PREVENTING CHRONIC DISEASE

PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY

PCD Collection:
Eliminating Health Disparities

A Collection of Papers Dedicated to the Life and Work of Dr. Timothy Cunningham

Contents

Eliminating Health Disparities: A Collection of Papers Dedicated to the Life and Work of Dr. Timothy Cunningham

PCD is fortunate to have some of the most talented, well-trained, and insightful public health professionals working closely with us to achieve our mission and vision. Dr. Timothy (Tim) Cunningham, ScD, SM, was one of those gifted individuals. He was appointed Associate Editor in June of 2017, and during his tenure he provided exemplary scientific review and oversight of manuscripts on many important research and evaluation topic areas, including randomized trials of behavioral interventions; epidemiological studies examining the influence of social determinants of health on health outcomes among racial/ethnic groups; the application of survey methods to assess effectiveness of local interventions; and public health approaches to mediating the effect of food insecurity among vulnerable populations.

Dr. Cunningham was masterful at providing both novice and seasoned researchers with accurate and detailed feedback that greatly improved the quality of research submitted to PCD. He assisted researchers with developing and refining research topics; identifying and addressing research bias; critically examining the quality of data and determining its fit for reported use; assessing the quality of statistical analyses; and communicating in writing to convey complex information in user-friendly ways. Dr. Cunningham brought his rich research experience to every article assigned to him as Associate Editor, and he had a thirst for knowledge that encouraged authors to move past the familiar to make a stronger case for publication in our journal. He strongly encouraged authors to challenge their work by sharing not only the strengths but also the limitations of their research. Dr. Cunningham was a tremendous asset to PCD in so many ways. He was a vital member of our team of Associate Editors and brought an impressive blend of expertise to the journal.

Dr. Cunningham understood and shared the journal's commitment to serving the public, and his contributions helped us to fulfill our mission of disseminating proven and promising public health findings, innovations, and practices. In honor of Dr. Cunningham's illustrious career and in appreciation for his many contributions to the journal, this collection is dedicated in memory of his career as a social epidemiologist, published author, and esteemed PCD Associate Editor.

PREVENTING CHRONIC DISEASE
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EDITOR IN CHIEF'S COLUMN

Advancing Health Disparities Research in Population Health

Leonard Jack Jr, PhD, MSc

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Leonard Jack Jr, PhD, MSc

The mission of *Preventing Chronic Disease* (PCD) is to promote dialogue among researchers, practitioners, and policy makers worldwide on the integration and application of research findings and practical experience to improve population health (1). Published by the Centers for Disease Control and Prevention (CDC), PCD is a peer-reviewed journal respected for its integrity and relevance to chronic disease prevention and whose articles are authored by experts worldwide. PCD is committed to publishing content that elucidates worldwide understanding of health disparities and determinants linked to disparate health outcomes. Toward that end, PCD was fortunate to have had the expertise of Dr Tim Cunningham as an associate editor. Until his untimely passing (2), Dr Cunningham provided exemplary review and oversight of manuscripts related to social determinants of health and health disparities. Through his efforts, PCD published critical research on this important topic. In honor of Dr Cunningham's career and in appreciation for his service to the journal, PCD is dedicating to his memory this special collection of articles on effective and innovative ways to address causes of disparities from a multifactorial perspective.

Healthy People 2020 defines health disparities as "a particular type of health difference that is closely linked with social, economic, and/or environmental disadvantage" (3). As part of its mission, PCD has published papers identifying the effect of behavioral, psychological, genetic, environmental, biological, and social factors on health outcomes. PCD has also sought out research on the effectiveness of interventions addressing these factors, with the focus on reducing the disproportionate burden of chronic diseases among at-risk populations. This collection features 9 articles that address this topic from multiple perspectives:

1. The influence of implementation factors on the efficacy of school-based behavioral change interventions in low-income schools;
2. The economic factors linked to food insecurity and dietary consumption on obesity among diverse populations;
3. The relationships between consuming nuts, obesity-related foods, and body mass index among overweight and obese African American women in a rural setting;
4. The differences in health care services for diabetes care between men and women;
5. The influence of income, employment status, and education level on the prevalence of chronic disease among American Indian/Alaska Natives;
6. The contribution of falls and fall-related injuries to injury and death among older adults with chronic kidney disease;
7. The influence of sedentary behavior and the use of electronic screen devices among Mexican-origin children;
8. The creation of a diabetic retinopathy screening tool for a low-income population; and

