a more stringent form in 2002. To date, the association between arthritis and obesity (an established risk factor for arthritis) has not been examined with the new definition. We describe the association between body mass index (BMI) (kg/m^2) and arthritis using the new arthritis case definition to provide a more accurate assessment of the relationship between weight and arthritis among US adults.

Methods
We used data from the 2005 Behavioral Risk Factor Surveillance System (N = 356,112) and univariate and multivariate analyses to assess the relationship between BMI and arthritis among US adults.

Results
Overall, 26% of US adults had self-reported arthritis. Obese respondents (BMI $\geq$30.0 kg/m^2) were 1.9 times more likely to report arthritis compared with normal-weight respondents (BMI <25.0 kg/m^2), and distinguishing between obese levels revealed an even greater association between BMI and arthritis (class III obesity [BMI $\geq$40.0], odds ratio [OR] = 3.3, 95% confidence interval [CI] = 3.1-3.6; class II obesity [BMI 35.0-39.9 kg/m^2], OR = 2.5, 95% CI = 2.3-2.7; class I obesity [BMI 30.0-34.9], OR = 1.9, 95% CI = 1.8-2.0).

Conclusion
BMI is an independent risk factor for self-reported arthritis. Maintaining a healthy weight may delay the onset of arthritis. More research is needed to determine the effect of weight loss on the progression of arthritis in overweight individuals.

Introduction

The prevalence of both obesity and arthritis in the United States continues to rise, and the medical, physical, and social costs associated with these conditions are enormous (1-7). Previous research has identified an association between obesity, defined by using body mass index (BMI) and certain types of arthritis (8-13), yet population-based studies on weight and arthritis in the United States are limited. Additionally, the Centers for Disease Control and Prevention (CDC) changed the surveillance case definition of arthritis in 2002 to a more exclusive form that only includes self-reported, doctor-diagnosed arthritis (http://www.cdc.gov/arthritis/data_statistics/case_def_additional.htm). To our knowledge, existing studies used the old, more inclusive definition. From 1996 through 2001, the case definition included people with doctor-diagnosed arthritis and/or those with chronic joint symptoms; since 2002, the definition of arthritis is defined as a yes answer to the following question: "Have you ever been told by a doctor or other health professional that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?" Given the growing public health importance of obesity and arthritis, we aim to more accurately describe the relationship between BMI and arthritis among US adults.

Our 2 primary objectives are 1) to describe the prevalence of self-reported arthritis among US adults by various demographic and socioeconomic characteristics and 2) to determine whether BMI is significantly associated with arthritis at the population level, using the revised arthritis definition. Study findings will provide a more accurate assessment of the relationship between weight and arthritis in the United States and will enhance related clinical medical interventions and public health initiatives.

Methods

Data from the 2005 CDC Behavioral Risk Factor Surveillance System (BRFSS), an annual, state-based, random-digit–dialed telephone survey that collects information on health and risk behaviors for noninstitutionalized civilians aged 18 years or older, were used to examine the relationship between arthritis and BMI among adults in all 50 states, the District of Columbia, Puerto Rico, the US Virgin Islands, and Guam. BRFSS data were downloaded from the CDC Web site for this analysis, and all respondents who had answered the question pertaining to arthritis status were included (N = 356,112) (14). Respondents were defined as having arthritis if they answered yes to the question, "Have you ever been told by a doctor or other health professional that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?" This method of identifying people with arthritis is recommended by CDC (15) and has moderate sensitivity (ability to correctly identify people with arthritis) (70.3%) and specificity (ability to correctly identify people without arthritis) (72.4%) (16). BMI (kg/m^2) was calculated from self-reported height and weight and was classified into 5 categories: normal (<25.0), overweight (25.0-29.9), class I obesity (30.0-34.9), class II obesity (35.0-39.9), and class III obesity (≥40.0).

All other variables we examined were categorical: sex, race/ethnicity (non-Hispanic white, non-Hispanic black; Hispanic; other), age (18-34, 35-44, 45-54, 55-64, ≥65 years), education (less than high school graduate, high school graduate, attended college, college graduate), annual income (<$25,000, $25,000-$49,999, ≥$50,000), health insurance coverage (insured or uninsured), and physical activity (PA) level (active, insufficient activity, and inactive). PA categories were based on the Surgeon General's recommendations (17). "Active" was defined as meeting the recommendations (30 minutes or more of moderate-intensity PA on 5 or more days per week or 20 minutes or more of vigorous-intensity PA on 3 or more days per week) during the preceding month, "insufficient activity" was defined as not meeting the recommendations during the preceding month, and "inactive" was defined as reporting no PA outside of one's occupation during the preceding month.

SAS version 9.1 (SAS Institute Inc, Cary, North Carolina) was used for all analyses. Descriptive statistics were calculated to describe the population, and the prevalence of arthritis across population groups was reported with corresponding 95% confidence intervals (CIs). Univariate analyses were conducted to obtain the crude odds ratios (ORs) and to estimate the associations between arthritis and the independent variables. Multivariate logistic regression was used to characterize the association between BMI and arthritis, and the final model consists of all covariates (sex, age, race/ethnicity, insurance status, and PA level) and 1 interaction (interaction between education and income), which was simultaneously entered into the model. Significance was established at $P < .05$. Data were weighted to adjust for differences in the probability of selection, nonresponse, and noncoverage of the survey, which often varies because of geographic location, availability of residential telephones, and number of adults per household. (For further discussion of data weighting, see http://www.cdc.gov/brfss/technicalinfodata/weighting.htm).

Results

Women (51%) and men (49%) were almost equally represented, and 38% were aged 35 to 54 years (Table 1). Most were non-Hispanic white (69%) and had graduated from high school (87%). Most participants earned $50,000 or more and most had some type of insurance coverage (84%). Almost 60% of participants were in the overweight and obese range, 8% of whom were severely obese (BMI ≥35.0 kg/m^2). Nearly half (48%) did not meet the recommended level of PA during the preceding month.

Among respondents who reported having arthritis, more women (59%) than men (41%) were affected. Participants in the oldest age category (≥65 years) comprised more than one-third of all cases, and more than 75% of reported arthritis was among non-Hispanic whites. Slightly more high school graduates (33%) reported arthritis compared with participants who had attended college (27%), and participants with less than a high school degree accounted for 14% of reported arthritis. The number of arthritis cases by income category did not vary greatly, and uninsured participants comprised only 10% of those reporting arthritis. Three-fourths of all arthritis cases were reported by people who engaged in some PA, and overweight and obese participants accounted for most cases (68%). Among participants at a normal weight, 40% reported no arthritis, and the proportion of participants without arthritis decreased dramatically as weight increased.

Overall, 26% of US adults reported doctor-diagnosed arthritis (Table 2). Higher prevalence of arthritis was associated with being female, older, and overweight or obese. Doctor-diagnosed arthritis was nearly twice as prevalent in obese participants (38%) compared with normal-weight participants (20%). Arthritis prevalence increased with increasing BMI category and with decreasing levels of PA. Compared with other participants, the prevalence of arthritis was higher for non-Hispanic whites, participants with low educational attainment, and participants in the lowest income category. Respondents who reported having insurance were more likely to report doctor-diagnosed arthritis (28%) than were respondents who reported not having insurance coverage (16%).

Age was the strongest predictor of arthritis in both the univariate and multivariate models (Table 3). Respondents in older age categories were significantly more likely to have arthritis, and participants aged 65 years or older were 13 times more likely to have arthritis (adjusted OR = 13.8; 95% CI, 13.0-14.7). The higher risk of arthritis among women remained stable after adjustment (unadjusted OR = 1.6; adjusted OR = 1.5). After adjustment for age, sex, race/ethnicity, socioeconomic variables, and levels of PA, high BMI remained a risk factor for arthritis. Participants in high BMI categories were significantly more likely to have arthritis compared with those in low BMI categories. Compared with normal-weight participants, the odds of arthritis were 3.3 times greater among participants who had class III obesity, 2.5 times greater among participants who had class II obesity, and 1.9 times greater among participants who had class I obesity. The odds of reporting arthritis increased by nearly 40% among participants who were overweight, and the association between BMI and arthritis remained after adjusting for covariates.

Respondents who reported having no insurance coverage were 52% less likely to report arthritis than those who reported having insurance coverage. After adjusting for all of the covariates, the association between uninsured status and arthritis weakened. Participants who reported having no coverage were only 20% less likely to report arthritis. The association between insufficient PA and arthritis was attenuated after adjustment (unadjusted OR = 1.2; adjusted OR = 1.0).

The interaction between education and income was significant ($P = .047$) (Table 3). Because education and income were not correlated (Pearson r = 0.0536), the final model consisted of all covariates and 1 interaction (interaction between education and income) (Table 4). Overall, risk of reporting arthritis was seen to decrease with increasing income category, regardless of educational attainment; the most pronounced decrease was observed among college graduates. Because education and income levels may vary by sex, we examined the interaction separately among men and women. The findings for men follow the trend observed for the overall results, while the findings for women were less consistent. The least educated women within the highest income category were at increased risk of reporting arthritis (OR = 1.1; 95% CI, 0.8-1.5).

Discussion

BMI and arthritis

The results of this study highlight the strong independent relationship between excess body weight and self-reported arthritis among adults in the United States. Because a more exclusive case definition of arthritis was used, we expected to find a lower risk of reported arthritis among all weight groups. However, our results were similar for people who were overweight and who had class I obesity, compared with a previous study, which used the old definition of arthritis, that reported similar ORs and 95% CIs for these weight categories (18). However, our results did differ among participants who had class II and class III obesity when compared with that same study, which found a lower odds of reporting arthritis among people with class II obesity (OR = 2.4; 95% CI, 2.1-2.5) and a higher odds of reporting arthritis among people with class

III obesity (OR = 3.6; 95% CI, 3.2-3.8). The lower odds of reporting arthritis that we found for people with class III obesity may demonstrate that these people are more likely to report chronic joint symptoms than arthritis, but more research is needed in this area to be certain.

Our findings showed that the highest BMI category was associated with significantly higher odds of arthritis, and the association between high BMI and arthritis remained after adjusting for demographic and socioeconomic variables. Given the increasing prevalence of obesity in the United States and the alarming rate of increase among youth, arthritis symptoms may develop at a younger age. Clinicians should become aware of these trends and implement strategies to prevent obesity and reduce weight gain among this population. Physicians should recommend losing weight to their patients, and studies have shown that such counseling can promote weight-loss efforts among adults (19).

Demographic and socioeconomic variables and arthritis

Age was the strongest independent predictor of arthritis, and this was not surprising given that previous studies have reported that nearly half of all arthritis cases occur in adults aged 65 years or older (20,21). The odds of reporting arthritis more than doubled from people aged 45 to 54 years to people aged 65 years or older, so it seems especially important for adults to maintain a healthy weight before they reach age 45.

After adjustment for all of the covariates included in the model, the risk of arthritis was 50% higher among women. Although the prevalence of obesity is higher among women than among men and although women typically live longer than men (22), our results show that the association between sex and arthritis is independent of BMI and age. Furthermore, the odds of women reporting arthritis remained high even after taking education and income into account. Biologic risk factors (eg, genetics, hormones) may explain the increased risk of arthritis among women (23,24), and more research is needed in these areas.

In unadjusted analyses, higher education and higher income categories were associated with significantly decreased odds of reporting arthritis. However, income and education were found to interact significantly, and results showed that the highest income earners, regardless of educational level, were less likely to report arthritis. These coincide with the results of previous research that indicated that the lowest income earners were at highest risk of arthritis (4). The association between low educational attainment and arthritis is less clear (25), and the interaction we detected may mask the true, independent association between income level and odds of having arthritis. Furthermore, the arthritis case definition we used required a diagnosis by a health professional. This fact may explain the decreased likelihood of participants without health insurance to report arthritis, because they may be more likely to not seek professional advice.

Non-Hispanic blacks were slightly less likely to report arthritis than were participants in the referent group, and Hispanics were nearly 50% less likely to report arthritis after adjustment. The prevalence of arthritis by race/ethnicity that we found was similar to that reported previously, with a higher prevalence of arthritis among whites (29%) and African Americans (26%) and a lower prevalence among Hispanics (15%) (20).

Physical activity and arthritis

PA level was significantly associated with arthritis only among participants who did not participate in any type of PA during the preceding month. Participants who were inactive were 30% more likely to report arthritis, whereas the association between insufficient activity and arthritis was no longer significant after adjusting for all of the covariates and BMI. Our findings support the recommendations of the American College of Rheumatology for people to engage in recommended levels of PA to lower the risk of arthritis (26,27).

Study limitations

Study findings are subject to certain limitations. Causal relationships cannot be inferred because the BRFSS is cross-sectional in design. Data obtained may be inaccurate because all variables rely on self-report; specifically, survey respondents often overreport height and underreport weight (28), and this fact may have resulted in lower estimates of BMI. Additionally, the case definition of arthritis we used excludes respondents who did not consult a health professional for their symptoms. Given that poor, uninsured people are more likely to be overweight and to forego formal medical treatment, results may not reflect the true association between BMI and arthritis (29). Furthermore, many types of arthritis vary significantly in etiology; some forms actually lead to weight gain (due to corticosteroid use and/or pain-related activity limitations). The BRFSS does not collect information on the type of arthritis or rheumatic disease or on the specific use of medications that could lead to weight gain, so study findings cannot be generalized to all people with arthritis. BRFSS is administered only to noninstitutionalized, nonmilitary adults, so findings may not be generalized to the entire US population.

Conclusion

Arthritis and obesity are costly to the individual and the nation. As the US population ages and lives longer and as the prevalence of obesity continues to rise, arthritis may become an even greater public health concern. Achieving and maintaining a healthy weight may help delay the onset of arthritis. Given that body weight is modifiable, we have the opportunity to reduce the effects of arthritis. Our study results indicate that programs that target women who are overweight and members of the younger generation may have the greatest potential for decreasing arthritis prevalence among US adults. Future research is needed to determine whether maintaining a healthy weight delays the onset of arthritis and to investigate mechanisms by which excess body weight possibly leads to arthritis. More research will enhance efforts to address the public health challenges that arthritis and obesity create for our nation.

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Author Information

Corresponding Author: Diane B. Wilson, EdD, MS, RD, Associate Professor, Departments of Internal Medicine and Massey Cancer Center, Virginia Commonwealth University, PO Box 980306, Richmond, VA 23298-0306. Telephone: 804-828-9891. E-mail: dbwilson@vcu.edu.

Author Affiliations: Jamie M. Zakkak, Jack O. Lanier, Virginia Commonwealth University School of Medicine, Richmond, Virginia.

References

1. Elders MJ. The increasing impact of arthritis on public health. J Rheumatol Suppl 2000;60:6-8.
2. At a glance — targeting arthritis. Atlanta (GA): US Department of Health and Human Services, Centers for Disease Control and Prevention; 2007.
3. Centers for Disease Control and Prevention. Arthritis prevalence and activity limitations — United States, 1990. MMWR Morb Mortal Wkly Rep 1994;43(24):433-8.
4. Finkelstein EA, Fiebelkorn IC, Wang G. National medical spending attributable to overweight and obesity: how much, and who's paying? Health Aff (Millwood) 2003;W3;219-26.
5. Arterburn DE, Maciejewski ML, Tsevat J. Impact of morbid obesity on medical expenditures in adults. Int J Obes (Lond) 2005;29(3):334-9.
6. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. JAMA 2006;295(13):1549-55.
7. Yelin E, Murphy L, Cisternas MG, Foreman AJ, Pasta DJ, Helmick CG. Medical care expenditures and earnings losses among persons with arthritis and other rheumatic conditions in 2003, and comparisons with 1997. Arthritis Rheum 2007;56(5):1397-407.
8. Felson DT, Zhang Y. An update on the epidemiology of knee and hip osteoarthritis with a view to prevention. Arthritis Rheum 1998;41(8):1343-55.
9. Pearson-Ceol J. Literature review on the effects of obesity on knee osteoarthritis. Orthop Nurs 2007;26(5);289-92.
10. Sturmer T, Gunther KP, Brenner H. Obesity, overweight and patterns of osteoarthritis: the Ulm Osteoarthritis Study. J Clin Epidemiol 2000;53(3):307-13.
11. Mallbris L, Ritchlin CT, Stahle M. Metabolic disorders in patients with psoriasis and psoriatic arthritis. Curr Rheumatol Rep 2006;8(5):355-63.
12. Choi HK, Atkinson K, Karlson EW, Curhan G. Obesity, weight change, hypertension, diuretic use, and risk of gout in men: the health professionals follow-up study. Arch Intern Med 2005;165(7):742-8.
13. Centers for Disease Control and Prevention. Factors associated with prevalent self-reported arthritis and other rheumatic conditions — United States, 1989-1991. MMWR Morb Mortal Wkly Rep 1996;45(23):487-91.

14. Gentry EM, Kalsbeek WD, Hogelin GC, Jones JT, Gaines KL, Forman MR, et al. The behavioral risk factor surveys: II. Design, methods, and estimates from combined state data. Am J Prev Med 1985;1(6):9-14.
15. Centers for Disease Control and Prevention. Prevalence of doctor-diagnosed arthritis and possible arthritis — 30 states, 2002. MMWR Morb Mortal Wkly Rep 2004;53(18):383-6.
16. Bombard JM, Powell KE, Martin LM, Helmick CG, Wilson WH. Validity and reliability of self-reported arthritis: Georgia senior centers, 2000-2001. Am J Prev Med 2005;28(3):251-8.
17. Physical activity and health: a report of the Surgeon General. Atlanta (GA): US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996.
18. Mehrotra C, Naimi TS, Serdula M, Bolen J, Pearson K. Arthritis, body mass index, and professional advice to lose weight: implications for clinical medicine and public health. Am J Prev Med 2004;27(1):16-21.
19. Kreuter MW, Chheda SG, Bull FC. How does physician advice influence patient behavior? Evidence for a priming effect. Arch Fam Med 2000;9(5):426-33.
20. Centers for Disease Control and Prevention. Racial/ethnic differences in the prevalence and impact of doctor-diagnosed arthritis — United States, 2002. MMWR Morb Mortal Wkly Rep 2005;54(5):119-23.
21. Hootman JM, Helmick CG. Projections of US prevalence of arthritis and associated activity limitations. Arthritis Rheum 2006;54(1):226-9.
22. Buckwalter JA, Lappin DR. The disproportionate impact of chronic arthralgia and arthritis among women. Clin Orthop Relat Res 2000;372:159-68.
23. Zhang Y, McAlindon TE, Hannan MT, Chaisson CE, Klein R, Wilson PW, et al. Estrogen replacement therapy and worsening of radiographic knee osteoarthritis: the Framingham study. Arthritis Rheum 1998;41(10):1867-73.
24. Spector TD, Cicuttini F, Baker J, Loughlin J, Hart D. Genetic influences on osteoarthritis in women: a twin study. BMJ 1996;312(7036):940-3.
25. Leigh JP, Fries JF. Occupation, income, and education as independent covariates of arthritis in four national probability samples. Arthritis Rheum 1991;34(8):984-95.
26. Chang R, Roubenoff R, Mayer J, Brandt KD, Schanberg LE. Work Group recommendations: 2002 Exercise and Physical Activity Conference, St. Louis, Missouri. Arthritis Rheum 2003;49(2):280.
27. American College of Rheumatology Subcommittee on Osteoarthritis Guidelines. Recommendations for the medical management of osteoarthritis of the hip and knee: 2000 update. Arthritis Rheum 2000;43(9):1905-15.
28. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. JAMA 2002;288(14):1723-7.
29. Zhang Q, Wang Y. Trends in the association between obesity and socioeconomic status in US adults: 1971 to 2000. Obes Res 2004;12(10):1622-32.

Tables

Table 1. Respondent Characteristics (N = 356,112) by Arthritis Status, Behavioral Risk Factor Surveillance System, 2005

Characteristic	Total No. (%)	No. With Arthritis[a] (%)	No. Without Arthritis (%)
Total overall	356,112 (100.0)	119,485 (26.0)	230,651 (71.8)
Sex			
Male	136,201 (48.5)	38,902 (40.6)	95,060 (51.4)
Female	219,911 (51.5)	80,583 (59.4)	135,591 (48.6)
Age, y			
18-34	64,903 (31.1)	5,690 (8.3)	58,184 (39.4)
35-44	63,425 (19.7)	11,414 (12.4)	51,003 (22.4)
45-54	73,297 (18.5)	23,195 (20.9)	49,005 (17.6)
55-64	64,441 (13.4)	29,774 (22.7)	33,719 (10.1)
≥65	87,351 (16.7)	48,673 (35.2)	36,986 (10.0)
Race/Ethnicity			
Non-Hispanic white	278,672 (68.7)	97,682 (76.4)	176,988 (66.5)
Non-Hispanic black	27,735 (9.4)	8,831 (9.3)	18,205 (9.4)
Hispanic	25,539 (14.8)	5,471 (8.3)	19,438 (16.8)
Other	20,750 (6.2)	6,277 (5.1)	14,044 (6.5)
Education			
Less than high school graduate	38,202 (12.5)	16,285 (13.9)	20,979 (11.7)
High school graduate	109,830 (29.9)	40,501 (32.6)	67,309 (28.9)
Attended college	93,228 (26.1)	31,682 (26.5)	60,264 (26.1)
College graduate	113,944 (31.3)	30,772 (26.7)	81,638 (33.2)
Annual income, $			
<25,000	94,577 (24.5)	40,499 (29.5)	52,477 (22.6)
25,000-49,999	94,113 (24.9)	30,749 (25.6)	62,257 (25.0)
≥50,000	118,676 (37.0)	30,343 (30.8)	87,065 (39.8)
Insurance coverage			
Insured	311,213 (83.6)	109,032 (90.1)	197,114 (81.4)
Uninsured	43,954 (16.0)	10,258 (9.7)	32,844 (18.1)

Abbreviation: PA, physical activity.
[a] Respondents with arthritis were defined as those who answered yes to the question, “Have you ever been told by a doctor or other health professional that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?”
[b] PA categories were based on the Surgeon General’s recommendations (17). “Active” was defined as meeting the recommendations (30 minutes or more of moderate-intensity PA on 5 or more days per week or 20 minutes or more of vigorous-intensity PA on 3 or more days per week) during the preceding month, “insufficient activity” was defined as not meeting the recommendations during the preceding month, and “inactive” was defined as reporting no PA outside of one’s occupation during the preceding month.

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Table 1. (continued) Respondent Characteristics (N = 356,112) by Arthritis Status, Behavioral Risk Factor Surveillance System, 2005

Characteristic	Total No. (%)	No. With Arthritis[a] (%)	No. Without Arthritis (%)
Body mass index			
Normal (<25.0 kg/m^2)	129,513 (37.0)	34,853 (28.5)	92,653 (40.2)
Overweight (25.0-29.9 kg/m^2)	123,692 (35.1)	41,718 (35.8)	80,168 (35.1)
Class I obesity (30.0-34.9 kg/m^2)	55,599 (15.2)	22,761 (19.2)	32,098 (13.8)
Class II obesity (35.0-39.9 kg/m^2)	19,439 (5.2)	9,025 (7.6)	10,176 (4.4)
Class III obesity (≥40.0 kg/m^2)	11,419 (3.0)	5,976 (5.0)	5,291 (2.2)
PA level[b]			
Active	155,418 (44.7)	45,351 (39.3)	109,509 (47.8)
Insufficient activity	125,166 (35.0)	42,736 (35.9)	81,977 (35.6)
Inactive	50,399 (13.2)	23,502 (18.7)	26,582 (11.4)

Abbreviation: PA, physical activity.
[a] Respondents with arthritis were defined as those who answered yes to the question, "Have you ever been told by a doctor or other health professional that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?"
[b] PA categories were based on the Surgeon General's recommendations (17). "Active" was defined as meeting the recommendations (30 minutes or more of moderate-intensity PA on 5 or more days per week or 20 minutes or more of vigorous-intensity PA on 3 or more days per week) during the preceding month, "insufficient activity" was defined as not meeting the recommendations during the preceding month, and "inactive" was defined as reporting no PA outside of one's occupation during the preceding month.

Table 2. Prevalence of Arthritis by Selected Characteristics, Behavioral Risk Factor Surveillance System, 2005

Characteristic	Arthritis Prevalence, % (95% CI)
Total overall	26.0 (26.0-26.0)
Sex	
Male	21.8 (21.8-21.8)
Female	30.1 (30.0-30.1)
Age, y	
18-34	7.0 (7.0-7.0)
35-44	16.4 (16.4-16.5)
45-54	29.4 (29.4-29.5)
55-64	44.1 (44.0-44.2)
≥65	54.8 (54.7-54.9)

Abbreviation: CI, confidence interval; PA, physical activity.
[a] PA categories were based on the Surgeon General's recommendations (17). "Active" was defined as meeting the recommendations (30 minutes or more of moderate-intensity PA on 5 or more days per week or 20 minutes or more of vigorous-intensity PA on 3 or more days per week) during the preceding month, "insufficient activity" was defined as not meeting the recommendations during the preceding month, and "inactive" was defined as reporting no PA outside of one's occupation during the preceding month.

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Table 2. (continued) Prevalence of Arthritis by Selected Characteristics, Behavioral Risk Factor Surveillance System, 2005

Characteristic	Arthritis Prevalence, % (95% CI)
Race/Ethnicity	
Non-Hispanic white	28.9 (28.9-29.0)
Non-Hispanic black	25.7 (25.6-25.8)
Hispanic	14.5 (14.5-14.6)
Other	21.3 (21.1-21.5)
Education	
Less than high school graduate	29.1 (29.0-29.3)
High school graduate	28.4 (28.3-28.5)
Attended college	26.5 (26.4-26.6)
College graduate	22.3 (22.2-22.4)
Annual income, $	
<25,000	31.4 (31.2-31.5)
25,000-49,999	26.7 (26.5-26.8)
≥50,000	21.7 (21.6-21.8)
Insurance coverage	
Insured	28.1 (28.0-28.2)
Uninsured	15.8 (15.7-16.0)
Body mass index	
Normal (<25.0 kg/m^2)	20.1 (19.9-20.2)
Overweight (25.0-29.9 kg/m^2)	26.5 (26.4-26.7)
Class I obesity (30.0-34.9 kg/m^2)	33.0 (32.7-33.3)
Class II obesity (35.0-39.9 kg/m^2)	37.9 (37.4-38.4)
Class III obesity (≥40.0 kg/m^2)	44.0 (43.3-44.8)
PA level[a]	
Active	22.9 (22.7-23.1)
Insufficient activity	26.7 (26.5-26.9)
Inactive	37.1 (36.7-37.5)

Abbreviation: CI, confidence interval; PA, physical activity.
[a] PA categories were based on the Surgeon General's recommendations (17). "Active" was defined as meeting the recommendations (30 minutes or more of moderate-intensity PA on 5 or more days per week or 20 minutes or more of vigorous-intensity PA on 3 or more days per week) during the preceding month, "insufficient activity" was defined as not meeting the recommendations during the preceding month, and "inactive" was defined as reporting no PA outside of one's occupation during the preceding month.

Table 3. Unadjusted and Adjusted Risk of Arthritis, by Covariates, Behavioral Risk Factor Surveillance System, 2005[a]

Characteristic	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Sex		
Male	1 [Reference]	1 [Reference]
Female	1.6 (1.5-1.6)	1.5 (1.5-1.6)
Age, y		
18-34	1 [Reference]	1 [Reference]
35-44	2.6 (2.5-2.8)	2.5 (2.4-2.7)
45-54	5.6 (5.3-5.9)	5.2 (4.9-5.5)
55-64	10.6 (10.0-11.3)	9.5 (8.9-10.0)
≥65	16.7 (15.7-17.6)	13.8 (13.0-14.7)
Race/Ethnicity		
Non-Hispanic white	1 [Reference]	1 [Reference]
Non-Hispanic black	0.9 (0.8-0.9)	0.8 (0.8-0.9)
Hispanic	0.4 (0.4-0.5)	0.5 (0.5-0.6)
Other	0.7 (0.6-0.7)	0.9 (0.8-1.0)
Insurance coverage		
Insured	1 [Reference]	1 [Reference]
Uninsured	0.5 (0.5-0.5)	0.8 (0.7-0.8)
Body mass index		
Normal (<25.0 kg/m2)	1 [Reference]	1 [Reference]
Overweight (25.0-29.9 kg/m^2)	1.4 (1.4-1.5)	1.4 (1.3-1.4)
Class I obesity (30.0-34.9 kg/m^2)	2.0 (1.9-2.1)	1.9 (1.8-2.0)
Class II obesity (35.0-39.9 kg/m^2)	2.4 (2.3-2.6)	2.5 (2.3-2.7)
Class III obesity (≥40.0 kg/m^2)	3.1 (2.9-3.4)	3.3 (3.1-3.6)
PA level[b]		
Active	1 [Reference]	1 [Reference]
Insufficient activity	1.2 (1.2-1.3)	1.0 (1.0-1.1)
Inactive	2.0 (1.9-2.1)	1.3 (1.2-1.3)

Abbreviations: OR, odds ratio; CI, confidence interval; PA, physical activity.
[a] Because the education and income variables were not correlated (Pearson r = 0.0536), the final model used to derive the adjusted values consisted of all independent covariates and the interaction between education and income; all predictors were simultaneously entered into the model (P = .047).
[b] PA categories were based on the Surgeon General's recommendations (17). "Active" was defined as meeting the recommendations (30 minutes or more of moderate-intensity PA on 5 or more days per week or 20 minutes or more of vigorous-intensity PA on 3 or more days per week) during the preceding month, "insufficient activity" was defined as not meeting the recommendations during the preceding month, and "inactive" was defined as reporting no PA outside of one's occupation during the preceding month.

Table 4. Interaction Between Education and Annual Income and Risk of Arthritis, Overall and Stratified by Sex, Behavioral Risk Factor Surveillance System, 2005

Education	Income, $	Overall OR (95% CI)	Men OR (95% CI)	Women OR (95% CI)
Less than high school graduate	<25,000	1.0 [Reference]	1.0 [Reference]	1.0 [Reference]
Less than high school graduate	25,000-49,999	0.9 (0.7-1.0)	0.9 (0.7-1.1)	0.8 (0.7-1.0)
Less than high school graduate	≥50,000	0.8 (0.7-1.0)	0.6 (0.5-0.9)	1.1 (0.8-1.5)
High school graduate	<25,000	0.9 (0.9-1.0)	0.9 (0.8-1.0)	0.9 (0.9-1.0)
High school graduate	25,000-49,999	0.7 (0.6-0.9)	0.7 (0.5-1.0)	0.7 (0.5-1.0)
High school graduate	≥50,000	0.6 (0.5-0.8)	0.6 (0.4-0.9)	0.7 (0.5-0.9)
Attended college	<25,000	1.0 (0.9-1.1)	0.9 (0.8, 1.1)	1.0 (0.9-1.2)
Attended college	25,000-49,999	0.8 (0.6-1.0)	0.7 (0.5-1.0)	0.8 (0.5-1.1)
Attended college	≥50,000	0.6 (0.5-0.8)	0.6 (0.4-0.9)	0.6 (0.4-0.8)
College graduate	<25,000	0.8 (0.7-0.9)	0.7 (0.6-0.9)	0.9 (0.7-1.0)
College graduate	25,000-49,999	0.6 (0.5-0.8)	0.6 (0.4-0.8)	0.7 (0.5-0.9)
College graduate	≥50,000	0.5 (0.4-0.6)	0.5 (0.3-0.7)	0.5 (0.4-0.7)

Abbreviations: OR, odds ratio; CI, confidence interval.

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ORIGINAL RESEARCH

Caregivers of Older Adults With Cognitive Impairment

Erin L. DeFries, MPH, Lisa C. McGuire, PhD, Elena M. Andresen, PhD, Babette A. Brumback, PhD, Lynda A. Anderson, PhD

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PEER REVIEWED

Abstract

Introduction

Because of the growing number of caregivers and the awareness of related health and quality-of-life issues, caregiving has emerged as an important public health issue. We examined the characteristics and caregiving experiences of caregivers of people with and without cognitive impairment.

Methods

Participants (n = 668) were adults who responded to the 2005 North Carolina Behavioral Risk Factor Surveillance System. Caregivers were people who provided regular care to a family member or friend aged 60 years or older either with or without cognitive impairment (ie, memory loss, confusion, or Alzheimer's disease).

Results

Demographic characteristics of caregivers of people with cognitive impairment were similar to those of caregivers of people without cognitive impairment. However, compared with caregivers of people without cognitive impairment, caregivers of people with cognitive impairment reported higher levels of disability, were more likely to be paid, and provided care for a longer duration. Care recipients with cognitive impairment were more likely than care recipients without cognitive impairment to be older, have dementia or confusion, and need assistance with memory and learning.

Conclusion

State-level caregiving surveillance is vital in assessing and responding to the needs of the growing number of caregivers.

Introduction

The expansion of the aging population in the United States is well documented. According to census estimates, 1 in every 5 (20.7%) people in the United States will be aged 65 or older by 2050, compared with 1 in 10 (10.4%) in 2000 (1). Because disability increases with age (2), the number of people who need assistance with activities of daily living (ADL) (eg, bathing) and instrumental activities of daily living (IADL) (eg, meal preparation) will continue to increase as the population ages. Historically, family members and friends have provided most of the assistance needed for the aging population in the United States. Approximately two-thirds of community-dwelling adults who need assistance with ADL rely on family members and friends alone to meet their needs (3).

Informal caregiving is a component of health, social, and aging services infrastructures (4-7). Although no universally accepted definition of informal caregiving exists, it is commonly understood as providing assistance to a family member or friend in a nonprofessional, usually unpaid, role to support the capacity of an individual to remain at home in the community for as long as possible (8). An estimated 16% to 30% of Americans provide informal care (9-11). Furthermore, among caregivers of people aged 60 years or older, between 25% and 29% provide assistance to someone with cognitive impairment, a memory problem, or a disorder, such as Alzheimer's disease (10,12).

Aspects of cognition, such as memory, thought, and language, influence a person's ability to interact socially and to function independently (13,14). Cognitive impairment can affect a person's memory as well as the ability to perform daily tasks (15). Caregivers of people with cognitive impairment face challenges common to those of other caregivers, but they also encounter issues unique to the characteristics of the recipient's impairment. Studies have shown that providing care for a person with cognitive impairment is more demanding than caring for someone with physical problems alone, as indicated by reports of higher levels of burden, stress, and depression among caregivers of people with cognitive impairment (4,10,16-19).

Studies of caregivers of people with cognitive impairment have shaped our understanding of specific experiences and outcomes related to caregiving. However, such studies typically focus on a specific group of caregivers and care recipients, such as spousal caregivers, primary caregivers, or those seeking care in a clinic (17,18), which do not represent all caregivers in the population. A consistent source of state-level information on caregiving is needed to adequately assess the population and to plan appropriately for programs and services targeting caregivers. Typically, these services are delivered at the state level. Likewise, surveillance systems such as the Behavioral Risk Factor Surveillance System (BRFSS) provide the opportunity to monitor the burden of cognitive impairment, which is critical to understand the effects of these issues on families and communities in the United States (13,20).

Healthy People 2010 recommends the use of population-based data for tracking and measuring health indicators over time (21). One of the systems commonly used to monitor *Healthy People* goals is the BRFSS, an annual, list-assisted, random-digit–dialed telephone survey of the noninstitutionalized adult population of the United States and its territories. The BRFSS has been used to survey Americans on health behaviors and risk factors since 1984. Detailed methods have been described elsewhere (22,23), and information about questions, response characteristics, and methods can be found at www.cdc.gov/brfss.

We examined the characteristics of caregivers of people with and without cognitive impairment and the differences in their caregiving experiences.

Methods

From May through August 2005, an 11-item module of caregiving questions was added to the North Carolina BRFSS (24). These questions were created through collaborative efforts with key national stakeholders as part of a larger pilot study that also involved a follow-back survey of consenting caregivers (24). North Carolina was chosen as the pilot site because the large sample planned for 2005 BRFSS allowed a sufficient number of responses (study plan, n = 5,000) within 4 months. This study was approved by the institutional review board of the University of Florida.

Measures

The demographic factors of age, race/ethnicity, sex, education, and income were used to characterize caregivers. Age was reported as a categorical variable (18-34, 35-44, 45-54, 55-64, and ≥65 years). Categories for race/ethnicity (non-Hispanic white; non-Hispanic black; other/multirace, non-Hispanic; and Hispanic), sex, education level (<high school diploma, high school diploma, and >high school diploma), and annual income (<$25,000; $25,000-$34,999; $35,000-$49,999; $50,000-$74,999; and ≥$75,000) also were reported.

Health-related quality of life of the caregiver was measured by responses to the following 3 core questions: 1) "Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?"; 2) "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?"; and 3) "Would you say that in general your health is excellent, very good, good, fair, or poor?" The reliability of these questions is reported elsewhere (25). Social and emotional support was assessed through a single question: "How often do you get the social and emotional support you need?" Life satisfaction was measured by a single question: "In general, how satisfied are you with your life?"

Respondents were characterized as having a disability if they answered yes to either of the 2 following core questions: 1) "Are you limited in any way in any activities because of physical, mental, or emotional problems?" or 2) "Do you now have any health problem that requires you to use special equipment, such as a cane, a wheelchair, a special bed, or a special telephone?" Objective 6-1 of *Healthy People 2010* suggests that these items be used nationally to assess disability (21).

Respondents were classified as caregivers if they replied yes to the following question: "People may provide regular care or assistance to someone who has a long-term illness or disability. During the past month, did you provide any such care or assistance to a family member or friend?" This item was modified from a question asked nationally during the 2000 BRFSS that restricted the definition of caregiver to one who provided care to someone aged 60 or older (9). If respondents provided care for more than 1 person, they were instructed to answer all subsequent questions on the basis of the person for whom they provided the most care. Additionally, caregivers who reported that the care recipient was aged 60 years or older were asked, "Did that person have a problem with memory loss or confusion or a disorder like Alzheimer's disease?" Those who said yes were classified as caregivers of people with cognitive impairment. Because the cognitive impairment question was asked only of caregivers of people aged 60 or older, all analyses were restricted to caregivers of people aged 60 or older.

Caregiving experience

Caregivers were asked a series of questions about their experiences providing care, which included several components: 1) description of the care recipient, 2) type and duration of care provided, and 3) caregiving intensity. Caregivers provided the following information about the person to whom they provided the most care: age (classified as 60-69, 70-79, 80-89, or ≥90 years), sex, relationship to caregiver (spouse/partner, other family member, nonfamily member, or paid caregiver), and major health problem (26 diagnoses possible). Unless otherwise noted, caregivers were limited to 1 answer choice per question.

Type of care provided was assessed through a single question: "Given this condition, with which two of the following areas does he/she most need your help?" (response options: learning, remembering, and confusion; seeing or hearing; taking care of oneself, such as eating, dressing, bathing, or toileting; communicating with others; moving around; getting along with people; or feeling anxious or depressed). Duration of care included the questions: "For how long have your provided care for him/her?" and "In an average week, how many hours do you provide care for him/her because of his/her long-term illness or disability?" Responses to these questions are reported as months of caregiving and average hours of care provided per week.

A variable was created to quantify caregiving intensity. The intensity variable was adapted from a measure of burden in the National Alliance for Caregiving (NAC) and AARP study that measured activities and time spent in caregiving (10) and was constructed as follows: if respondents chose either "taking care of oneself, such as eating, dressing, bathing, or toileting" or "moving around" (items related to ADL) on the type-of-care question, they were assigned 3 points; if caregivers chose both options, they were assigned 4 points. Average hours of care provided per week were divided into 4 categories (0-8, 9-19, 20-39, and ≥40). Each category counted as 1 to 4 points, respectively. Points from the 2 questions were added and then categorized into a 5-level caregiver intensity variable, in which higher scores indicated higher levels of intensity. We found a moderately strong correlation between the newly created intensity measure and the 5-level NAC/AARP scale ($r = 0.61$), using data from a subset of respondents (n = 329) who participated in a follow-up survey and who answered a full list of questions about ADL and IADL.

Statistical analysis

All analyses were completed by using SPSS version 14.0 with Complex Samples (SPSS Inc, Chicago, Illinois) to account for the sampling design. Because caregiving module data were collected during only a portion of the year (May-August 2005), we adjusted the final weights so that the 4-month period of data collection represented the entire North Carolina population. Statistical analyses using the full 2005 North Carolina BRFSS weights and the reweighting that accounted for the 4-month sample yielded similar results, but we report only the reweighted results. We report means and frequencies as well as 95% confidence intervals. We used independent-sample t tests to compare means and χ^2 tests to compare frequency measures. To test for trends across ordered categorical variables (age, income, education, and intensity), logistic regression models were fit in SPSS wherein the outcome was caregiver status (caring for a person with or without cognitive impairment), and each categorical item was included as the exposure variable, coded in 1-point increments (ie, 1, 2, 3 . . .). The trend test provided a global P value for the trend across ordered levels of a variable rather than individual *P* values for each level of the variable. This method generalizes the Cochran-Armitage trend test (26) for use with complex survey data (27). Differences were considered significiant at $P < .05$.

Results

In total, 5,681 people responded to the caregiver question, of which 895 (15.4% weighted) were caregivers. Of these, 672 reported caring for someone aged 60 or older, and 668 answered the cognitive impairment question; the other 4 respondents were excluded from our analyses because they could not be classified as caregivers of persons with or without cognitive impairment. There were 279 caregivers of people with cognitive impairment (41.5% weighted) and 389 caregivers of people without cognitive impairment (58.5% weighted).