9. The building of chronic disease epidemiology, surveillance, and evaluation in state and local health departments.

Childhood obesity continues to be a national concern, especially among low-income households (4). Blaine and colleagues described efforts to implement the “Eat Well and Keep Moving” and “Planet Health” behavioral change interventions as part of the Massachusetts Childhood Obesity Research Demonstration (MA-CORD) project in 2 school districts facing resource limitations and competing priorities (5). Researchers shared important insights on the role that key implementation outcomes such as fidelity, cost, reach, and sustainability played in school participation and sustainability of intervention activities.

The effect of short-term and long-term economic strain on the health and well-being of individuals and families is well established in published literature (6). Economic factors have been linked to food insecurity and obesity across the life stages (7). Using a spatial-based approach, Kim and colleagues identified new insights into the relationship between county-level income inequality, poverty, and obesity prevalence across New York State (8). Researchers found that higher income inequality was associated with lower obesity rates and that higher percentages of poverty were associated with higher obesity rates.

High obesity rates among African Americans continue to be a tremendous public health concern (9). High obesity rates have been linked to numerous factors, including biology, dietary consumption, population characteristics, access to care, socioeconomic status, and environment (10). Sterling and coauthors conducted research that monitored and analyzed changes in nut intake, other obesity-related foods (red or processed meats, added sugars), and body mass index during a 2-year weight loss intervention (11). The weight loss intervention targeted 383 overweight and obese African American women living in rural Alabama and Mississippi. Researchers found that nut consumers had a lower body mass index than non-nut eaters. Even after accounting for kilocalorie consumption and physical activity engagement, weight loss by the end of the intervention was significant among nut consumers but not among non-nut consumers. Researchers found that intervention results were linked to nut consumers consuming less red meat than non-nut consumers and greater amounts of other nutritionally rich foods, such as fruits and vegetables.

The existence of disparities in the use of health care services by men and women has been the subject of increased empirical study in recent years (12,13). Mesa observed 100 patients with type 2 diabetes aged 45 or older who lived in Ventura County, California, to compare differences in health care services (hemoglobin A_{1c} test, cholesterol test, and retina examination) between men and women (14). During 1 year, although men and women had access to similar health care services for diabetes, men had higher hemoglobin A_{1c} levels and lower rates of showing up for appointments. Findings from this study provide evidence that continued efforts are needed to identify motivating factors to increase appointment scheduling and attendance among men.

Chronic diseases such as heart disease, diabetes, kidney disease, and chronic lower respiratory disease disproportionately affect American Indians/Alaska Native populations, resulting in low life expectancy (15). Adamsen and colleagues conducted a national survey to measure the influence of income, employment status, and education level on the prevalence of chronic disease in a sample of 14,632 American Indians/Alaska Natives from 2011 through 2014 (16). Researchers found that most (89.7%) study participants were diagnosed with at least 1 chronic disease. American Indians/Alaska Natives with middle-to-low income levels and those who were unemployed were more likely to have received a diagnosis of a chronic disease. The authors discussed how economic development and job creation may decrease the prevalence of chronic disease in tribal communities.

Falls and fall-related injuries are the leading cause of injury and death among adults aged 65 or older (17), especially among those with chronic kidney disease (18). Kistler and colleagues performed a secondary analysis of 157,753 adults aged 65 or older in the 2014 Behavioral Risk Factor Surveillance System (19). Researchers found that adults aged 65 or older with chronic kidney disease were at increased risk of falling compared with adults in the same age range without chronic kidney disease. Researchers also found that modifiable factors such as physical function and recent exercise were most closely related to reduced risk and could be an appropriate target for fall prevention and rehabilitation programs.

Diverse factors, including family history, behavior, dietary habits, and environmental characteristics, simultaneously influence obesity among children in the United States (20). McDonald and her team of researchers examined sedentary behavior and the use of electronic screen devices among low-income Mexican-origin children aged 6 to 10 years living in rural communities near the US–Mexico border (21). Through interviews of 202 parents, researchers found that increased odds of heavy screen use were associated with having a television on while children ate. Parents reported that children also had access to electronic devices, social media, and the internet. Consistent with previously published research, this research affirmed the need to reduce screen time among children, particularly those at high risk for obesity.