No statistically significant differences were found by age, race/ethnicity, sex, level of education, annual household income, healthy days, self-rated health, social support, or life satisfaction between caregivers of people with and without cognitive impairment (Table 1). A significantly higher proportion of caregivers of people with cognitive impairment had a disability; 24.0% of caregivers of people with cognitive impairment indicated they had a disability compared with 16.1% of caregivers of people without cognitive impairment ($P = .03$). Specifically, 23.4% of caregivers of people with cognitive impairment reported their activities were limited by physical, mental, or emotional problems compared with 15.1% of caregivers of people without cognitive impairment ($P = .02$).

Caregivers of people with cognitive impairment differed significantly from other caregivers in care-recipient attributes and the type of care provided (Table 2). Care recipients with cognitive impairment were significantly older than care recipients without cognitive impairment ($P = .001$), but they were no more likely to be women. Caregivers of people with cognitive impairment were significantly more likely to report being paid than were caregivers of people without cognitive impairment ($P < .001$), although the percentage was low for both groups. Caregivers of people with cognitive impairment were significantly more likely to report that the person they care for had dementia than were caregivers of people without cognitive impairment ($P < .001$), although caregivers of people without cognitive impairment were significantly more likely to report that the person they care for had cancer ($P = .002$) or heart disease ($P = .03$) than were caregivers of people with cognitive impairment. Caregivers of people with cognitive impairment were significantly more likely to report that the people they care for need help with "learning, remembering, confusion" and significantly less likely to report that the people they care for need help with "moving around" than caregivers of people without cognitive impairment ($P < .001$ for both). Caregivers of people with cognitive impairment provided care for a significantly longer period of time than did caregivers of people without cognitive impairment ($P = .001$). No significant differences were found between the 2 caregiver groups for hours of care provided per week or for caregiving intensity.

Discussion

We found that more than 41% of self-identified caregivers of people aged 60 years or older reported a cognitive impairment in the person for whom they provided care. This percentage is considerably higher than those reported in previous caregiver surveys, such as the NAC/AARP survey that reported a rate of 25% (10). Both the North Carolina BRFSS caregiver module and the NAC/AARP survey were conducted during a 4-month interval; queried respondents using a closed-end question to determine whether the person they cared for had Alzheimer's disease, dementia, or other mental confusion; and relied on the caregiver's assessment rather than a medical diagnosis. However, these surveys varied in terms of respondent eligibility and the age of the care recipient. The 25% prevalence of cognitive impairment (ie, Alzheimer's, dementia, or mental confusion) from the NAC/AARP survey was based on care recipients aged 50 or older; we collected data on care recipients aged 60 years or older. Given that the risk of cognitive impairment and dementia increases with age (14), the prevalence of caregiving for people with such impairments may be higher among older populations of care recipients. The NAC/AARP study included only caregivers who assisted with at least 1 ADL or IADL, yielding a sample of caregivers who potentially provided care to more people who had disabilities than did caregivers in our study. Our study was limited to a single state, whereas the NAC/AARP was a national survey, and the prevalence of cognitive impairment may vary in the United States. For example, the Reasons for Geographic and Racial Differences in Stroke Study showed regional variations in the incidence of stroke and identified a "stroke belt" located in several states in the southeastern United States (28). Similar regional variation in cognitive impairment may exist.

Caregivers of people with cognitive impairment were more likely than caregivers of people without cognitive impairment to have a disability and to report that their activities were limited by their disability. Furthermore, many of the caregivers themselves reported having a disability, even while caring for a person who required assistance with learning, memory, and confusion. Data from one study showed that 36% of caregivers who were aged 65 years or older were considered to be vulnerable, with their health status ranging from fair to poor, and had a serious health condition (29).

In our study, caregivers of people with cognitive impairment reported lower levels of caregiving intensity than did caregivers in the NAC/AARP study (10). However, the construction of the intensity scales differed because we did not ask caregivers the complete list of ADL and IADL. In our study, 62.0% of caregivers of people with cognitive impairment reported they assisted with at least 1 of the categories of ADL-like activities (self-care or moving around), the same percentage of caregivers of people with Alzheimer's disease, dementia, or other mental confusion found in the NAC/AARP study (10). Duration of care was not included in the caregiver intensity variable, but long-term caregiving may contribute to caregiver stress or burden, items not measured in our study. In a study of caregivers of people with Alzheimer's disease, duration of caregiving was not related to caregiver health, when adjusting for behavioral changes in the person receiving care (30). The caregiving intensity measure implies an indirect level of burden or negative impact. A measurement of the positive aspects of caregiving was not captured in our study but may help in future population-based surveillance. One study found that 81% of family caregivers for people with Alzheimer's disease or some other form of dementia reported gains as well as strains associated with their caregiving experience; the remaining 19% reported only burden (31). Previous studies have found mixed results in mental health outcomes for caregivers of people with dementia compared with other caregivers (4,17,19). The results of our study do not indicate any significant differences in frequent mental distress, social support, or life satisfaction between caregivers of people with and without cognitive impairment, which may mean that all caregivers are at equal risk for poor mental health outcomes. Future research is needed to investigate the mental health, including stress and depression, of caregivers.

Our study had several limitations. First, cognitive functioning of the care recipient was not formally assessed. Therefore, care recipients classified as being cognitively impaired may not have had clinical symptoms. Second, there was no indication of the care recipient's severity of cognitive impairment. Previous studies have shown that proxies do not always accurately report disability attributes, such as severity or limitations (32), so proxy assessments of severity of cognitive impairment need validation before inclusion. Third, our data were based on BRFSS respondents in North Carolina, and characteristics of the US population may be different. Future studies should evaluate the possible regional variations in the prevalence of cognitive impairment. Finally, our study included only noninstitutionalized adults (aged ≥18 years) who had traditional home telephone landlines. Despite these limitations, the general attributes of the BRFSS, including its population-based sampling technique and the demonstrated reliability and validity of its core measures (33), allowed comparison of informal caregivers of people with and without cognitive impairment in terms of demographic variables and characteristics of care. Future studies should establish the psychometric properties of the caregiver items, including the abbreviated version of the intensity scale.

The number of caregivers in the United States, including the number of caregivers of people with cognitive impairment, is expected to grow (13). If these caregivers are to continue to provide the foundation of care for people who need assistance, their health, both physical and mental, must be assured. Caregivers, particularly caregivers of people with cognitive impairment, dedicate substantial time to providing care, as our results show. Caregivers of people with cognitive impairment may provide care for long periods of time because of the slow progression of many types of dementia (17). Therefore, caregiving is of public health importance, and caregiving surveillance is vital in assessing and responding to the needs of the growing number of caregivers (5). Evaluating trends in cognitive impairment and caregiving over time is also important. Quantifying the number and type of caregivers in a community will improve our understanding of the health and quality-of-life consequences of providing care and will aid in policy making and decision making.

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Author Information

Corresponding Author: Erin DeFries, MPH, Department of Epidemiology and Biostatistics, College of Public Health and Health Professions, University of Florida, PO Box 100231, Gainesville, FL 32610. Telephone: 352-273-5279. E-mail: edefries@phhp.ufl.edu.

Author Affiliations: Lisa C. McGuire, Centers for Disease Control and Prevention, Atlanta, Georgia; Elena M. Andresen, Babette A. Brumback, University of Florida, Gainesville, Florida; Lynda A. Anderson, Centers for Disease Control and Prevention, Emory University, Atlanta, Georgia.

References

1. US interim projections by age, sex, race, and Hispanic origin: 2000-2050. Washington (DC): US Census Bureau; 2004. http://www.census.gov/ipc/www/usinterimproj/. Accessed June 10, 2008.
2. Institute of Medicine. The future of disability in America. Washington (DC): The National Academies Press; 2007.
3. Older Americans act. Washington (DC): US Administration on Aging; 2007. http://www.aoa.dhhs.gov/about/legbudg/oaa/legbudg_oaa.asp. Accessed April 18, 2008.
4. Schulz R, Martire LM. Family caregiving of people with dementia. Am J Geriatr Psychiatry 2004;12(3):240-9.
5. Talley RC, Crews JE. Framing the public health of caregiving. Am J Public Health 2007;97(2):224-8.
6. Carter R. Addressing the caregiving crisis. Prev Chronic Dis 2008;5(1). http://www.cdc.gov/pcd/issues/2008/jan/07_0162.htm. Accessed April 18, 2008.
7. Institute of Medicine. Retooling for an aging America: building the health care workforce. Washington (DC): The National Academies Press; 2008.
8. McGuire LC, Anderson LA, Talley RC, Crews JE. Supportive care needs of Americans: a major issue for women as both recipients and providers of such care. J Women's Health 2007;16(6):784-9.
9. McKune S, Andresen EM, Zhang J, Neugaard B. Caregiving: a national profile and assessment of caregiver services and needs. Americus (GA): Rosalyn Carter Institute for Caregiving; 2006. http://www.rosalynncarter.org/UserFiles/File/UFL_RCI_FinalCaregiverReport.pdf. Accessed April 18, 2008.
10. Caregiving in the US. Washington (DC): National Alliance for Caregiving, AARP; 2004. http://www.caregiving.org/data/04finalreport.pdf. Accessed April 18, 2008.
11. Informal caregiving: compassion in action. Washington (DC): US Department of Health and Human Services; 1998. http://aspe.hhs.gov/daltcp/reports/carebro2.pdf. Accessed April 18, 2008.
12. Alzheimer's disease facts and figures, 2007. Chicago (IL): Alzheimer's Association; 2007. http://www.alz.org/national/documents/Report_2007FactsAndFigures.pdf. Accessed April 18, 2008.
13. Anderson LA, McConnell SR. Cognitive health: an emerging public health issue. Alzheimers Dement 2007;3:s70-73.
14. Hendrie HC. Epidemiology of dementia and Alzheimer's disease. Am J Geriatr Psychiatry 1998;6(2 Suppl 1):S3-18.
15. McGuire LC, Ford ES, Ajani UA. Cognitive functioning as a predictor of functional disability in later life. Am J Geriatr Psychiatry 2006;14(1):36-42.
16. Bertrand RM, Fredman L, Saczynski J. Are all caregivers created equal? Stress in caregivers to adults with and without dementia. J Aging Health 2006;18(4):534-51.
17. Bruce DG, Paley GA, Nichols P, Roberts D, Underwood PJ, Schaper F. Physical disability contributes to caregiver stress in dementia caregivers. J Gerontol A Biol Sci Med Sci 2005;60(3):345-9.
18. Garand L, Dew MA, Eazor LR, DeKosky ST, Reynolds CF 3rd. Caregiving burden and psychiatric morbidity in spouses of people with mild cognitive impairment.

Int J Geriatr Psychiatry 2005;20(6):512-22.
19. Pinquart M, Sörensen S. Differences between caregivers and noncaregivers in psychological health and physical health: a meta-analysis. Psychol Aging 2003;18(2):250-67.
20. The state of aging and health in America 2007. Atlanta (GA): Centers for Disease Control and Prevention, The Merck Company Foundation; 2007. http://www.cdc.gov/aging/pdf/saha_2007.pdf. Accessed April 18, 2008.
21. Healthy people 2010: understanding and improving health. 2nd edition. Washington (DC): US Department of Health and Human Services, US Government Printing Office; 2000.
22. Gentry EM, Kalsbeek WD, Hogelin GC, Jones JT, Gaines KL, Forman MR, et al. The Behavioral Risk Factor surveys: II. Design, methods, and estimates from combined state data. Am J Prev Med 1985;1(6):9-14.
23. Remington PL, Smith MY, Williamson DF, Anda RF, Gentry EM, Hogelin GC. Design, characteristics, and usefulness of the state-based BRFSS: 1981-87. Public Health Rep 1988;103(4):366-75.
24. Centers for Disease Control and Prevention. The characteristics of caregivers and care recipients: North Carolina — 2005. MMWR Morb Mortal Wkly Rep 2007;56(21):529-532.
25. Andresen EM, Catlin TK, Wyrwich KW, Jackson-Thompson J. Retest reliability of surveillance questions on health-related quality of life. J Epidemiol Community Health 2003;57(5):339-43.
26. Agresti A. An introduction to categorical data analysis. 2nd edition. New York: John Wiley and Sons, Inc; 1996.
27. Korn EL, Graubard BI. Analysis of health surveys. New York: John Wiley and Sons, Inc; 1999.
28. Howard VJ, Cushman M, Pulley L, Gomez CR, Go RC, Prineas RJ, et al. The reasons for geographic and racial differences in stroke study: objectives and design. Neuroepidemiology 2005;25(3):135-43.
29. Navaie-Waliser M, Feldman PH, Gould DA, Levine C, Kuerbis AN, Donelan K. When the caregiver needs care: the plight of vulnerable caregivers. Am J Public Health 2002;92(3):409-13.
30. Hooker K, Bowman SR, Coehlo DP, Lim SR, Kaye J, Guariglia R, et al. Behavioral change in persons with dementia: relationships with mental and physical health of caregivers. J Gerontol B Psychol Sci Soc Sci 2002;57(5):P453-60.
31. Sanders S. Is the glass half empty or full? Reflections on strain and gain in caregivers of individuals with Alzheimer's disease. Soc Work Health Care 2005;40(3):57-73.
32. Andresen EM, Vahle VJ, Lollar D. Proxy reliability: health-related quality of life (HRQoL) measures for people with disability. Qual Life Res 2001;10(7):609-19.
33. Nelson D, Holtzman D, Bolen J, Stanwyck CA, Mack KA. Reliability and validity of measures for the Behavioral Risk Factor Surveillance System (BRFSS). Soz Praventivmed 2001;46 Suppl 1:S3-42.

Tables

Table 1. Characteristics of Caregivers of People With and Without Cognitive Impairment (Weighted), North Carolina Behavioral Risk Factor Surveillance System, 2005[a]

Characteristic	Caregivers of People With Cognitive Impairment (n = 279)	Caregivers of People Without Cognitive Impairment (n = 389)	*P* Value[b]
Age, y			
18-34	19.7 (13.0-28.6)	23.5 (15.4-34.1)	.13[c]
35-44	16.0 (11.3-22.1)	18.5 (13.9-24.2)	
45-54	27.8 (21.6-34.8)	19.2 (14.8-24.5)	
55-64	20.8 (15.7-27.1)	17.8 (13.6-22.8)	
≥65	15.8 (11.7-21.0)	21.0 (16.5-26.4)	
Race/ethnicity			
Non-Hispanic white	76.7 (70.1-82.2)	74.1 (64.5-81.8)	.63
Non-Hispanic black	15.4 (11.1-21.0)	21.8 (14.3-31.9)	.18
Other/multi-race, non-Hispanic	4.9 (2.5-9.4)	2.4 (1.1-5.2)	.17
Hispanic	3.0 (1.3-6.7)	1.7 (0.6-4.4)	.35
Sex, female	59.9 (51.7-67.6)	60.9 (52.2-68.9)	.89
Education level			
<High school diploma	6.6 (4.1-10.6)	13.9 (7.3-24.8)	.18
High school diploma	29.6 (22.9-37.4)	29.0 (23.0-35.8)	
>High school diploma	63.7 (56.0-70.8)	57.2 (49.0-65.0)	
Annual household income, $			
<25,000	30.3 (23.6-37.9)	23.3 (17.7-30.1)	.10[c]
25,000-34,999	14.8 (9.4-22.6)	20.9 (15.3-27.9)	
35,000-49,999	12.7 (8.6-18.4)	20.5 (12.8-31.1)	
50,000-74,999	21.1 (15.3-28.3)	13.6 (9.8-18.6)	
≥75,000	21.0 (15.0-28.6)	21.7 (16.4-28.1)	
Health-related quality of life			
Healthy days in the past 30, mean (95% CI)	24.3 (23.0-25.5)	23.9 (22.4,25.4)	.64[d]
No. of days physical health not good	2.9 (2.1-3.7)	3.3 (2.4-4.3)	.34[d]

Abbreviation: CI, confidence interval.
[a] Data are reported as % (95% CI), except where indicated. Numbers may not total to 100% because of rounding.
[b] Except where indicated, *P* values are reported for the difference in frequencies between caregivers of people with and without cognitive impairment, as measured by χ^2 test.
[c] *P* value reported for the difference in frequencies between caregivers of people with and without cognitive impairment, as measured by logistic regression to assess trend across ordinal variables.
[d] *P* value reported for the difference in means between caregivers of people with and without cognitive impairment, as measured by *t* test.

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Table 1. (continued) Characteristics of Caregivers of People With and Without Cognitive Impairment (Weighted), North Carolina Behavioral Risk Factor Surveillance System, 2005[a]

Characteristic	Caregivers of People With Cognitive Impairment (n = 279)	Caregivers of People Without Cognitive Impairment (n = 389)	*P* Value[b]
Health-related quality of life (continued)			
No. of days mental health not good	3.9 (2.7-5.0)	3.7 (2.4-5.0)	.81[d]
General health rated fair or poor	16.6 (11.9-22.5)	16.2 (12.3-21.2)	.93
Rarely or never receive social or emotional support	8.7 (5.5-13.7)	6.7 (3.9-11.5)	.47
Dissatisfied or very dissatisfied with life	3.7 (2.0-6.8)	2.7 (1.5-5.0)	.49
Disability status			
Have a disability	24.0 (18.6-30.5)	16.1 (12.4-20.8)	.03
Activities limited by physical, mental, or emotional problems	23.4 (18.0-29.9)	15.1 (11.6-19.6)	.02
Use special equipment	7.4 (4.5-12.0)	4.6 (2.7-7.6)	.18

Abbreviation: CI, confidence interval.
[a] Data are reported as % (95% CI), except where indicated. Numbers may not total to 100% because of rounding.
[b] Except where indicated, *P* values are reported for the difference in frequencies between caregivers of people with and without cognitive impairment, as measured by χ^2 test.
[c] *P* value reported for the difference in frequencies between caregivers of people with and without cognitive impairment, as measured by logistic regression to assess trend across ordinal variables.
[d] *P* value reported for the difference in means between caregivers of people with and without cognitive impairment, as measured by *t* test.

Table 2. Characteristics of Caregiving Experience for Caregivers of People With and Without Cognitive Impairment (Weighted), North Carolina Behavioral Risk Factor Surveillance System, 2005[a]

Characteristic	Caregivers of People With Cognitive Impairment (n = 279)	Caregivers of People Without Cognitive Impairment (n = 389)	*P* Value[b]
Age of person receiving care, y			
60-69	10.5 (7.1-15.4)	26.9 (21.3-33.4)	.001[c]
70-79	33.3 (26.3-41.2)	27.9 (22.0-34.7)	
80-89	46.5 (39.0-54.1)	35.6 (27.9-44.1)	
≥90	9.6 (5.5-16.4)	9.6 (6.2-14.5)	
Sex of person receiving care, female	74.0 (67.5-79.7)	70.5 (63.4-76.4)	.41

Abbreviation: CI, confidence interval.
[a] Data are reported as % (95% CI), except as noted. Numbers may not add to 100% because of rounding.
[b] Except where indicated, all *P* values are reported for the difference in frequencies between caregivers of people with and without cognitive impairment, as measured by χ^2 test.
[c] *P* value reported for the difference in frequencies between caregivers of people with and without cognitive impairment, as measured by logistic regression to assess trend across ordinal variables.
[d] *P* value reported for the difference in means between caregivers of people with and without cognitive impairment, as measured by *t* test.
[e] See Methods section for a detailed description of this variable.

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Table 2. (continued) Characteristics of Caregiving Experience for Caregivers of People With and Without Cognitive Impairment (Weighted), North Carolina Behavioral Risk Factor Surveillance System, 2005[a]

Characteristic	Caregivers of People With Cognitive Impairment (n = 279)	Caregivers of People Without Cognitive Impairment (n = 389)	*P* Value[b]
Relationship of caregiver to person receiving care			
Spouse/partner	6.3 (3.9-9.9)	10.0 (7.0-14.0)	.12
Other family member	77.4 (70.9-82.8)	69.2 (60.4-76.8)	.07
Nonfamily member	10.9 (7.5-15.7)	18.9 (11.8-28.8)	.07
Paid caregiver	2.7 (1.1-6.4)	0.1 (0.0-0.7)	<.001
Major health problem of person receiving care			
Cancer	7.1 (4.5-11.3)	15.7 (11.7-20.7)	.002
Dementia	28.9 (22.0-37.0)	0.6 (0.1-3.0)	<.001
Diabetes	5.9 (3.1-10.7)	10.5 (6.2-17.3)	.14
Heart disease	10.5 (7.0-15.6)	17.8 (13.5-23.1)	.03
Stroke	11.2 (7.3-16.8)	11.3 (7.2-17.3)	.97
Areas in which person receiving care needs most help			
Learning, remembering, confusion	37.4 (30.5-44.8)	7.8 (4.2-13.9)	<.001
Seeing or hearing	6.5 (3.9-10.6)	9.4 (6.0-14.5)	.27
Taking care of himself/herself	42.3 (35.1-49.8)	39.2 (31.5-47.6)	.59
Communicating with others	10.3 (6.7-15.6)	7.8 (5.3-11.3)	.32
Moving around	30.5 (23.5-38.6)	51.9 (44.1-59.6)	<.001
Getting along with people	7.1 (4.1-12.1)	4.4 (2.4-7.9)	.24
Feeling anxious or depressed	15.2 (10.8-20.9)	14.9 (11.0-20.0)	.95
Average hours of care per week, mean (95% CI)	20.2 (15.2-25.2)	16.6 (12.8-20.4)	.07[d]
Length of care in months, mean (95% CI)	45.6 (36.1-55.0)	35.5 (29.6-41.4)	.001[d]
Caregiving intensity[e]			
Level 1	31.6 (24.8-39.2)	21.4 (15.7-28.5)	.25[c]
Level 2	34.9 (27.1-43.5)	38.0 (29.6-47.2)	
Level 3	14.6 (10.2-20.5)	20.8 (15.3-27.6)	
Level 4	17.0 (12.4-22.9)	17.3 (12.9-22.7)	
Level 5	2.0 (0.7-5.8)	2.5 (1.3-4.9)	

Abbreviation: CI, confidence interval.
[a] Data are reported as % (95% CI), except as noted. Numbers may not add to 100% because of rounding.
[b] Except where indicated, all *P* values are reported for the difference in frequencies between caregivers of people with and without cognitive impairment, as measured by χ^2 test.
[c] *P* value reported for the difference in frequencies between caregivers of people with and without cognitive impairment, as measured by logistic regression to assess trend across ordinal variables.
[d] *P* value reported for the difference in means between caregivers of people with and without cognitive impairment, as measured by *t* test.
[e] See Methods section for a detailed description of this variable.

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ORIGINAL RESEARCH

Sociodemographic and Health Characteristics Associated With Attempting Weight Loss During Pregnancy

Jennifer H. Cohen, PhD, MPH, Hyoshin Kim, PhD

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PEER REVIEWED

Abstract

Introduction

Approximately 40% of women of childbearing age report that they are attempting to lose weight. No professional medical organization recommends attempting to lose weight during pregnancy because of the possible risks to both mother and baby. Since half of all pregnancies are unintended, women may attempt to lose weight before they know they are pregnant, and some women may continue or initiate weight loss attempts even after they know they are pregnant. This study examines the extent to which pregnant women report attempting to lose weight and associated sociodemographic and health characteristics.

Methods

We used aggregated multiple-year data (1996-2003) from the Behavioral Risk Factor Surveillance System to assess the prevalence of attempting to lose weight among pregnant women and the extent to which sociodemographic and health characteristics are associated with the behavior.

Results

The prevalence of attempting to lose weight during pregnancy was 8.1%. Attempting to lose weight during pregnancy was associated with age 35-44 years, Hispanic ethnicity, obesity, alcohol consumption, and mental distress during the previous month.

Conclusion

A substantial proportion of pregnant women attempt to lose weight. Preconception and prenatal care should include counseling women to achieve a healthy weight before becoming pregnant, to maintain healthy weight during pregnancy, and not to attempt weight loss during pregnancy. Further research should be conducted to understand how attempting weight loss during pregnancy translates into dietary change and weight loss and associated maternal and fetal outcomes.

Introduction

Approximately 40% of women of childbearing age report that they are attempting to lose weight (1). Because half of all pregnancies are unintended (2), pregnant women may attempt to lose weight before they know they are pregnant. Most women believe that weight gain in pregnancy is positive and cease weight loss efforts when they realize they are pregnant (3), and no professional medical organization or public health agency recommends attempting to lose weight during pregnancy because of the possible risks to both the mother (complications at childbirth) and baby (neural tube defects [NTDs], preterm delivery, increased lifetime risk of diabetes) (4-13), even for obese women. Nevertheless, some women may continue or initiate weight loss attempts even after they know they are pregnant because of negative perceptions of weight gain and dissatisfaction with body weight (14-16).

Attempting to lose weight during pregnancy is problematic only if it leads to changes in diet that impair maternal and fetal health. Attempting to lose weight is associated with low caloric and micronutrient intake (9,17-19), but few studies have examined outcomes associated with attempting weight loss during pregnancy. In a population-based, case-control study, attempting to lose weight was associated with an increased risk of NTDs in the infant (9). Among women who reported attempting to lose weight during the first trimester of pregnancy, the odds of NTD were 2.1 (95% confidence interval [CI], 1.1-4.1) higher than among women who did not report attempting to lose weight (9). Another recent study suggests that weight loss among obese pregnant women may reduce the risks for preeclampsia, cesarean delivery, small-for-gestational-age birth, and large-for-gestational-age birth; however, risk levels for the 4 outcomes did not vary between women who did not gain any weight and women who lost weight across all categories of obesity (20). Furthermore, the study was restricted to full-term live births, which may have excluded adverse maternal and fetal outcomes associated with maternal weight loss, and the study did not include women who were not obese.

Other studies of correlates of attempting weight loss during pregnancy are limited by insufficient samples of pregnant women (21) or are limited in generalizability by study designs, such as case series or clinic-based, or tend to focus on pathologic eating disorders or fasting (14,22-25). The most recent estimate of the extent to which pregnant women attempt to lose weight is based on data from 16 years ago (21). Despite the lack of evidence on maternal and fetal outcomes associated with attempted weight loss and actual weight loss during pregnancy, the behavior is not recommended and may indicate, like smoking and alcohol consumption, a high-risk pregnancy. Understanding the prevalence of attempting weight loss during pregnancy and factors associated with this potentially unhealthful behavior will inform future outcomes research and aid in developing appropriate interventions to prevent and control the behavior.

Methods

We aggregated data from the Behavioral Risk Factor Surveillance System (BRFSS) from 1996, 1998, 2000, and 2003 — the 4 most recent years that included the weight-loss module as part of the core survey. This method provided sufficient numbers of pregnant women to evaluate sociodemographic and health correlates of attempting to lose weight. Data from interim years are not included because weight-loss measurements were not part of the core BRFSS survey instrument. Pooling multiple years of BRFSS data can help estimate prevalence of health behaviors and diseases, and their correlates, among pregnant women (26-28).

BRFSS is an ongoing, state-based, random-digit–dialed telephone survey of the noninstitutionalized US population aged 18 years or older in all 50 states, the District of Columbia, and US territories. BRFSS includes a core survey with questions that are asked each year by all states, rotating questions asked in alternating years by all states, optional modules that states may elect to ask, and questions that are added by individual states. Median response rates varied by state for the 4 years of data, from approximately 50% to 65% (29,30). Rates of missing data are minimal for pregnancy status and attempting weight loss across all years of the survey. BRFSS has higher rates of missing data for alcohol consumption, income, and mental health distress. A detailed description of the BRFSS survey methods and data are available on the BRFSS Web site (www.cdc.gov/brfss).

Our sample consisted of 8,036 pregnant women aged 18 to 44 who had information on attempting to lose weight. Missing data rates for other main variables of interest, including demographic (race and ethnicity, age, marital status, and number of children younger than 18 in the household), socioeconomic (education and household income), and health (health care coverage, mental health, smoking, diabetes, and body mass index) characteristics, are consistent with BRFSS analyses of data for women and men and with what is seen in other survey research for similar variables. Percentages of missing data range from less than 0.01% for demographic variables to 10% for income. The sample that was available for multivariate analysis was 6,593 pregnant women with data on all variables of interest. Because data on alcohol consumption were collected only in selected states, a subsample of 3,315 pregnant women who provided data on alcohol consumption was used for the multivariate model that included alcohol use and binge drinking as covariates.

Pregnancy status was self-reported. Women were asked, “To your knowledge, are you now pregnant?” Those who answered yes were included for analysis as pregnant women. In a separate module of the survey, those respondents were also asked, “Are you now trying to lose weight?” Those who answered yes were defined for the analysis as attempting to lose weight.

The following demographic characteristics were constructed for analyses: 4 categories of race/ethnicity (white, black, Hispanic, or other), 4 categories of age (18-24, 25-29, 30-34, or 35-44 years), 4 categories of marital status (married; divorced, separated, or widowed; never married; or member of an unmarried couple), and 2 categories for number of children younger than 18 in the household (0 or ≥1). Our 3 socioeconomic measures included 4 categories of education (less than high school graduate, high school graduate, some college, or college graduate), 5 categories of household income (<$15,000, $15,000-$24,999, $25,000-$49,999, $50,000-$74,999, or ≥$75,000), and 2 categories of health care coverage (having or not having coverage). Coverage was based on the question, “Do you have any kind of health care coverage, including health insurance, prepaid plans such as a health maintenance organization, or government plans such as Medicare?”

We also constructed measures for 3 health-related characteristics. Three categories of mental distress were based on the response to the question, “For how many days during the past 30 days was your mental health not good?” (0, ≤13, or >13). The measure of diabetes was based on the question, “Has your doctor ever told you that you have diabetes, including during pregnancy?” Respondents who reported currently smoking were categorized as currently smoking. On the basis of self-reported body weight and height, we calculated 4 categories of body mass index (BMI): underweight (BMI <18.5 kg/m^2), normal weight (BMI 18.5-24.9 kg/m^2), overweight (BMI 25.0-29.9 kg/m^2), or obese (BMI ≥30.0 kg/m^2).

We used the subsample of 3,315 pregnant women who had information on alcohol consumption to explore the associations of alcohol consumption and binge drinking with attempting to lose weight. Alcohol consumption was defined as having had at least 1 drink in the past month, and binge drinking was defined as having had at least 5 drinks on 1 occasion in the past month.

We estimated overall prevalence of attempting to lose weight among pregnant women and the prevalences by sociodemographic and health characteristics. Unadjusted odds ratios of attempting to lose weight among pregnant women based on sociodemographic and health characteristics were estimated from logistic regression models. Adjusted odds ratios were also estimated in multivariate models that controlled for sociodemographic and health characteristics. To account for the complex sampling design of BRFSS, we used Stata version 9 (StataCorp LP, College Station, Texas) survey procedures for all of the analyses.

Results

The proportion of pregnant women who were attempting to lose weight was 8.1% (95% CI, 7.0%-9.2%). This proportion did not vary significantly across years of data. Most pregnant women were younger than 35, white, married, and lived in a household with 1 or more children younger than 18 years (Table 1). Approximately 80% of the sample had at least a high school education, and one-third lived in a household with an income of $50,000 or more per year. Most women reported having health insurance coverage. For the subanalysis, 10.7% (95% CI, 9.1%-12.3%) women reported having had at least 1 drink in the past month, and approximately 1.7% (95%, CI 1.1%-2.3%) reported binge drinking in the past month.

The ratio of pregnant women who were attempting to lose weight was highest among women older than 34 (Table 2). Hispanic women were more likely to attempt to lose weight than were white women. Married women were less likely to attempt to lose weight than were women who were divorced, separated, widowed, or never married. Women with 1 or more children at home were more likely to attempt to lose weight than were women without children at home. The proportion of women who were attempting to lose weight generally increased as level of education decreased. Women who lived in households with an annual income of less than $15,000 were more likely to attempt to lose weight than were women with household income greater than $75,000. Women who had no health insurance, who were currently smoking, or who had diabetes were more likely to attempt to lose weight than their counterparts. Women who experienced any mental distress in the past month were more likely to attempt to lose weight than were women who experienced no mental distress. Obese women were more likely to attempt to lose weight than were women of normal weight. In the alcohol subanalysis, binge drinkers were significantly more likely to attempt to lose weight than nonbinge drinkers, and women who reported consuming at least 1 drink in the past month were more likely to report attempting to lose weight than nondrinkers.

After adjusting for covariates, the associations of most variables with attempting to lose weight during pregnancy were attenuated, and some of the variables became nonsignificant. Age 35 years or older, Hispanic ethnicity, having 1 or more children at home, reporting any days of mental distress in the past 30 days, and BMI of 30 or higher remained significantly associated with attempting to lose weight during pregnancy after adjusting for covariates. For the alcohol subanalysis, after adjusting for covariates, the odds of attempting weight loss were higher for drinkers than for nondrinkers, and the association with binge drinking became nonsignificant. Slight changes in the odds ratios for some covariates were observed, which suggests that alcohol use during pregnancy may be associated with sociodemographic characteristics and attempting weight loss.

Discussion

We found that a substantial proportion (8.1%) of pregnant women report attempting to lose weight. Attempting to lose weight during pregnancy is associated with being older than 34, Hispanic ethnicity, obesity, alcohol consumption, and mental distress in the past month. This figure may be an underestimate of the true prevalence because women may attempt to lose weight before they learn that they are pregnant and because pregnant women may underreport the behavior if they believe that it is socially undesirable.

Our findings are consistent with those of other studies that found that women who experience mental distress are more likely to attempt to lose weight or engage in high-risk dietary or other health behaviors (15,19,25-27,29-31) and with studies that show that women of childbearing age who are overweight or obese or older than 34 are more likely to attempt to lose weight (1,21). The magnitude of the association between Hispanic ethnicity and attempting to lose weight, while significant, was small and disappeared when alcohol use was accounted for. The subsample analysis that included alcohol use shows that alcohol consumption in the past month is associated with attempting to lose weight in pregnant women. This finding may indicate that certain high-risk behaviors coexist among pregnant women.

This study has several limitations that must be considered in its interpretation. First, BRFSS is a telephone-based survey that does not reach people without telephones or who only have cell phones. It is also a cross-sectional study, which limits conclusions regarding causal associations. Second, BMI data are based on self-report. Respondents tend to overreport height and underreport weight; however, we found an association between obesity and attempting to lose weight. Third, no measure of week of gestation was available in the BRFSS data. Although measures of mental health status and alcohol consumption represent behavior during the past month and may indicate prepregnancy behavior in women who have been pregnant for less than a month, most women do not know they are pregnant until at least a month after conception. A previous study (21) reported that most women who were attempting to lose weight were in the first trimester of pregnancy. Without information on gestational stage, we do not know if the prevalence of attempting weight loss varies by gestational stage or if the observed associations vary by gestational stage. Fourth, we did not have information to evaluate the intensity or effectiveness of weight-loss attempts or what specific methods women may have used to lose weight. Different methods — such as exercise, caloric restriction, increased protein intake, lower fat intake, herbal supplements, binge eating, vomiting, diet pills, laxatives, water pills, and skipping meals — may be associated with better or worse outcomes (1,32).

The health consequences of obesity (including complications of pregnancy) are well documented (4,33), and the health benefits of even small amounts of prepregnancy weight loss are evident (4). Clinicians and public health agencies do not recommend attempting weight loss during pregnancy (4,8,34); however, a substantial proportion of pregnant women report attempting to lose weight. Further research should be conducted to understand the extent to which attempting to lose weight translates into dietary change and weight loss and associated maternal and fetal outcomes. Given the high prevalence of attempting to lose weight during pregnancy and the association with other high-risk behaviors, such as alcohol consumption and mental health distress, preconceptional and prenatal care should include counseling women to achieve a healthy weight before becoming pregnant, to maintain a healthy weight during pregnancy, and not to attempt weight loss during pregnancy.

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Author Information

Corresponding Author: Jennifer H. Cohen, PhD, MPH, Battelle Centers for Public Health Research and Evaluation, 1100 Dexter Ave North, Ste 400, Seattle, WA 98109-3598. Telephone: 206-528-3116. E-mail: cohenj@battelle.org.

Author Affiliations: Hyoshin Kim, Battelle Centers for Public Health Research and Evaluation, Seattle, Washington.

References

1. Kruger J, Galuska DA, Serdula MK, Jones DA. Attempting to lose weight: specific practices among US adults. Am J Prev Med 2004;26(5):402-6.
2. Henshaw SK. Unintended pregnancy in the United States. Fam Plann Perspect 1998;30:24-9.
3. Rocco PL, Orbitello B, Perini L, Pera V, Ciano RP, Balestrieri M. Effects of pregnancy on eating attitudes and disorders: a prospective study. J Psychosom Res 2005;59:175-9.
4. Johnson K, Posner SF, Biermann J, Cordero JF, Atrash HK, Parker CS, et al. Recommendations to improve preconception health and health care — United States. A report of the CDC/ATSDR Preconception Care Work Group and the Select Panel on Preconception Care. MMWR Recomm Rep 2006;55(RR-6):1-23.
5. Dewey KG, McCrory MA. Effects of dieting and physical activity on pregnancy and lactation. Am J Clin Nutr 1994;59:446S-52S.
6. Anderson AS. Symposium on nutritional adaptation to pregnancy and lactation. Pregnancy as a time for dietary change? Proc Nutr Soc 2001;60:497-504.
7. Kaiser LL, Allen L. Position of the American Dietetic Association: nutrition and lifestyle for a healthy pregnancy outcome. J Am Diet Assoc 2002;102:1479-90.
8. American College of Obstetricians and Gynecologists. ACOG Committee Opinion number 315, September 2005. Obesity in pregnancy. Obstet Gynecol 2005;106:671-5.
9. Carmichael SL, Shaw GM, Schaffer DM, Laurent C, Selvin S. Dieting behaviors and risk of neural tube defects. Am J Epidemiol 2003;158:1127-31.
10. Shaw GM, Todoroff K, Carmichael SL, Schaffer DM, Selvin S. Lowered weight gain during pregnancy and risk of neural tube defects among offspring. Int J Epidemiol 2001;30:60-5.
11. Siega-Riz AM, Herrmann T, Savitz DA, Thorp J. The frequency of eating during pregnancy and its effect on preterm delivery. Am J Epidemiol 2001;153:647-52.
12. Herrmann TS, Siega-Riz AM, Hobel CJ, Aurora C, Dunkel-Schetter C. Prolonged periods without food intake during pregnancy increase risk for elevated maternal corticotropin-releasing hormone concentrations. Am J Obstet Gynecol 2001;185:403-12.
13. Stocker CJ, Arch JR, Cawthorne MA. Fetal origins of insulin resistance and obesity. Proc Nutr Soc 2005;64:143-51.
14. Franko DL, Blais MA, Becker AE, Delinsky SS, Greenwood DN, Flores AT, et al. Pregnancy complications and neonatal outcomes in women with eating disorders. Am J Psychiatr 2001;158:1461-6.
15. Dipietro JA, Millet S, Costigan KA, Gurewitsch E, Caulfield LE. Psychosocial influences on weight gain attitudes and behaviors during pregnancy. J Am Diet Assoc 2003;103:1314-9.
16. Hickey CA. Sociocultural and behavioral influences on weight gain during pregnancy. Am J Clin Nutr 2000:71(5 Suppl):1364S-70S.
17. Neumark-Sztainer D, French SA, Jeffery RW. Dieting for weight loss: associations with nutrient intake among women. J Am Diet Assoc 1996;96:1172-5.
18. Kant AK. Weight-loss attempts and reporting of foods and nutrients, and biomarkers in a national cohort. Int J Obes Relat Metab Disord 2002;26:1194-204.
19. Laessle RG, Tuschl RJ, Kotthaus BC, Pirke KM. Behavioral and biological correlates of dietary restraint in normal life. Appetite 1989;12:83-94.
20. Kiel DW, Dodson E, Artal R, Boehmer TK, Leet TL. Gestational weight gain and pregnancy outcomes in obese women: how much is enough? Obstet Gynecol 2007;110(4)752-8.
21. Cogswell ME, Serdula MK, Mokdad AH, Williamson DF. Attempted weight loss during pregnancy. Int J Obes Relat Metab Disord 1996;20:373-5.
22. Park RJ, Senior R, Stein A. The offspring of mothers with eating disorders. Eur Child Adolesc Psychiatry 2003;12(Suppl 1):I110-19.
23. Pearlstein T. Eating disorders and comorbidity. Arch

Womens Ment Health 2002;4:67-78.
24. Turton P, Hughes P, Bolton H, Sedgwick P. Incidence and demographic correlates of eating disorder symptoms in a pregnant population. Int J Eat Disord 1999;26:448-52.
25. Mirghani HM, Hamud OA. The effect of maternal diet restriction on pregnancy outcome. Am J Perinatol 2006;23:21-4.
26. Ahluwalia IB, Mack KA, Mokdad A. Mental and physical distress and high-risk behaviors among reproductive-age women. Obstet Gynecol 2004;104:477-83.
27. Petersen AM, Leet TL, Brownson RC. Correlates of physical activity among pregnant women in the United States. Med Sci Sports Exerc 2005;37:1748-53.
28. Iachan R, Schulman J, Collins S, Powell-Griner E, Nelson D. Methods for combining state BRFSS survey data for national estimation. Proceedings of the Section on Survey Research Methods, American Statistical Association; 1999. p. 711-4.
29. 2000 BRFSS summary data quality report. Atlanta (GA): Centers for Disease Control and Prevention. http://www.cdc.gov/brfss/technical_infodata/2000QualityReport.htm. Accessed August 5, 2008.
30. 2003 BRFSS summary data quality report. Atlanta (GA): Centers for Disease Control and Prevention. http://www.cdc.gov/brfss/technical_infodata/2003QualityReport.htm. Accessed August 5, 2008.
31. Cohen JH, Kristal AR, Neumark-Sztainer D, Rock CL, Neuhouser ML. Psychological distress is associated with unhealthful dietary practices. J Am Diet Assoc 2002;102:699-703.
32. Hurley KM, Caulfield LE, Sacco LM, Costigan KA, Dipietro JA. Psychosocial influences in dietary patterns during pregnancy. J Am Diet Assoc 2005;105:963-6.
33. Galtier-Dereure F, Boegner C, Bringer J. Obesity and pregnancy: complications and cost. Am J Clin Nutr 2000;71:1242S-8S.
34. Institute of Medicine. Nutrition during pregnancy. Washington (DC): National Academies Press; 1990.