Diabetes is a major public health crisis in Mexico, with mortality rates among the highest in the world (22). Diabetes is associated with complications, such as diabetic retinopathy, that impede quality of life among patients (23). Last year's PCD Student Research Paper Contest winner in the graduate (master's degree) category, authored by Mendoza-Herrera and colleagues, presented research results on a tool they developed to screen for diabetic retinopathy in a low-income population (24). These researchers developed the screening tool after analyzing biochemical, clinical, anthropometric, and sociodemographic information on 1,000 adults living with diabetes in low-income communities in Mexico. They developed a low-cost and easy-to-use screening tool that accounted for risk factors for diabetic retinopathy such as time since diabetes diagnosis, high blood glucose levels, systolic hypertension, and physical inactivity.

And finally in this collection, PCD examined the unique position of public health workers in state and local health departments to address social determinants of health, health inequities, and population health improvements across a range of chronic conditions in the United States (25). Calanan and colleagues described the efforts of CDC's State Chronic Disease Epidemiology Assignee Program, a national program designed to build state and local chronic disease epidemiology, surveillance, and evaluation capacity by placing CDC field assignees in state and local health departments (26). The authors discussed how these assignees provide assistance in critical areas including conducting epidemiologic studies, building surveillance systems, evaluating chronic disease prevention and control programs, analyzing data, and training entry-level and mid-level chronic disease epidemiologists.

The articles selected for this collection demonstrate PCD's commitment to publishing cutting-edge research for researchers, practitioners, and policy makers to better understand the multifactorial causes of health disparities, so they can develop the most effective strategies for improving health outcomes. Findings across research shared in this collection highlight the importance of employing effective interventions that address both individual and contextual factors (27). In dedicating this special collection to Dr Cunningham for his career as a social epidemiologist, published author, and esteemed PCD associate editor, we honor the excellent work that has been accomplished so far and promise to continue identifying and publishing health disparities research that increases the public health field's understanding of what actions to take. Authors are encouraged to visit the Author's Corner section of the journal's website at https://www.cdc.gov/pcd/for_authors/index.htm to learn more about article types that best fit their research addressing population-based approaches to ameliorate health disparities.

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ORIGINAL RESEARCH

Using School Staff Members to Implement a Childhood Obesity Prevention Intervention in Low-Income School Districts: the Massachusetts Childhood Obesity Research Demonstration (MA-CORD Project), 2012–2014

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PEER REVIEWED

Abstract

Introduction
Although evidence-based interventions to prevent childhood obesity in school settings exist, few studies have identified factors that enhance school districts' capacity to undertake such efforts. We describe the implementation of a school-based intervention using classroom lessons based on existing "Eat Well and Keep Moving" and "Planet Health" behavior change interventions and schoolwide activities to target 5,144 children in 4th through 7th grade in 2 low-income school districts

Methods
The intervention was part of the Massachusetts Childhood Obesity Research Demonstration (MA-CORD) project, a multisector community-based intervention implemented from 2012 through 2014. Using mixed methods, we operationalized key implementation outcomes, including acceptability, adoption, appropriateness, feasibility, implementation fidelity, perceived implementation cost, reach, and sustainability.

Results
MA-CORD was adopted in 2 school districts that were facing resource limitations and competing priorities. Although strong leadership support existed in both communities at baseline, one district's staff reported less schoolwide readiness and commitment. Consequently, fewer teachers reported engaging in training, teaching lessons, or planning to sustain the lessons after MA-CORD. Interviews showed that principal and superintendent turnover, statewide testing, and teacher burnout limited implementation; passionate wellness champions in schools appeared to offset implementation barriers.

Conclusion
Future interventions should assess adoption readiness at both leadership and staff levels, offer curriculum training sessions during school hours, use school nurses or health teachers as wellness champions to support teachers, and offer incentives such as staff stipends or play equipment to encourage school participation and sustained intervention activities.