Tables

Table 1. Characteristics of Pregnant Women Who Were Attempting to Lose Weight, Behavioral Risk Factor Surveillance System (1996, 1998, 2000, 2003), United States

Characteristic	No. of Respondents	Weighted % (SE)[a]
Age, y		
18-24	2,225	31.8 (0.9)
25-29	2,469	28.6 (0.8)
30-34	2,167	25.3 (0.8)
35-44	1,286	14.3 (0.6)
Race/ethnicity		
White	5,787	64.9 (0.9)
Black	749	10.2 (0.6)
Hispanic	1,047	19.5 (0.8)
Other	544	5.4 (0.4)
Marital status		
Married	5,943	71.9 (0.9)
Divorced, separated, widowed	527	5.5 (0.4)
Never married	1,222	16.5 (0.7)
Member of unmarried couple	447	6.2 (0.5)
No. of children aged <18 y at home		
0	2,654	33.9 (0.9)
≥1	5,483	66.1 (0.9)
Household income, $		
<15,000	831	13.0 (0.7)
15,000-24,999	1,383	20.3 (0.8)
25,000-49,999	2,537	34.1 (0.9)
50,000-74,999	1,278	16.0 (0.7)
≥75,000	1,158	16.7 (0.7)
Education level		
Less than high school graduate	804	14.5 (0.8)
High school graduate	2,212	23.4 (0.8)
Some college	2,342	26.8 (0.8)
College graduate	2,783	30.2 (0.8)
Health insurance coverage		
Yes	7,327	87.6 (0.7)
No	813	12.4 (0.7)
Mental health status		
No mental health distress (0 days in past 30 days)	5,172	64.1 (0.9)
Few days of mental health distress (1-13 days in past 30 days)	2,246	28.8 (0.8)
Frequent mental health distress (≥14 days in past 30 days)	619	7.1 (0.4)
Smoking		
Not current	7,136	88.2 (0.6)
Current	999	11.8 (0.6)
Alcohol consumption		
No alcohol consumption	3,692	89.3 (0.8)
≥1 Drink in past month	462	10.7 (0.8)
Binge drinking		
No binge drinking	4,073	98.3 (0.3)
≥5 Drinks on 1 occasion in past month	78	1.7 (0.3)
Ever told by doctor that you have diabetes, including during pregnancy		
No	7,804	96.6 (0.3)
Yes	339	3.4 (0.3)
Body mass index, kg/m^2		
<18.5 (Underweight)	183	2.5 (0.3)
18.5-24.9 (Normal weight)	3,682	47.4 (0.9)
25.0-29.9 (Overweight)	2,271	29.9 (0.9)
≥30.0 (Obese)	1,467	20.2 (0.8)

Abbreviation: SE, standard error.
[a] Percentages may not add to 100% because of rounding.

Table 2. Associations Between Sociodemographic and Health Characteristics and Attempting to Lose Weight Among Pregnant Women, Behavioral Risk Factor Surveillance System (1996, 1998, 2000, 2003)

Characteristic	% of Women Attempting to Lose Weight (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]	
			Full Sample (N = 6,593)	Restricted Subsample[b] of Alcohol Users (n = 3,315)
Age, y				
18-24	7.1 (5.4-9.2)	1 [Referent]	1 [Referent]	1 [Referent]
25-29	8.1 (6.3-10.3)	1.2 (0.8-1.7)	1.4 (0.9-2.4)	1.6 (0.7-3.6)
30-34	6.2 (4.8-7.9)	0.9 (0.6-1.3)	1.2 (0.7-2.0)	1.5 (0.8-3.0)
35-44	13.6 (10.6-17.2)	2.1 (1.4-3.1)	2.7 (1.5-4.7)	2.9 (1.3-6.6)
Race/ethnicity				
White	6.5 (5.5-7.6)	1 [Referent]	1 [Referent]	1 [Referent]
Black	8.0 (4.9-12.8)	1.3 (0.7-2.2)	1.1 (0.5-2.2)	1.0 (0.5-2.3)
Hispanic	13.1 (10.2-16.7)	2.2 (1.6-3.0)	1.7 (1.1-2.7)	1.0 (0.5-2.2)
Other	8.5 (5.1-14.0)	1.3 (0.8-2.4)	1.6 (0.8-3.1)	1.4 (0.6-3.0)
Marital status				
Married	7.0 (5.9-8.2)	1 [Referent]	1 [Referent]	1 [Referent]
Divorced, separated, widowed	13.6 (9.0-20.0)	2.1 (1.3-3.4)	1.2 (0.7-2.0)	0.5 (0.2-1.4)
Never married	11.1 (8.4-14.4)	1.7 (1.2-2.3)	1.5 (0.8-2.7)	2.0 (0.9-4.4)
Member of unmarried couple	8.2 (4.7-14.1)	1.2 (0.6-2.2)	0.9 (0.4-2.1)	0.8 (0.2-3.9)
No. of children aged <18 y at home				
0	5.9 (4.6-7.5)	1 [Referent]	1 [Referent]	1 [Referent]
≥1	9.2 (7.9-10.7)	1.6 (1.2-2.2)	1.5 (1.1-2.2)	1.7 (1.0-3.1)
Household income, $				
<15,000	13.3 (9.8-18.0)	3.0 (1.8-5.0)	1.6 (0.8-3.1)	2.0 (0.6-6.4)
15,000-24,999	7.3 (5.3-10.0)	1.6 (0.9-2.6)	1.0 (0.5-1.8)	1.2 (0.4-3.0)
25,000-49,999	8.2 (6.3-10.6)	1.8 (1.1-2.8)	1.5 (0.9-2.4)	2.0 (0.9-4.2)
50,000-74,999	6.7 (5.0-9.1)	1.4 (0.9-2.3)	1.4 (0.8-2.4)	3.3 (1.5-7.0)
≥75,000	4.8 (3.3-6.8)	1 [Referent]	1 [Referent]	1 [Referent]
Education level				
Less than high school graduate	11.0 (7.8-15.3)	2.1 (1.3-3.2)	1.2 (0.6-2.2)	2.3 (0.8-6.7)
High school graduate	8.7 (6.9-11.0)	1.6 (1.1-2.3)	1.3 (0.8-2.0)	2.0 (1.1-3.6)
Some college	8.6 (6.8-10.8)	1.6 (1.1-2.2)	1.2 (0.8-1.8)	1.7 (0.9-3.0)
College graduate	5.6 (4.5-7.0)	1 [Referent]	1 [Referent]	1 [Referent]

Abbreviations: CI, confidence interval; OR, odds ratio; NA, not applicable.
[a] Indicators for different survey years were included to control for variations across survey years in the multivariate models.
[b] Information on alcohol consumption was not available from the core Behavioral Risk Factor Surveillance System survey in each of the 4 years, which reduced the sample size for analysis to 3,315 pregnant women.

(Continued on next page)

Table 2. (continued) Associations Between Sociodemographic and Health Characteristics and Attempting to Lose Weight Among Pregnant Women, Behavioral Risk Factor Surveillance System (1996, 1998, 2000, 2003)

Characteristic	% of Women Attempting to Lose Weight (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]	
			Full Sample (N = 6,593)	Restricted Subsample[b] of Alcohol Users (n = 3,315)
Health insurance coverage				
Yes	7.5 (6.5-8.7)	1 [Referent]	1 [Referent]	1 [Referent]
No	11.9 (8.8-16.0)	1.7 (1.1-2.4)	1.5 (0.9-2.4)	1.4 (0.5-3.4)
Mental health status				
No mental health distress (0 days in past 30 days)	6.46 (5.4-7.5)	1 [Referent]	1 [Referent]	1 [Referent]
Few days of mental health distress (1-13 days in past 30 days)	10.4 (8.1-13.2)	1.7 (1.2-2.3)	1.7 (1.2-2.4)	2.0 (1.1-3.4)
Frequent mental health distress (≥14 days in past 30 days)	14.6 (10.6-19.7)	2.5 (1.7-3.8)	2.2 (1.4-3.6)	1.7 (0.8-3.7)
Smoking				
Not current	7.3 (6.3-8.6)	1 [Referent]	1 [Referent]	1 [Referent]
Current	12.3 (9.4-15.9)	1.7 (1.2-2.4)	1.3 (0.8-2.0)	1.1 (0.5-2.2)
Alcohol consumption				
No alcohol consumption	5.5 (4.2-7.2)	1 [Referent]	NA	1 [Referent]
≥1 Drink in past month	19.7 (14.6-26.0)	4.2 (2.7-6.6)	NA	3.7 (2.0-6.9)
Binge drinking				
No binge drinking	6.6 (5.3-8.2)	1 [Referent]	NA	1 [Referent]
≥5 Drinks on 1 occasion in past month	32.0 (18.6-49.2)	6.7 (3.1-14.3)	NA	2.0 (0.7-6.2)
Ever told by doctor that you have diabetes, including during pregnancy				
No	7.9 (6.9-9.0)	1 [Referent]	1 [Referent]	1 [Referent]
Yes	14.6 (9.5-21.9)	2.0 (1.2-3.4)	1.5 (0.9-2.7)	2.1 (0.9-4.9)
Body mass index, kg/m^2				
<18.5 (Underweight)	2.9 (1.1-7.5)	0.4 (0.2-1.2)	0.2 (0.1-0.9)	0.3 (0.03-2.6)
18.5-24.9 (Normal weight)	6.7 (5.3-8.3)	1 [Referent]	1 [Referent]	1 [Referent]
25.0-29.9 (Overweight)	7.9 (6.3-9.9)	1.2 (0.9-1.7)	1.2 (0.8-1.7)	1.2 (0.6-2.3)
≥30.0 (Obese)	12.3 (9.6-15.6)	2.0 (1.4-2.8)	1.8 (1.2-2.5)	1.8 (1.0-3.4)

Abbreviations: CI, confidence interval; OR, odds ratio; NA, not applicable.
[a] Indicators for different survey years were included to control for variations across survey years in the multivariate models.
[b] Information on alcohol consumption was not available from the core Behavioral Risk Factor Surveillance System survey in each of the 4 years, which reduced the sample size for analysis to 3,315 pregnant women.

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ORIGINAL RESEARCH

Patterns of Clinically Significant Symptoms of Depression Among Heavy Users of Alcohol and Cigarettes

Joan Faith Epstein, MS, Marta Induni, PhD, Tom Wilson, MA

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PEER REVIEWED

Abstract

Introduction
Depression is among the most prevalent and treatable diseases, and it is associated with cigarette smoking and heavy alcohol use. This study estimates the prevalence of depression, its variation among demographic subgroups, and its association with heavy alcohol use and cigarette smoking in California.

Methods
The 2006 California Behavioral Risk Factor Surveillance System (BRFSS) includes the 8-item Patient Health Questionnaire, a standardized instrument used to measure depressive symptoms. We used findings from the 2006 BRFSS to calculate the prevalence of depression in California; we used logistic models to explore the relationships between depression, alcohol use, and smoking.

Results
We found that 9.2% of adults in California had clinically significant depressive symptoms. Logistic models indicated that daily smokers were more than 3 times more likely to have clinically significant depressive symptoms than were nonsmokers, and heavy drinkers were approximately 3 times more likely to have clinically significant depressive symptoms than were nondrinkers.

Conclusions
Because heavy alcohol use and daily smoking are each associated with depression, people who do both may be at an increased risk for depression. This is a public health issue because people who drink alcohol often also smoke and vice versa. Intervention efforts might target persons who are users of both these drugs, and practitioners should be aware that smokers who are heavy alcohol users are at an increased risk for depression.

Introduction

Depression is a leading cause of disability worldwide (1) and is among the most prevalent and treatable diseases (2). Cigarette smoking and heavy alcohol use, which are closely linked (3), are associated with a number of physical illnesses, including cancer and cardiovascular, respiratory, and other chronic diseases (4-7), and both are associated with depression. According to the National Survey on Drug Use and Health, 7.2% of all US adults in 2006 had had at least 1 major depressive episode (MDE) in the previous year (8). Estimates from this study indicated a strong association between MDE and daily cigarette smoking and between MDE and heavy alcohol use. Among adults with a history of MDE, 8.6% were heavy alcohol users; among adults who reported no MDE, the rate was 7.3%. Similarly, among adults with a history of MDE, the rate of daily cigarette use was 29.7%, and among adults who reported no MDE, the rate was 16.0%. When associations between drinking and MDE were estimated from the 2000-2001 National Epidemiologic Survey on Alcohol and Related Conditions, they indicated that among heavy drinkers, 9.0% had had an MDE in the previous year, and among light drinkers the rate was 7.9%. The overall rate among adults in the United States was 7.1% (9).

Measuring mental illnesses in a population survey is problematic, not only because many people are not aware of their illness but also because diagnostic scales used by clinicians are generally too long or too cumbersome to be included in a general population survey. The Patient Health Questionnaire (PHQ-8) is a short, 8-item depression scale to diagnose depression and measure its severity (2). Because it is half the length of other depression scales, it is useful in population-based surveys.

Although estimates at the national level have shown an association between depression and alcohol use and between depression and cigarette smoking separately, we are not aware of any studies that have looked at the association between depression and heavy alcohol use among smokers or the association between depression and smoking among heavy alcohol users at the national and the state levels. We estimate the prevalence of clinically significant depressive symptoms in the California population and their variation among demographic subgroups. We also examine the association between clinically significant depressive symptoms and smoking and between clinically significant depressive symptoms and alcohol use. We assess the effect of smoking on depression while controlling for alcohol use and other confounders, the effect of alcohol use on depression while controlling for smoking and other confounders, and the combined effect of alcohol use and smoking on depression. We also demonstrate the use of the PHQ-8 in a general population survey in California.

Methods

Data source

We used data from the 2006 California Behavioral Risk Factor Surveillance System (BRFSS), an ongoing telephone survey of randomly selected adults that is designed to assess the prevalence of and trends in health-related behaviors in the California population aged 18 years and older. The 2006 BRFSS sample was randomly selected within 2 strata consisting of Los Angeles County and the rest of California. Interviewers made up to 16 calls at all times of the day to maximize the number of respondents. The final sample included 5,692 adults. The upper-bound response rate was 65% (the proportion of eligible households that completed the interview). This study was approved by the California Department of Public Health Committee for the Protection of Human Subjects.

Dependent variable: depression symptoms

Having clinically significant depressive symptoms was the dependent variable for the logistic models in this study. Clinically significant depressive symptoms were measured by using the PHQ-8 (2). The 2006 BRFSS included the PHQ-8, a brief depression scale similar to the PHQ-9. The PHQ-9, a well-validated and widely used diagnostic and severity measure (10-12), consists of the 9 criteria on which the diagnosis of a major depressive disorder is based. Research suggests that it can be used without adjustment in diverse populations (13). Telephone administration of the PHQ-9 is also a reliable procedure for assessing depression in primary care (14). The only difference between the PHQ-8 and the PHQ-9 is that the PHQ-8 omits the 9th criterion ("thoughts that you would be better off dead or hurting yourself in some way") (2). In the BRFSS, each question asks about the number of days a symptom occurred during the last 2 weeks. To score the questions, days are converted to points (0-1 day = 0 points, 2-6 days = 1 point, 7-11 days = 2 points, and 12-14 days = 3 points) and summed to obtain a total score. The total score indicates the depressive symptom severity (a score of 1-4 indicates no to minimal depression, 5-9 indicates mild depression, 10-14 indicates moderate depression, 15-19 indicates moderately severe depression, and 20 or higher indicates severe depression). A person with a score of 10 or higher is defined as having clinically significant depressive symptoms. For this article, people who had clinically significant depressive symptoms in the previous 2 weeks were defined as having current depression.

Independent variables

The main independent variables that could influence current depression were smoking and drinking. Other possible confounding variables that were independent variables in the model include age, race/ethnicity, sex, marital status, employment status, education level, body mass index (BMI), poverty status, vigorous exercise, and income.

Extent of drinking was classified into 4 categories: nondrinker (no alcohol use in the previous month), past-month drinker, binge drinker, and heavy drinker. For men, binge drinking was defined as having 5 or more drinks on at least 1 occasion during the preceding month. For women, binge drinking was defined as having 4 or more drinks on at least 1 occasion during the preceding month. Heavy drinking was defined as binge drinking on 5 or more occasions in the previous month. To make the categories mutually exclusive, past-month drinkers did not include binge drinkers, and binge drinkers did not include heavy drinkers.

Extent of smoking was also classified into 4 categories: nonsmoker, former smoker, current smoker, and daily smoker. Respondents were classified as current smokers if they reported having smoked 100 cigarettes or more during their lifetimes and acknowledged smoking 1 cigarette or more in the previous 30 days. Respondents were classified as former smokers if they had smoked 100 cigarettes or more during their lifetimes but had not smoked during the previous 30 days. Daily smokers reported smoking daily. To make categories mutually excusive, current smokers did not include daily smokers.

Employment status was coded as employed for wages, self-employed, out of work 1 year or more, out of work less than 1 year, homemaker, student, retired, or unable to work. Education level was based on highest grade of school completed and was coded as less than ninth grade, some high school, high school graduate or General Educational Development certified, some technical school, technical school graduate, some college, college graduate, or postgraduate. Self-reported weight and height were used to calculate BMI, and participants were classified into BMI categories according to Centers for Disease Control and Prevention guidelines (underweight, BMI <18.5 kg/m^2; healthy weight, BMI 18.5-24.9 kg/m^2; overweight, BMI 25.0-29.9 kg/m^2; obese, BMI ≥30.0 kg/m^2) (15). Participants were classified as participating in vigorous exercise if they reported doing activities such as running, aerobics, heavy yard work, or any other activity that caused increases in breathing or heart rate for at least 20 minutes on at least 3 days per week.

Statistical analysis

To describe the magnitude of current depression in this population, we calculated rates of current depression by sociodemographic characteristics as well as other characteristics that might be related to depression. We used logistic regression to calculate odds ratios (ORs) for levels of alcohol and cigarette use. All estimates were weighted, and all standard errors were calculated by using SAS version 7.0 (SAS Institute Inc, Cary, North Carolina). All pairwise comparisons of estimates were tested for significance by using SUDAAN version 9.0.1 (RTI International, Research Triangle Park, North Carolina) to adjust for the complex sample design. We considered differences significant at $P \leq .05$.

Logistic models were developed by using current depression as the dependent variable. Model 1 included drinking and smoking as the only dependent variables to determine the effect of smoking and drinking on depression, without controlling for other possible confounding and interacting variables. Model 2 included all possible confounders in BRFSS. In addition to smoking and drinking, this model included sex, race/ethnicity, age, marital status, education level, employment status, income, poverty status, BMI, and vigorous exercise.

Additional models were developed to determine the model with the most parsimonious fit by using Akaike's information criterion (AIC — in comparing 2 models, a lower AIC indicates more parsimonious fit) and to control for confounding and interacting variables. Adjusted odds ratios for smoking and drinking were estimated for each model, and their change from model to model was examined to determine the effect of confounding. An analysis of effects that indicated the significance of a variable in the presence of all other variables in the model was used to determine which variables to exclude from the model. Possible confounders that were not significant in the presence of other variables in the model were not included in the next model.

Model 3 included age, marital status, employment status, income, BMI, and vigorous exercise in addition to smoking and drinking. Each variable in this model was significant in the presence of all other variables in the model. Model 4 was the same as model 3 but included an interaction term for drinking and smoking. Model 4 had the most parsimonious fit with the lowest AIC value, but the ORs in this model were unstable.

Results

Descriptive analysis

We found a 9.2% prevalence of current depression in

California, and prevalence was higher among Hispanics (12.1%) than among whites (7.2%). Current depression was most common in people aged 50 to 59 years (13.5%) and least common among people aged 60 or older (5.6%). The prevalence of current depression was lowest among married people (6.7%) and highest among divorced or separated people (17.9% and 17.4%, respectively). Rates of current depression generally decreased as annual household income rose. Rates were highest among people with the lowest income level (27.1% among people with an income <$10,000) and lowest among people with the highest income level (2.5% among people with an income >$100,000). People who did not participate in vigorous exercise were twice as likely to have current depression as people who participated in vigorous exercise (10.9% vs 5.0%). Obese people were more likely to be depressed than were those who were underweight, healthy, or overweight (16.5% vs 6.8%, 7.9%, and 5.8%, respectively).

Prevalence of current depression was higher among daily smokers (23.8%) and past-month smokers (22.5%) than among former smokers (11.2%) or nonsmokers (5.8%). Prevalence of current depression was highest among heavy drinkers (24.2%) and lowest among binge drinkers (7.8%) and past-month drinkers (6.0%). Among nondrinkers, the prevalence was 11.6%. Current depression was most common among daily smokers who were also binge drinkers (43.5%) or heavy drinkers (36.8%) and least common among people who never smoked and were past-month drinkers (3.6%) or binge drinkers (1.4%).

Logistic regression models

In the model that did not account for possible confounding variables, smokers in all categories (daily, former, and current) were more likely than nonsmokers to have clinically significant depressive symptoms (Table 1). Heavy drinkers were somewhat more likely to have current depression than were nondrinkers, although binge and past-month drinkers were only approximately half as likely as nondrinkers to have current depression. The AIC measure of fit was highest for this model, which was expected because this model did not control for any possible confounding variables.

Model 2 (data not shown) included the most possible confounding variables available in BRFSS, and model 3 (Table 2) retained only those variables from model 2 that were significant in the presence of all other variables (race/ethnicity, sex, education level, and poverty status were dropped from model 2). In model 3, all levels of smoking (daily, former, and current) were associated with higher odds of depression than was nonsmoking, although the difference between former smokers and nonsmokers did not reach significance. Heavy drinkers were approximately 3 times more likely to report depression than were nondrinkers; binge and past-month drinkers were less likely to report depression than were nondrinkers, but the difference did not reach significance. These associations were nearly identical to those seen in model 2, which indicates that the eliminated variables were not true confounders.

Model 4 (Table 3) included the same variables as model 3 but also included an interaction term for smoking and drinking. The interaction between the smoking and drinking variables was significant, which indicates that the relationship between depression and smoking changes depending on an adult's drinking level, and the relationship between depression and drinking changes depending on an adult's smoking level. The odds of current depression for daily smokers compared with nonsmokers was more than 4 times higher among heavy drinkers than among nondrinkers (OR, 14.3 vs 2.9). Similarly, the odds of current depression for heavy drinkers compared with nondrinkers was more than 4 times higher among daily smokers than among nonsmokers (OR, 9.3 vs 1.9).

Discussion

We found that smoking and heavy alcohol use are associated with current depression in California. Rates of current depression were more than 3 times as high among daily smokers and past-month smokers as among nonsmokers. Heavy drinkers were more than 3 times more likely to have current depression than were past-month drinkers and binge drinkers.

The association between depression and smoking and between depression and heavy drinking persisted even after controlling for confounding variables and examining interactions for smoking and alcohol use. In all models examined, the odds of depression were significantly higher for daily and past-month smokers than for nonsmokers. Similarly, in every model except the 1 that did not control for confounders, the odds of current depression were significantly higher for heavy drinkers than for nondrinkers.

The models with an interaction term and the descriptive statistics imply that heavy and binge drinking interact with smoking to increase the likelihood of current depression. People who both smoke and are heavy drinkers are more likely to have current depression than are those who do only 1 of these activities. Prevention efforts might target people who are dual users, and practitioners should be aware that smokers who are also heavy alcohol users are at an increased risk for current depression.

To the best of our knowledge, this is the first time the PHQ-8 has been included in a general population study in the United States and, therefore, the first time in a population-based study in California. We found a prevalence of current depression in California of 9.2%, which is consistent with the estimate of 9.2% seen in a validity study of the PHQ-9 that used a representative sample of the general population of Germany (16). Patterns of depression by most sociodemographic characteristics were similar to those seen in national, population-based surveys (17,18). We found no significant difference in prevalence by sex (8.7% in men and 10.1% in women), although national surveys indicate that depression is more prevalent in women (8).

Caution must be observed in interpreting these results. Because of the small sample sizes of some subgroups, estimates of ORs by different levels of the interacting variable have large standard errors, which indicates instability. Because this is a cross-sectional survey, these results do not indicate whether smoking and drinking cause depression or whether depression causes people to smoke and drink.

Another limitation of the study relates to the use of telephones. Because this study was conducted by telephone, it excludes people who do not have residential telephone service. Certain populations, such as very poor ones, may be missed by this type of survey (19), and the effect of this limitation on our findings is unclear. However, approximately 95% of US households are estimated to have at least 1 telephone (20), and approximately 92% of US adults live in households with landline telephone service (21). Telephone surveys with low response rates might not contain differential response bias compared with those with higher response rates and may increase reporting of sensitive behaviors compared with face-to-face surveys (22). In a study that evaluated the agreement between a self-administered and a telephone-administered PHQ-9, the intra-class correlation coefficient and weighted κ indicated excellent agreement between the administration procedures (14).

This study demonstrated the use of the PHQ-8 in a population-based survey. Because the PHQ-8 is half the length of many other depression scales and has comparable sensitivity and specificity, it may be useful in other studies of depression in which a longer instrument would not be feasible.

People who drink heavily tend to smoke heavily, and people who are dependent on alcohol are likely to be dependent on cigarettes (23). Over time, dependence on these drugs may lead to long-term changes in neuronal activity (24). Depression can complicate co-occurring alcohol and nicotine dependence and impede attempts to quit (25). Intervention efforts should target people who are dual users, and practitioners should be aware that smokers who are heavy alcohol users are at an increased risk for depression.

Author Information

Corresponding Author: Joan Faith Epstein, MS, Survey Research Group Section, Cancer Surveillance and Research Branch, California Department of Public Health, 1700 Triute Rd, Sacramento, CA 95815-1402. Telephone: 916-779-0114. E-mail: jepstein@ccr.ca.gov.

Author Affiliations: Marta Induni, California Department of Public Health, Sacramento, California; Tom Wilson, California Department of Mental Health, Sacramento, California.

References

1. Balon R. Mood, anxiety, and physical illness: body and mind, or mind and body? Depress Anxiety 2006;23(6):377-87.
2. Kroenke K, Spitzer RL. The PHQ-9: a new depression diagnostic and severity measure. Psychiatr Ann 2002;32(9):1-7.
3. Anthony JC, Echeagry-Wagner F. Epidemiologic analysis of alcohol and tobacco use. Alcohol Res Health 2000:24(4):201-7.
4. Bradely KA, Badrinath S, Bush K, Boyd-Wickizer J,

Anawalt B. Medical risks for women who drink alcohol. J Gen Intern Med 1998;13(9):627-39.
5. US Department of Health and Human Services. The health consequences of smoking: cancer. Washington (DC): Office of Smoking and Health; 1982. Publication no. 82-50179.
6. US Department of Health and Human Services. The health consequences of smoking: cardiovascular disease. Washington (DC): Office of Smoking and Health; 1983. Publication no. 82-50204.
7. US Department of Health and Human Services. The health consequences of smoking: chronic and obstructive lung disease. Washington (DC): Office of Smoking and Health; 1984. Publication no. 82-50205.
8. Substance Abuse and Mental Health Services Administration. Results from the 2006 National Survey on Drug Use and Health: national findings. Rockville (MD): Office of Applied Studies; 2007. Publication no. SMA 07-4293.
9. Alcohol use and alcohol use disorders in the United States: main findings from the 2001-2002 National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). Bethesda (MD): National Institute on Alcohol Abuse and Alcoholism; 2006.
10. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. J Gen Intern Med 2001;16(9):606-13.
11. Löwe B, Kroenke K, Herzog W, Gräfe K. Measuring depression outcome with a brief self-report instrument: sensitivity to change of the Patient Health Questionnaire (PHQ-9). J Affect Disorders 2004;81(1)61-6.
12. Löwe B, Spitzer RL, Gräfe K, Kroenke K, Quenter A, Zipfel S, et al. Comparative validity of 3 screening questionnaires for DSM-IV depressive disorders and physicians' diagnoses. J Affect Disorders 2004;78(2):131-40.
13. Huang FY, Chung H, Kroenke K, Delucchi KL, Spitzer RL. Using the Patient Health Questionnaire-9 to measure depression among racially and ethnically diverse primary care patients. J Gen Intern Med 2006;21(6):547-52.
14. Pinto-Meza A, Serrano-Blanco A, Peñarrubia MT, Blanco E, Haro JM. Assessing depression in primary care with the PHQ-9: can it be carried out over the telephone? J Gen Intern Med 2005;20(8):738-42.
15. Defining overweight and obesity. Atlanta (GA): Centers for Disease Control and Prevention. http://www.cdc.gov/nccdphp/dnpa/obesity/defining.htm. Accessed August 18, 2008.
16. Martin A, Reif W, Klaiberg A, Braehler E. Validity of the brief Patient Health Questionnaire Mood Scale (PHQ-9) in the general population. Gen Hosp Psychiatry 2006;28(1):71-7.
17. Johnson EO, Rhee SH, Chase GA, Breslau N. Comorbidity of depression with levels of smoking: an exploration of the shared familial risk hypothesis. Nicotine Tob Res 2004;6(6):1029-38.
18. Kessler RC, Nelson CB, McGonagle KA, Edlund MJ, Frank RG, Leaf PJ. Epidemiology of co-occurring addictive and mental disorders: implications for prevention and service utilization. Am J Orthopsychiatry 1996;66(1):17-31.
19. Lawn S. White Pages misses important population segments [letter]. Aust N Z J Public Health 2001;25(5):472.
20. US Census Bureau Report. Table 1099: utilization of selected media: 1980 to 2005. Washington (DC): US Census Bureau; 2008.
21. Galesic M, Tourangeau R, Couper MP. Complementing random-digit-dial telephone surveys with other approaches to collecting sensitive data. Am J Prev Med 2006;31(5):437-42.
22. Keeter S, Miller C, Kohut A, Groves RM, Presser S. Consequences of reducing nonresponse in a national telephone survey. Public Opin Q 2000;64:125-48.
23. Drobes DJ. Concurrent alcohol and tobacco dependence: mechanisms and treatment. http://pubs.niaaa.nih.gov/publications/arh26-2/136-142.htm. Accessed September 15, 2008.
24. Little J. Behavioral mechanisms underlying the link between smoking and drinking. Alcohol Res Health 2000;24(4):215-24.
25. Kodl MM, Fu SS, Willenbring ML, Gravely A, Nelson DB, Joseph AM. The impact of depressive symptoms on alcohol and cigarette consumption following treatment for alcohol and nicotine dependence. Alcohol Clin Exp Res 2008;32(1):92-9.

Tables

Table 1. Logistic Regression Coefficients and Fit Statistics for a Model (Model 1[a]) That Examines the Relationship Between Current Depression and Smoking and Alcohol Use Among Adults Aged 18 or Older, 2006 California Behavioral Risk Factor Surveillance System

Variable	β	SE of β	*P* Value	OR (95% CI)	Type 3 Analysis of Effects	
					χ^2	*P* Value
Intercept	−2.57	0.23	<.001	NA	NA	NA
Extent of smoking[b]						
Nonsmoker	1 [Reference]				34.6	<.001
Daily	1.76	0.37	<.001	5.82 (2.80-12.09)		
Former	0.69	0.31	.02	2.00 (1.10-3.63)		
Current	1.98	0.48	<.001	7.24 (2.82-8.60)		
Extent of alcohol use[c]						
Nondrinker	1 [Reference]				9.7	.02
Heavy	0.46	0.39	.23	1.59 (0.75-3.39)		
Binge	−0.55	0.53	.29	0.58 (0.21-1.61)		
Past month	−0.72	0.29	.01	0.49 (0.28-0.86)		

Abbreviations: SE, standard error; OR, odds ratio; CI, confidence interval; NA, not applicable.
[a] Akaike's information criterion: 9,805,316.
[b] Daily smokers reported smoking daily; former smokers reported smoking ≥100 cigarettes during their lifetimes but had not smoked in the previous 30 days; current smokers reported smoking ≥100 cigarettes during their lifetimes and ≥1 cigarette during the previous 30 days. Current smokers did not include daily smokers.
[c] Nondrinkers reported no alcohol use in the previous month; heavy drinkers reported binge drinking on ≥5 occasions in the previous month; binge drinkers reported having ≥5 drinks on ≥1 occasion (for men) or ≥4 drinks on ≥1 occasion (for women) in the previous month; past-month drinkers reported having ≥1 drink in the previous month. Past-month drinkers did not include binge drinkers, and binge drinkers did not include heavy drinkers.

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Table 2. Logistic Regression Coefficients and Fit Statistics for a Model (Model 3[a]) That Examines the Relationship Between Current Depression and Smoking and Alcohol Use, Including Only Significant Confounders, Among Adults Aged 18 or Older, 2006 California Behavioral Risk Factor Surveillance System

Variable	β	SE of β	*P* Value	OR (95% CI)	Type 3 Analysis of Effects χ^2	Type 3 Analysis of Effects *P* Value
Intercept	−6.09	0.66	<.001	NA	NA	NA
Extent of smoking[b]						
Nonsmoker	1 [Reference]				14.9	<.01
Daily	1.32	0.29	<.001	3.74 (2.11-6.65)		
Former	0.53	0.32	.09	1.70 (0.91-3.16)		
Current	1.04	0.43	.01	2.84 (1.23-6.55)		
Extent of drinking[c]						
Nondrinker	1 [Reference]				21.3	<.001
Heavy	1.07	0.45	.02	2.90 (1.21-6.95)		
Binge	−0.50	0.36	.17	0.61 (0.30-1.23)		
Past month	−0.28	0.28	.31	0.77 (0.44-1.30)		
Age, y						
18-24	2.61	0.63	<.001	13.59 (3.92-48.75)	18.9	<.01
25-34	1.94	0.56	<.001	6.96 (2.32-20.90)		
35-44	1.54	0.55	<.01	4.69 (1.61-13.66)		
45-54	1.42	0.56	.01	4.15 (1.38-12.45)		
55-64	0.92	0.56	.10	2.52 (0.84-7.60)		
≥65	1 [Reference]					
Employment status						
Employed for wages	1 [Reference]				87.1	<.001
Out of work <1 year	0.40	0.52	.60	1.49 (0.54-4.09)		
Out of work >1 year	1.20	0.60	.05	3.31 (1.02-10.68)		
Retired	0.79	0.52	.13	2.21 (0.79-6.17)		
Self-employed	0.32	0.38	.39	1.38 (0.66-2.89)		
Homemaker	0.06	0.41	.88	1.06 (0.48-2.36)		
Student	−0.51	0.64	.42	0.60 (0.17-2.10)		
Unable to work	3.31	0.37	<.001	27.26 (13.12-56.65)		

Abbreviations: SE, standard error; OR, odds ratio; CI, confidence interval; NA, not applicable; BMI, body mass index.
[a] Akaike's information criterion: 7,278,444.
[b] Daily smokers reported smoking daily; former smokers reported smoking ≥100 cigarettes during their lifetimes but had not smoked in the previous 30 days; current smokers reported smoking ≥100 cigarettes during their lifetimes and ≥1 cigarette during the previous 30 days. Current smokers did not include daily smokers.
[c] Nondrinkers reported no alcohol use in the previous month; heavy drinkers reported binge drinking on ≥5 occasions in the previous month; binge drinkers reported having ≥5 drinks on ≥1 occasion (for men) or ≥4 drinks on ≥1 occasion (for women) in the previous month; past-month drinkers reported having ≥1 drink in the previous month. Past-month drinkers did not include binge drinkers, and binge drinkers did not include heavy drinkers.

(Continued on next page)

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Table 2. (continued) Logistic Regression Coefficients and Fit Statistics for a Model (Model 3[a]) That Examines the Relationship Between Current Depression and Smoking and Alcohol Use, Including Only Significant Confounders, Among Adults Aged 18 or Older, 2006 California Behavioral Risk Factor Surveillance System

Variable	β	SE of β	*P* Value	OR (95% CI)	Type 3 Analysis of Effects	
					χ^2	*P* Value
BMI						
≥30.0 kg/m^2 (obese)	0.70	0.28	.01	2.01 (1.17-3.46)	19.9	<.001
25.0-29.9 kg/m^2 (overweight)	−0.48	0.27	.08	0.62 (0.36-1.06)		
18.5-24.9 kg/m^2 (healthy weight)	1 [Reference]					
<18.5 kg/m^2 (underweight)	−0.59	0.48	.22	0.56 (0.22-1.41)		
Annual income, $						
<10,000	0.17	0.74	.82	2.63 (0.92-7.51)	21.9	<.01
10,000-14,999	−0.58	0.74	.44	1.22 (0.40-3.69)		
15,000-19,999	−0.81	0.78	.30	0.88 (0.28-2.78)		
20,000-24,999	0.53	0.71	.45	3.41 (1.29-9.03)		
25,000-34,999	0.65	0.61	.28	4.06 (1.46-11.33)		
35,000-49,999	0.75	0.50	.14	2.90 (1.08-7.77)		
50,000-74,999	0.53	0.44	.23	1.90 (0.79-4.58)		
75,000-100,000	0.16	0.50	.75	1.25 (0.46-3.38)		
>100,000	1 [Reference]					
Marital status						
Married	1 [Reference]				21.8	.001
Divorced	1.25	0.39	<.001	3.50 (1.62-7.55)		
Never married	0.07	0.30	.82	1.07 (0.60-1.91)		
Widowed	1.47	0.52	<.01	4.34 (1.56-11.05)		
Unmarried couple	0.97	0.40	.02	2.63 (1.20-5.76)		
Separated	0.59	0.51	.25	1.80 (0.67-4.83)		
Vigorous exercise						
Yes	0.40	0.13	<.01	2.20 (1.35-3.60)	9.9	<.01
No	1 [Reference]					

Abbreviations: SE, standard error; OR, odds ratio; CI, confidence interval; NA, not applicable; BMI, body mass index.
[a] Akaike's information criterion: 7,278,444.
[b] Daily smokers reported smoking daily; former smokers reported smoking ≥100 cigarettes during their lifetimes but had not smoked in the previous 30 days; current smokers reported smoking ≥100 cigarettes during their lifetimes and ≥1 cigarette during the previous 30 days. Current smokers did not include daily smokers.
[c] Nondrinkers reported no alcohol use in the previous month; heavy drinkers reported binge drinking on ≥5 occasions in the previous month; binge drinkers reported having ≥5 drinks on ≥1 occasion (for men) or ≥4 drinks on ≥1 occasion (for women) in the previous month; past-month drinkers reported having ≥1 drink in the previous month. Past-month drinkers did not include binge drinkers, and binge drinkers did not include heavy drinkers.

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Table 3. Odds of Current Depression (Model 4[a]), Taking Into Account the Interaction Term for Smoking by Different Levels of Drinking, 2006 California Behavioral Risk Factor Surveillance System

Extent of Smoking or Drinking[b]	OR	SE	95% CI
Extent of smoking among nondrinkers			
Nonsmoker	1 [Reference]		
Daily	2.89	1.32	1.18-7.07
Former	1.65	0.72	0.70-3.86
Current	1.70	0.93	0.58-4.99
Extent of smoking among past-month drinkers			
Nonsmoker	1 [Reference]		
Daily	1.05	0.53	0.39-2.85
Former	1.55	0.70	0.64-3.74
Current	4.79	2.93	1.44-15.91
Extent of smoking among binge drinkers			
Nonsmoker	1 [Reference]		
Daily	39.50	32.1	8.04-194.00
Former	8.97	8.30	1.46-55.02
Current	5.04	6.03	0.48-52.56
Extent of smoking among heavy drinkers			
Nonsmoker	1 [Reference]		
Daily	14.30	14.43	1.98-103.30
Former	0.24	0.34	0.01-4.14
Current	4.56	5.23	0.48-43.15

Extent of Smoking or Drinking[b]	OR	SE	95% CI
Extent of drinking among nonsmokers			
Nondrinker	1 [Reference]		
Heavy	1.87	1.58	0.36-9.78
Binge	0.16	0.11	0.04-0.62
Past month	0.79	0.33	0.35-1.78
Extent of drinking among former smokers			
Nondrinker	1 [Reference]		
Heavy	1.87	1.58	0.36-9.78
Binge	0.85	0.63	0.20-3.63
Past month	0.79	0.33	0.35-1.78
Extent of drinking among current smokers			
Nondrinker	1 [Reference]		
Heavy	5.02	4.92	0.74-34.20
Binge	0.46	0.50	0.06-3.86
Past month	2.23	1.60	0.55-9.09
Extent of drinking among daily smokers			
Nondrinker	1 [Reference]		
Heavy	9.26	6.89	2.16-39.79
Binge	2.13	1.33	0.62-7.25
Past month	0.29	0.16	0.10-0.84

Abbreviations: OR, odds ratio; SE, standard error; CI, confidence interval.
[a] Akaike's information criterion: 7,091,514.
[b] Daily smokers reported smoking daily; former smokers reported smoking ≥100 cigarettes during their lifetimes but had not smoked in the previous 30 days; current smokers reported smoking ≥100 cigarettes during their lifetimes and ≥1 cigarette during the previous 30 days. Current smokers did not include daily smokers. Nondrinkers reported no alcohol use in the previous month; heavy drinkers reported binge drinking on ≥5 occasions in the previous month; binge drinkers reported having ≥5 drinks on ≥1 occasion (for men) or ≥4 drinks on ≥1 occasion (for women) in the previous month; past-month drinkers reported having ≥1 drink in the previous month. Past-month drinkers did not include binge drinkers, and binge drinkers did not include heavy drinkers.

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TOOLS AND TECHNIQUES

Use of BRFSS Data and GIS Technology for Rapid Public Health Response During Natural Disasters

James B. Holt, PhD, MPA, Ali H. Mokdad, PhD, Earl S. Ford, MD, MPH, Eduardo J. Simoes, MD, MSc, MPH, William P. Bartoli, MS, George A. Mensah, MD

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Abstract

Having information about preexisting chronic diseases and available public health assets is critical to ensuring an adequate public health response to natural disasters and acts of terrorism. We describe a method to derive this information using a combination of data from the Behavioral Risk Factor Surveillance System and geographic information systems (GIS) technology. Our demonstration focuses on counties in states that are within 100 miles of the Gulf of Mexico and the Atlantic Ocean coastlines. To illustrate the flexible nature of planning made possible through the interactive use of a GIS, we use a hypothetical scenario of a hurricane making landfall in Myrtle Beach, South Carolina.

Introduction

The aftermaths of recent natural disasters have highlighted the catastrophic social, economic, and public health impact that these events can have. In December 2004, the Indian Ocean tsunami killed 226,408 people, rendered 1,033,464 homeless, adversely affected an additional 1,356,339, and cost an estimated $7,710,800,000 in damage (1). Between July and October 2005, hurricanes Dennis, Katrina, Rita, and Wilma resulted in the deaths of 1852 people and affected 830,000 more, many of whom became homeless (2).

Although much attention rightly has been given to the immediate safety and acute health needs of these people (3-6), less emphasis has been devoted to the needs, both immediate and long-term, of people with preexisting health conditions. Often, the magnitude of the public health impact is determined by the underlying vulnerabilities of the affected population, including people with chronic diseases, pregnant women, and children, and by the extent of damage to the local public health infrastructure. The public health assets of surrounding communities, which could be used to mitigate damage and provide service to evacuees, also play important roles. Lessons learned from recent disasters suggest that prospective assessment of existing health problems and available resources is essential for effective preparedness and response. Unfortunately, these data are not readily available for most communities at risk.

Hurricane Katrina, which devastated the third most populated metropolitan area on the U.S. Gulf Coast, taught us that this prospective assessment is essential (7). Interruptions in treatment brought on by a disaster increase the risk of death or serious complications for people who require insulin to control their diabetes, for heart attack survivors who take daily clot-preventing medications, for people with severe chronic lung disease who require home oxygen therapy, and for people with kidney failure who are treated with outpatient hemodialysis. Natural disasters often interfere with or totally disrupt the availability of supplemental oxygen supplies. Power outages prevent the use of dialysis and other medical equipment and can exacerbate existing health conditions by preventing the cooling or heating that patients require. Conditions of extreme heat and cold are particularly dangerous for elderly people, pregnant women and their fetuses, neonates, and young children. Lastly, chronic diseases are often aggravated by the lack of food and clean water and the increased levels of physical and mental stress that accompany a disaster (7).

To effectively plan a response to natural disasters, such as hurricanes, floods, and earthquakes, and man-made disasters, such as acts of terrorism, public health officials and first responders need analytic methods to quickly estimate the number of people who will be affected and the subpopulations that are at particular risk. Equally as important is the ability to locate and quantify facilities such as hospitals and schools that are needed during a response. Given the complexity and the sometimes lengthy lead times required for state and local health officials to prepare personnel, facilities, and medical supplies for a public health response, establishing a baseline dataset in advance of a disaster is vital. Preferably, this dataset would be updated frequently and would have the analytic tools needed to model contingencies and develop effective responses, including estimates of the required quantities of essential maintenance medication and treatment for patients with chronic diseases (7).

In the wake of the 2005 hurricanes, Mokdad et al (7) addressed the need for a surveillance tool to support disaster response planning that gives appropriate consideration to people with chronic diseases and other vulnerable populations. Recommendations were that the surveillance tool should have three components: 1) a means of determining the baseline magnitude of the disaster and needs of these vulnerable people, 2) a means of assessing needs and levels of response in an affected area during a disaster, and 3) a means of monitoring the long-term effects of a disaster.

In response to these recommendations, we demonstrate how the Behavioral Risk Factor Surveillance System (BRFSS) and geographic information system (GIS) technology available from Centers for Disease Control and Prevention's (CDC's) National Center for Chronic Disease Prevention and Health Promotion can be combined to meet the need for rapid assessment of subpopulations at risk and to identify available resources in advance of a disaster. We also note the value of the BRFSS in addressing the second and third components of the recommended surveillance tool.

Data and Technology

We used data from the BRFSS (8-11) to estimate the prevalence of health risk factors and chronic diseases, the 2000 U.S. census (Summary Tape File 3 [SF-3] Long Form) (12) to obtain a sociodemographic baseline, and the American Hospital Association Annual Survey Database to quantify hospital resources (13). Environmental Systems Research Institute, Inc (ESRI) provided data on school locations and attributes by collating data from the U.S. Geographic Names Information System and the U.S. Board of Geographical Names, both of which collect and archive data on civic institutions as part of the U.S. Geological Survey's National Map program (14).

The BRFSS, operated by state health departments with assistance from CDC, collects data on many of the behaviors and conditions associated with the leading causes of morbidity and mortality in the United States. Each month, trained interviewers use an independent probability sample of households with telephones to collect data from the noninstitutionalized population aged 18 years or older. A detailed description of the survey methods is available elsewhere (15). All questionnaires are available online (www.cdc.gov/brfss/questionnaires). We used data from the District of Columbia and the 21 states whose land area partially or completely extends to within 100 miles of the Gulf of Mexico and the Atlantic Ocean coastlines. To ensure that each county-level prevalence estimate was based on a combined sample of at least 50 responses, we combined data from survey years 2001, 2003, 2004, and 2005 (N = 904,531).

BRFSS respondents for the years that we used answered questions pertaining to high blood pressure, use of blood pressure medication, high blood cholesterol, heart attack, heart disease, stroke, diabetes, asthma, and pregnancy. From the answers, we estimated the prevalence of these medical conditions for the general population. We used SAS 9.1.3 (SAS Institute Inc, Cary, North Carolina) and the proc surveymeans design statement to account for the complex sampling design of the BRFSS.

GIS technology has been defined in various ways (16,17), but for succinctness we prefer the definition of Lo and Yeung: "a set of computer-based systems for managing geographic data and using these data to solve spatial problems" (18). For our demonstration, we used ArcGIS 9.2 (Environmental Systems Research Institute, Inc, Redlands, California), which enabled us to merge, analyze, and display data and results in one software application. We obtained GIS shapefiles (i.e., geographic boundary files) of U.S. states and counties (hereafter, *counties* refers to counties and county-equivalents: parishes in Louisiana and independent cities in Virginia) from ESRI, and extracted the coastlines of the Atlantic Ocean and the Gulf of Mexico through GIS-assisted manual editing. The resulting coastline shapefile became the baseline from which we constructed 50- and 100-mile buffers. We chose these radii arbitrarily, as reasonably good markers for the differences in area damage that result from hurricanes of various magnitudes.

Assessment Techniques

To estimate the underlying populations at risk within the two buffer zones, we determined which counties the zones comprised. We mapped the population-weighted centroid (center of mass) of the District of Columbia and each county and conducted two spatial joins (a GIS overlay function) between population-weighted centroids and county shapefiles to extract those counties with centroids in both buffer zones (≤50 miles and >50–100 miles from the coastline) (Figure 1). We used population-weighted centroids, which are analogous to centers of gravity, rather than geometric centroids because population-weighted centroids more accurately reflect the spatial distribution and density of county populations.

We imported county sociodemographic data from the 2000 U.S. census (19) into ArcGIS in database format and joined the database to the county shapefile, using county FIPS (Federal Information Processing Standards) codes as the primary join key. The National Institute of Standards and Technology issues a standardized set of numeric codes to ensure uniform identification of geographic entities by all federal government agencies (19,20). These data include variables on total population, age distribution, racial/ethnic distribution, housing units and occupancy status, median housing values, school enrollment by type of school, prevalence of disability by age group, median family income, and prevalence of poverty by age group. We also imported county public health data from the BRFSS into the GIS database. Once the data were joined to the county shapefiles, summary statistics and ratios of the individual variables were computed by area.

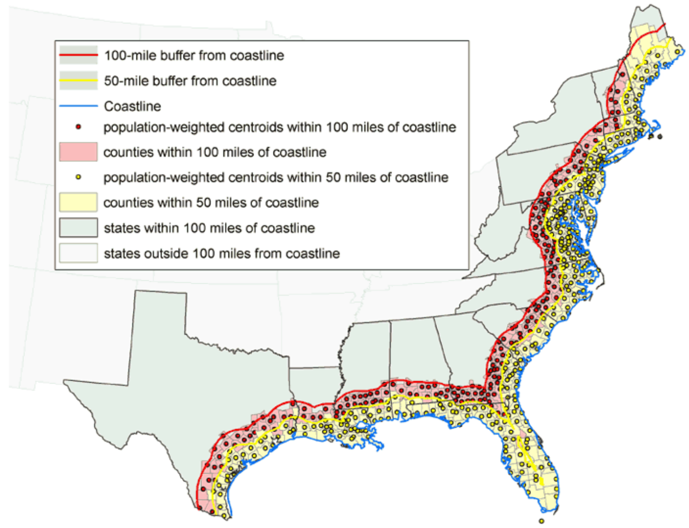

Figure 1. Counties with population-weighted centroids within 50- and 100-mile radius of Gulf of Mexico and Atlantic Ocean coastlines, 2000. Data from U.S. Census Bureau (12).

To demonstrate the usefulness of a GIS in a real-time emergency, we applied the technology to a hypothetical scenario in which a hurricane makes landfall in the vicinity of Myrtle Beach, South Carolina. We created a 100-mile buffer around the point location for the city of Myrtle Beach and used the GIS to extract those counties with population-weighted centroids within this buffer zone (Figure 2). All values for population demographics, people with chronic diseases, and resources for emergency

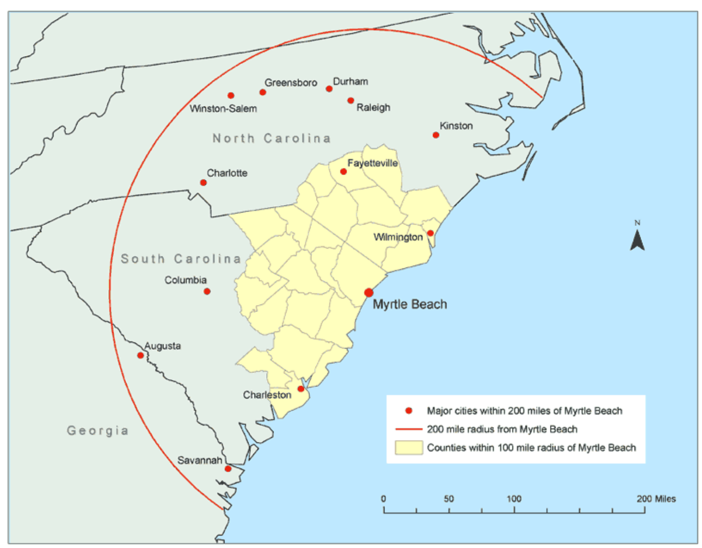

Figure 2. Counties with population-weighted centroids within a 100-mile radius and major cities within a 200-mile radius of Myrtle Beach, South Carolina, 2000. Data from U.S. Census Bureau (12).

response were contained within the extracted county-level geographic records in the GIS.

Sample Assessment

According to the 2000 U.S. census, 139,441,051 people, or approximately 50% of the U.S. population at that time, lived in the total area included in our demonstration (i.e., 21 states and the District of Columbia) (12). Of these people, 66% lived in counties with population-weighted centroids within 100 miles of the Gulf of Mexico and Atlantic Ocean coastlines (57% within ≤50 miles, 9% from >50–100 miles). Note that in our assessment, data for the two coastal buffer zones overlap, so that data for the area in the 100-mile zone include data for the area in the 50-mile zone.

Our assessment shows that approximately 18.2 million people within 100 miles of the coastline were likely to be at particular risk in a disaster because of their age (either <5 years or ≥65 years); approximately 13.8 million, because of being school-aged (i.e., being enrolled in nursery school, kindergarten, or elementary school); and approximately 208,246, because of being inpatients in a hospital (estimated by multiplying the number of hospital beds by a 70% occupancy rate) (Table 1).

Data joined with the GIS provide the number of hospitals, hospital beds, and hospital workers in total and by state for each zone (Table 2) and the estimated number of people with selected medical conditions in total and by state for each zone (Table 3). By combining the information in Tables 2 and 3, health officials can compare the extent of chronic diseases and the availability of response resources in any coastal area. The number of hospitals in a local area varies greatly throughout each coastal zone, as does the number of beds in a single hospital (Figure 3). As would be expected, areas with large populations tend to have access to greater numbers of hospitals and hospital beds, but the ratio of people to hospitals and of people to hospital beds may actually be lower in highly populated urban areas. This reality underscores the importance of establishing baseline data on the at-risk population and the resources available to respond to surges in demand.

For the Myrtle Beach scenario, an estimated 412,364 people would be at particular risk because of their age; 344,105, because of being in nursery, kindergarten, and

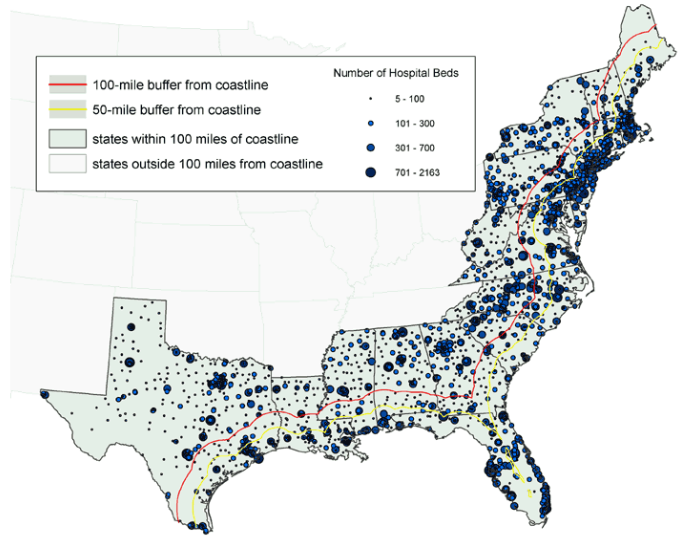

Figure 3. Locations of hospitals, with number of beds per hospital, in states with land area within 100 miles of the coastline. Data from the American Hospital Association (13).

elementary schools; and 4661, because of being inpatients in a hospital (Table 4). Given that 16% of people in the area live in poverty, many of these vulnerable people would have to rely on the government for evacuation.

Flexibility of the BRFSS and GIS

The BRFSS can and has been used to assess needs and levels of response during a disaster and to monitor the long-term effects of a disaster. In response to the unexpected shortfall in the 2004–2005 supply of influenza vaccine, CDC and the Advisory Committee on Immunization Practices (ACIP) recommended prioritizing vaccination for people aged 65 years and older and for others at high risk (21,22). To monitor coverage, the BRFSS added several questions about influenza vaccination, including new questions on priority status and the month and year of vaccination among children and adults (23). Because of the rapid turnaround of BRFSS data, public health officials were able to obtain near–real-time estimates of influenza coverage (24), including county-level estimates based on small-area estimation procedures (25). One study, using data for the New Orleans–Metairie–Kenner, Louisiana, Metropolitan Statistical Area, demonstrated the feasibility of using the BRFSS to estimate baseline information on the number of older adults who may have a disability and thus need assistance in evacuating to shelters or who may need special equipment in the event of a natural disaster (26).

Flexibility is one of the most useful features of a GIS. By altering the planning assumptions that are entered into the GIS, public health officials can conduct analyses quickly and efficiently on any issue for which data are available. Sources could include the National Hospital Ambulatory Medical Care Survey, which has asked questions in the past that may yield data on hospital preparedness for natural disasters and acts of terrorism (27); state-based trauma system registries, which contain data on mass casualties and trauma (28); and CDC's National Center for Health Statistics, which maintains data on the number of live birth deliveries by county, from which estimates can be derived of the number of pregnant women and neonates at a given time. The salient questions for health officials are: What sources of primary data are readily available? To what extent can the surge capacity of identified assets be ascertained reliably? How generalizable are the outputs, and how sensitive are they to the particular type of disaster?

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Author Information

Corresponding Author: James B. Holt, PhD, MPA, Centers for Disease Control and Prevention, 4770 Buford Hwy, NE, MS: K-67, Atlanta, GA 30341. Telephone: 770-488-5510. E-mail: jgh4@cdc.gov.

Author Affiliations: Ali H. Mokdad, Earl S. Ford, Eduardo J. Simoes, George A. Mensah, Centers for Disease Control and Prevention, Atlanta, Georgia. William P. Bartoli, Northrop Grumman Information Technology, Atlanta, Georgia.

References

1. EM-DAT: Emergency Disasters Data Base. Natural disasters: trends and relationships for the period 1900–2005. Brussels (BE): Centre for Research on the Epidemiology of Disasters. http://www em-dat net/disasters/trends.htm#Natural 2006.
2. EM-DAT: Emergency Disasters Data Base. Country profile for natural disasters: United States, 1900–2005. Brussels (BE): Centre for Research on the Epidemiology of Disasters. http://www.em-dat.net/disasters/Visualisation/profiles/natural-table-emdat,php?country=United+States&Submit= Display+Country+Profile 2006.
3. Farmer JC, Carlton PK Jr. Providing critical care during a disaster: the interface between disaster response agencies and hospitals. Crit Care Med 2006;34(3 Suppl):S56-9.
4. Pretto EA Jr, Safar P. National medical response to mass disasters in the United States. Are we prepared? JAMA 1991;266(9):1259-62.
5. Noji EK. Public health issues in disasters. Crit Care Med 2005;33(1 Suppl):S29-33.
6. Noji EK, Toole MJ. The historical development of public health responses to disaster. Disasters 1997;21(4):366-76.
7. Mokdad AH, Mensah GA, Posner SF, Reed E, Simoes EJ, Engelgau MM, and the Chronic Diseases and Vulnerable Populations in Natural Disasters Working Group. When chronic conditions become acute: prevention and control of chronic diseases and adverse health outcomes during natural disasters. Prev Chronic Dis 2005;2(Suppl 1). http://www.cdc.gov/pcd/issues/2005/nov/05_0201.htm.
8. Behavioral Risk Factor Surveillance System: technical information and data. Atlanta (GA): Centers for Disease Control and Prevention; 2001. http://www.cdc.gov/brfss/technical_infodata/surveydata.htm.
9. Behavioral Risk Factor Surveillance System: technical information and data. Atlanta (GA): Centers for Disease Control and Prevention; 2003. http://www.cdc.gov/brfss/technical_infodata/surveydata.htm.
10. Behavioral Risk Factor Surveillance System: technical information and data. Atlanta (GA): Centers for Disease Control and Prevention; 2004. http://www.cdc.gov/brfss/technical_infodata/surveydata.htm.
11. Behavioral Risk Factor Surveillance System: technical information and data. Atlanta (GA): Centers for Disease Control and Prevention; 2005. http://www.cdc.gov/brfss/technical_infodata/surveydata.htm.
12. 2000 census of population and housing, summary tape file 3; using American FactFinder. Washington (DC): U.S. Census Bureau. http://factfinder.census.gov.
13. American Hospital Association; Health Forum, LLC. American Hospital Association annual survey data-

base. Chicaco (IL): American Hospital Association; 2001.
14. United States Geological Survey. The national map. Reston (VA): U.S. Department of the Interior, U.S. Geological Survey. http://nationalmap.gov.
15. Mokdad AH, Stroup DF, Giles WH. Public health surveillance for behavioral risk factors in a changing environment. Recommendations from the Behavioral Risk Factor Surveillance Team. MMWR Recomm Rep 2003;52(RR-9):1-12.
16. Rhind DW. A GIS research agenda. Int J Geographic Information Systems 1988;2:23-8.
17. DeMers MN. Fundamentals of geographic information systems. 2nd ed. New York (NY): John Wiley & Sons, Inc; 2000.
18. Lo CP, Yeung AKW. Concepts and techniques of geographic information systems. Upper Saddle River (NJ): Prentice-Hall, Inc; 2002.
19. Codes for the identification of the states, the District of Columbia and the outlying areas of the United States, and associated areas. FIPS Pub 5-2. Washington (DC): U.S. Department of Commerce, National Institute of Standards and Technology; 1987.
20. Counties and equivalent entities of the United States, its possessions, and associated areas. FIPS Pub 6-4. Washington (DC): U.S. Department of Commerce, National Institute of Standards and Technology; 1991.
21. Centers for Disease Control and Prevention. Updated interim influenza vaccination recommendations, 2004–05 influenza season. MMWR Morb Mortal Wkly Rep 2004;53(50):1183-4.
22. Centers for Disease Control and Prevention. Revised interim guidance for late-season influenza vaccination January 27, 2005. Atlanta (GA): Centers for Disease Control and Prevention; 2005.
23. Link M, Ahluwalia I, Euler G, Bridges C, Chu S, Wortley P. Racial and ethnic disparities in influenza vaccination coverage among adults for the 2004–2005 season. Am J Epidemiol 2006;163(6):571-8.
24. Centers for Disease Control and Prevention. Estimated influenza vaccination coverage among adults and children — United States, September 1 – November 30, 2004. MMWR Morb Mortal Wkly Rep 2004;53(49):1147-53.
25. Jia H, Link M, Holt J, Mokdad AH, Li L, Levy PS. Monitoring county-level vaccination coverage during the 2004–2005 influenza season. Am J Prev Med 2006;31(4):275-80.
26. McGuire LC, Ford ES, Okoro CA. Natural disasters and older U.S. adults with disabilities: implications for evacuation. Disasters 2007;31(1):49-56.
27. Niska RW, Burt CW. Bioterrorism and mass casualty preparedness in hospitals: United States, 2003. Adv Data 2005;(364):1-14.
28. Mann NC, MacKenzie E, Anderson C. Public health preparedness for mass-casualty events: a 2002 state-by-state assessment. Prehosp Disaster Med 2004;19(3):245-55.

Tables

Table 1. Selected At-Risk Populations in Gulf of Mexico and Atlantic Ocean coastal zones, by Distance From the Coastline, United States, 2000[a]

At-Risk Populations	Distance from Coastline[b]		
	≤50 miles, No. of People	≤100 miles, No. of People	>100 miles, No. of People
Old and young	15,807,599	18,204,359	9,049,178
<5 y of age	5,269,967	6,069,337	3,206,434
≥65 y of age	10,537,632	12,135,022	5,842,744
Below poverty level (%)	9,585,589 (12.0)	11,409,425 (12.4)	6,402,990 (13.5)
School-aged population (total)	21,356,614	24,563,563	12,659,167
Nursery school	1,494,064	1,696,568	829,584
Kindergarten	1,149,218	1,328,574	698,459
Elementary school	9,303,221	10,755,108	5,619,833
High school	4,519,507	5,231,149	2,691,489
College	4,890,604	5,552,164	2,819,802
Hospital inpatients[c]	177,787	208,246	117,036

[a] Data are from the U.S. Census Bureau (12) and the American Hospital Association (13).
[b] Measured by population-weighted centroids.
[c] Based on 70% bed occupancy.

Table 2. Number of Hospitals and Hospital Beds and Workers in 21 States and the District of Columbia, by Distance From the Coast, United States, 2000[a]

State or District	Distance From Coastline[b]		
	≤50 Miles, No.	≤100 Miles, No.	>100 Miles, No.
Total			
Hospitals	1,189	1,521	1,161
Hospital Beds	253,891	297,494	167,081
Workers	1,313,786	1,529,468	816,505
Alabama			
Hospitals	15	35	86
Hospital Beds	2,990	4,626	13,328
Workers	11,357	17,640	59,546
Connecticut			
Hospitals	46	47	NA
Hospital Beds	8,862	8,940	NA
Workers	51,430	51,714	NA

NA indicates not applicable.
[a] Data are from the American Hospital Association (13).
[b] Measured by population-weighted centroids.

(Continued on next page)

Table 2. (continued) Number of Hospitals and Hospital Beds and Workers in 21 States and the District of Columbia, by Distance From the Coast, United States, 2000[a]

State or District	Distance From Coastline[b]		
	≤50 Miles, No.	≤100 Miles, No.	>100 Miles, No.
Delaware			
Hospitals	11	11	NA
Hospital Beds	2,237	2,237	NA
Workers	16,332	16,332	NA
District of Columbia			
Hospitals	16	16	NA
Hospital Beds	4,670	4,670	NA
Workers	28,623	28,623	NA
Florida			
Hospitals	209	219	NA
Hospital Beds	48,453	50,419	NA
Workers	224,536	230,866	NA
Georgia			
Hospitals	19	60	116
Hospital Beds	2,597	7,214	18,558
Workers	12,475	35,940	96,033
Louisiana			
Hospitals	102	118	59
Hospital Beds	12,699	14,191	6,229
Workers	59,261	64,342	25,945
Maine			
Hospitals	35	39	3
Hospital Beds	3,420	3,542	164
Workers	22,492	23,242	1,423
Maryland			
Hospitals	67	70	4
Hospital Beds	13,692	14,131	467
Workers	80,081	82,432	2,395
Massachusetts			
Hospitals	92	113	NA
Hospital Beds	19,033	21,758	NA
Workers	122,892	137,682	NA

NA indicates not applicable.
[a] Data are from the American Hospital Association (13).
[b] Measured by population-weighted centroids.

(Continued on next page)

Table 2. (continued) Number of Hospitals and Hospital Beds and Workers in 21 States and the District of Columbia, by Distance From the Coast, United States, 2000[a]

State or District	Distance From Coastline[b]		
	≤50 Miles, No.	≤100 Miles, No.	>100 Miles, No.
Mississippi			
Hospitals	12	27	80
Hospital Beds	1,892	3,622	10,497
Workers	8,598	16,071	38,048
New Hampshire			
Hospitals	18	31	1
Hospital Beds	2,212	3,091	16
Workers	13,447	20,537	100
New Jersey			
Hospitals	94	94	NA
Hospital Beds	27,453	27,453	NA
Workers	122,382	122,382	NA
New York			
Hospitals	130	142	112
Hospital Beds	44,160	46,251	19,863
Workers	239,885	247,274	105,345
North Carolina			
Hospitals	32	58	84
Hospital Beds	5,075	10,063	15,946
Workers	25,086	52,630	88,435
Pennsylvania			
Hospitals	85	135	118
Hospital Beds	18,942	27,242	17,960
Workers	99,945	144,892	96,533
Rhode Island			
Hospitals	16	16	NA
Hospital Beds	3,293	3,293	NA
Workers	17,748	17,748	NA
South Carolina			
Hospitals	24	52	30
Hospital Beds	3,124	7,890	4,155
Workers	16,374	40,408	22,246

NA indicates not applicable.
[a] Data are from the American Hospital Association (13).
[b] Measured by population-weighted centroids.

(Continued on next page)

Table 2. (continued) Number of Hospitals and Hospital Beds and Workers in 21 States and the District of Columbia, by Distance From the Coast, United States, 2000[a]

State or District	Distance From Coastline[b]		
	≤50 Miles, No.	≤100 Miles, No.	>100 Miles, No.
Texas			
Hospitals	104	150	360
Hospital Beds	17,666	21,557	45,585
Workers	87,908	104,928	212,164
Vermont			
Hospitals	NA	6	11
Hospital Beds	NA	376	1,214
Workers	NA	1,933	9,572
Virginia			
Hospitals	62	77	37
Hospital Beds	11,421	14,142	6,223
Workers	52,934	68,159	24,508
West Virginia			
Hospitals	NA	5	60
Hospital Beds	NA	786	6,876
Workers	NA	3,693	34,212

NA indicates not applicable.[a] Data are from the American Hospital Association (13).
[b] Measured by population-weighted centroids.

Table 3. Estimated Numbers of People With Selected Medical Conditions in 21 states and the District of Columbia, by Proximity to the Gulf of Mexico and Atlantic Ocean Coastlines[a]

State, District	Distance From Coastline[b]	
	≤50 Miles	≤100 Miles
Total		
High blood pressure	2,181,000	2,639,000
Taking blood pressure medication	1,271,000	1,532,000
High blood cholesterol	2,120,000	2,740,000
Heart attack	2,328,000	2,787,000
Heart disease	2,577,000	3,067,000
Stroke	1,489,000	1,773,000
Diabetes	662,000	801,000
Asthma	998,000	1,177,000
Pregnancy	113,000	130,000

NA indicates not applicable.
[a] Data are from the Behavioral Risk Factor Surveillance System (8-11).
[b] Measured by population-weighted centroids.

(Continued on next page)

Table 3. (continued) Estimated Numbers of People With Selected Medical Conditions in 21 states and the District of Columbia, by Proximity to the Gulf of Mexico and Atlantic Ocean Coastlines[a]

State, District	Distance From Coastline[b]	
	≤50 Miles	≤100 Miles
Alabama		
High blood pressure	19,000	32,000
Taking blood pressure medication	13,000	23,000
High blood cholesterol	15,000	28,000
Heart attack	26,000	41,000
Heart disease	15,000	29,000
Stroke	11,000	24,000
Diabetes	5,000	10,000
Asthma	7,000	11,000
Pregnancy	1,000	2,000
Connecticut		
High blood pressure	67,000	67,000
Taking blood pressure medication	48,000	48,000
High blood cholesterol	68,000	68,000
Heart attack	87,000	87,000
Heart disease	113,000	113,000
Stroke	44,000	44,000
Diabetes	21,000	21,000
Asthma	40,000	40,000
Pregnancy	4,000	4,000
Delaware		
High blood pressure	21,000	21,000
Taking blood pressure medication	14,000	14,000
High blood cholesterol	19,000	19,000
Heart attack	28,000	28,000
Heart disease	31,000	31,000
Stroke	17,000	17,000
Diabetes	5,000	5,000
Asthma	8,000	8,000
Pregnancy	1,000	1,000
District of Columbia		
High blood pressure	15,000	15,000
Taking blood pressure medication	11,000	11,000

NA indicates not applicable.
[a] Data are from the Behavioral Risk Factor Surveillance System (8-11).
[b] Measured by population-weighted centroids.

(Continued on next page)

Table 3. (continued) Estimated Numbers of People With Selected Medical Conditions in 21 states and the District of Columbia, by Proximity to the Gulf of Mexico and Atlantic Ocean Coastlines[a]

State, District	Distance From Coastline[b]	
	≤50 Miles	≤100 Miles
District of Columbia (continued)		
High blood cholesterol	18,000	18,000
Heart attack	13,000	13,000
Heart disease	13,000	13,000
Stroke	14,000	14,000
Diabetes	6,000	6,000
Asthma	11,000	11,000
Pregnancy	1,000	1,000
Florida		
High blood pressure	494,000	505,000
Taking blood pressure medication	289,000	295,000
High blood cholesterol	412,000	431,000
Heart attack	653,000	676,000
Heart disease	718,000	744,000
Stroke	393,000	403,000
Diabetes	172,000	178,000
Asthma	229,000	238,000
Pregnancy	29,000	29,000
Georgia		
High blood pressure	28,000	59,000
Taking blood pressure medication	13,000	32,000
High blood cholesterol	17,000	48,000
Heart attack	21,000	56,000
Heart disease	22,000	46,000
Stroke	18,000	47,000
Diabetes	7,000	16,000
Asthma	9,000	20,000
Pregnancy	1,000	2,000
Louisiana		
High blood pressure	67,000	75,000
Taking blood pressure medication	47,000	54,000
High blood cholesterol	52,000	57,000
Heart attack	80,000	85,000

NA indicates not applicable.
[a] Data are from the Behavioral Risk Factor Surveillance System (8-11).
[b] Measured by population-weighted centroids.

(Continued on next page)

Table 3. (continued) Estimated Numbers of People With Selected Medical Conditions in 21 states and the District of Columbia, by Proximity to the Gulf of Mexico and Atlantic Ocean Coastlines[a]

State, District	Distance From Coastline[b]	
	≤50 Miles	≤100 Miles
Louisiana (continued)		
Heart disease	91,000	101,000
Stroke	55,000	60,000
Diabetes	29,000	32,000
Asthma	35,000	38,000
Pregnancy	3,000	3,000
Maine		
High blood pressure	39,000	39,000
Taking blood pressure medication	19,000	19,000
High blood cholesterol	36,000	36,000
Heart attack	42,000	42,000
Heart disease	39,000	39,000
Stroke	22,000	22,000
Diabetes	12,000	12,000
Asthma	22,000	22,000
Pregnancy	2,000	2,000
Maryland		
High blood pressure	153,000	163,000
Taking blood pressure medication	98,000	103,000
High blood cholesterol	188,000	192,000
Heart attack	169,000	174,000
Heart disease	168,000	174,000
Stroke	98,000	101,000
Diabetes	54,000	55,000
Asthma	93,000	95,000
Pregnancy	10,000	10,000
Massachusetts		
High blood pressure	120,000	146,000
Taking blood pressure medication	73,000	91,000
High blood cholesterol	116,000	140,000
Heart attack	155,000	203,000
Heart disease	151,000	193,000
Stroke	83,000	106,000

NA indicates not applicable.
[a] Data are from the Behavioral Risk Factor Surveillance System (8-11).
[b] Measured by population-weighted centroids.

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Table 3. (continued) Estimated Numbers of People With Selected Medical Conditions in 21 states and the District of Columbia, by Proximity to the Gulf of Mexico and Atlantic Ocean Coastlines[a]

State, District	Distance From Coastline[b]	
	≤50 Miles	≤100 Miles
Massachusetts (continued)		
Diabetes	33,000	41,000
Asthma	73,000	88,000
Pregnancy	6,000	7,000
Mississippi		
High blood pressure	9,000	27,000
Taking blood pressure medication	7,000	17,000
High blood cholesterol	12,000	23,000
Heart attack	13,000	36,000
Heart disease	14,000	39,000
Stroke	12,000	24,000
Diabetes	4,000	10,000
Asthma	5,000	10,000
Pregnancy	1,000	2,000
New Hampshire		
High blood pressure	18,000	22,000
Taking blood pressure medication	11,000	15,000
High blood cholesterol	27,000	35,000
Heart attack	29,000	36,000
Heart disease	35,000	43,000
Stroke	17,000	23,000
Diabetes	7,000	9,000
Asthma	11,000	15,000
Pregnancy	1,000	1,000
New Jersey		
High blood pressure	244,000	244,000
Taking blood pressure medication	148,000	148,000
High blood cholesterol	288,000	288,000
Heart attack	233,000	233,000
Heart disease	282,000	282,000
Stroke	139,000	139,000
Diabetes	64,000	64,000
Asthma	91,000	91,000

NA indicates not applicable.
[a] Data are from the Behavioral Risk Factor Surveillance System (8-11).
[b] Measured by population-weighted centroids.

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Table 3. (continued) Estimated Numbers of People With Selected Medical Conditions in 21 states and the District of Columbia, by Proximity to the Gulf of Mexico and Atlantic Ocean Coastlines[a]

State, District	Distance From Coastline[b]	
	≤50 Miles	≤100 Miles
New Jersey (continued)		
Pregnancy	10,000	10,000
New York		
High blood pressure	267,000	283,000
Taking blood pressure medication	152,000	165,000
High blood cholesterol	346,000	361,000
Heart attack	254,000	266,000
Heart disease	292,000	314,000
Stroke	201,000	207,000
Diabetes	83,000	87,000
Asthma	132,000	140,000
Pregnancy	19,000	19,000
North Carolina		
High blood pressure	81,000	130,000
Taking blood pressure medication	39,000	68,000
High blood cholesterol	58,000	120,000
Heart attack	61,000	110,000
Heart disease	59,000	114,000
Stroke	41,000	79,000
Diabetes	22,000	42,000
Asthma	25,000	52,000
Pregnancy	3,000	7,000
Pennsylvania		
High blood pressure	225,000	357,000
Taking blood pressure medication	102,000	166,000
High blood cholesterol	152,000	456,000
Heart attack	119,000	224,000
Heart disease	138,000	247,000
Stroke	82,000	134,000
Diabetes	48,000	84,000
Asthma	82,000	129,000
Pregnancy	7,000	10,000

NA indicates not applicable.
[a] Data are from the Behavioral Risk Factor Surveillance System (8-11).
[b] Measured by population-weighted centroids.

(Continued on next page)

Table 3. (continued) Estimated Numbers of People With Selected Medical Conditions in 21 states and the District of Columbia, by Proximity to the Gulf of Mexico and Atlantic Ocean Coastlines[a]

State, District	Distance From Coastline[b]	
	≤50 Miles	≤100 Miles
Rhode Island		
High blood pressure	23,000	23,000
Taking blood pressure medication	17,000	17,000
High blood cholesterol	26,000	26,000
Heart attack	27,000	27,000
Heart disease	31,000	31,000
Stroke	15,000	15,000
Diabetes	7,000	7,000
Asthma	13,000	13,000
Pregnancy	1,000	1,000
South Carolina		
High blood pressure	61,000	100,000
Taking blood pressure medication	28,000	53,000
High blood cholesterol	42,000	88,000
Heart attack	42,000	86,000
Heart disease	37,000	77,000
Stroke	30,000	62,000
Diabetes	13,000	27,000
Asthma	13,000	28,000
Pregnancy	2,000	4,000
Texas		
High blood pressure	99,000	149,000
Taking blood pressure medication	65,000	93,000
High blood cholesterol	93,000	134,000
Heart attack	146,000	201,000
Heart disease	157,000	216,000
Stroke	102,000	135,000
Diabetes	38,000	51,000
Asthma	44,000	59,000
Pregnancy	6,000	7,000
Vermont		
High blood pressure	NA	5,000
Taking blood pressure medication	NA	2,000

NA indicates not applicable.
[a] Data are from the Behavioral Risk Factor Surveillance System (8-11).
[b] Measured by population-weighted centroids.

(Continued on next page)

Table 3. (continued) Estimated Numbers of People With Selected Medical Conditions in 21 states and the District of Columbia, by Proximity to the Gulf of Mexico and Atlantic Ocean Coastlines[a]

State, District	Distance From Coastline[b]	
	≤50 Miles	≤100 Miles
Vermont (continued)		
High blood cholesterol	NA	4,000
Heart attack	NA	4,000
Heart disease	NA	4,000
Stroke	NA	2,000
Diabetes	NA	1,000
Asthma	NA	2,000
Pregnancy	NA	1,000
Virginia		
High blood pressure	131,000	172,000
Taking blood pressure medication	77,000	95,000
High blood cholesterol	135,000	163,000
Heart attack	130,000	154,000
Heart disease	171,000	207,000
Stroke	95,000	113,000
Diabetes	32,000	41,000
Asthma	55,000	65,000
Pregnancy	5,000	6,000
West Virginia		
High blood pressure	NA	5,000
Taking blood pressure medication	NA	3,000
High blood cholesterol	NA	5,000
Heart attack	NA	5,000
Heart disease	NA	10,000
Stroke	NA	2,000
Diabetes	NA	2,000
Asthma	NA	2,000
Pregnancy	NA	1,000

NA indicates not applicable.
[a] Data are from the Behavioral Risk Factor Surveillance System (8-11).
[b] Measured by population-weighted centroids.

Table 4. Selected At-Risk Populations and Available Resources Within 100-mile Radius of Myrtle Beach, South Carolina[a]

Community Characteristics	No. ≤100 Miles From Coastline[b]
At-Risk Populations	
Total population	2,244,538
<5 y of age	153,529
≥65 y of age	258,835
Below poverty level (%)	359,126 (16.0)
School-aged children (total)	597,453
Nursery school	39,054
Kindergarten	34,130
Elementary school	270,921
High school	131,082
College	122,266
High-risk adults	443,000
High blood pressure	94,000
Taking blood pressure medication	20,000
High blood cholesterol	76,000
Heart attack	73,000
Heart disease	69,000
Stroke	51,000
Diabetes	28,000
Asthma	30,000
Pregnant	2,000
Available resources	
Schools	1,067
Hospitals	43
Hospital beds	6,658
Hospitalizations (70% bed occupancy)	4,661
Hospital workers	38,118

[a] Data are from the Behavioral Risk Factor Surveillance System (8-11), the U.S. Census Bureau (12), and the American Hospital Association (13).
[b] Measured by population-weighted centroids.

Preventing Chronic Disease
4770 Buford Hwy, NE
Mailstop, K-85
Atlanta, GA 30341-3717
pcdeditor@cdc.gov