Introduction

Childhood obesity threatens the health of American children, especially those in low-income households (1,2). Although evidence supports the efficacy of school-based interventions in reducing obesogenic behaviors and body mass index (BMI) among children (3–6), limited data describe school districts' capacity to undertake such interventions (7). In 2011, the Centers for Disease Control and Prevention funded 4 grantees to conduct a 4-year Childhood Obesity Research Demonstration (CORD) project aimed at improving low-income children's nutrition and physical activity behaviors. This study describes the implementation of a school-based obesity prevention intervention within the Massachusetts CORD project (MA-CORD) in 2 low-income school districts (8). Using a mixed methods design, we assessed facilitators and barriers to achieving implementation outcomes adapted from the taxonomy of Proctor et al (9). We hypothesized that a classroom-based health behavior intervention for 4th through 7th grade students would be most effective when the school staff felt activities were appropriate, feasible, and supported by district administrators.

Examining implementation outcomes (eg, extent to which an intervention is adopted by teachers) provides context for intervention outcomes (eg, change in children's BMI) and is needed to ensure that interventions are effectively adopted, translated, and sustained in community settings. Implementation outcomes can also serve as proximal indicators of intervention outcomes, which are described elsewhere (10). We provide an overview of MA-CORD adoption, implementation, and potential to be sustained, along with a summary of strategies for remediating implementation barriers.

Methods

MA-CORD was a multilevel, multisector intervention to prevent or control obesity among children aged 2 to 12 years in 2 low-income communities (mean annual per capita income <$35,000) in Massachusetts with greater-than-average prevalence of childhood obesity (combined mean, 26%) relative to national estimates (17%) (10). Community 1's population of approximately 40,000, and Community 2's population of approximately 95,000 each has a single school district. MA-CORD was implemented from 2012 through 2014 across 6 sectors (health care; early childhood care and education; school; afterschool; Women, Infants, and Children [WIC]; and the broad community). MA-CORD targeted obesity-related behaviors: fruit and vegetable consumption, sugar-sweetened beverage consumption, physical inactivity, screen time, and insufficient sleep duration and quality. Detailed information on MA-CORD intervention components is published elsewhere (8,10).

The MA-CORD school intervention consisted of evidence-based components: teacher training, curriculum delivery, use of wellness champions (eg, school nurses, teachers), provision of physical activity supplies (eg, balls, jump ropes), and educational materials (eg, flyers, banners). Each district used one part-time, paid coordinator to oversee administration of MA-CORD. Wellness champions were identified at baseline in each school and compensated $1,000 per academic year to lead school-wide wellness activities (eg, improved policies, fun runs, student media competitions) that reinforced MA-CORD messages and classroom interventions. School nurses received $500 per academic year to support MA-CORD data collection and wellness activities.

We focused on the role of teachers in administering adapted versions of evidence-based interventions designed for students in 4th and 5th grade elementary school (*Eat Well and Keep Moving*) and 6th and 7th grade middle school (*Planet Health*) (3,4). In year 1, teachers received a 3-hour training that introduced curricula materials to be integrated across major subjects (ie, math, language arts, and social studies). In Community 1, teachers were trained during school hours, and MA-CORD funds supplied substitute teachers for the time. In Community 2, teachers were trained after school hours and compensated $100. Teachers were encouraged to incorporate at least 6 lesson plans aligned with MA-CORD behavioral targets per academic year. In lieu of training all classroom teachers, Community 1 administrators opted to train health education teachers exclusively to implement the lessons across grades 4 through 7. Because each health teacher taught multiple classes across grades, this meant fewer teachers required training. In Community 2, both classroom teachers (grades 4 and 5) and health teachers (grades 6 and 7) received training.

We employed a convergent, parallel mixed-methods design (11) to examine facilitators and barriers to implementing MA-CORD. Informed by the taxonomy of Proctor et al of outcomes for implementation research (9), outcomes included were acceptability, adoption, appropriateness, feasibility, implementation fidelity, perceived implementation cost, reach, and sustainability. Throughout the intervention we collected data from school staff members using both qualitative methods (ie, in-depth interviews) and quantitative methods (eg, cross-sectional surveys) to assess these outcomes (Figure 1). Our design was ideally suited for process evaluation because interview findings provided context for outcomes not easily explained through survey data alone.

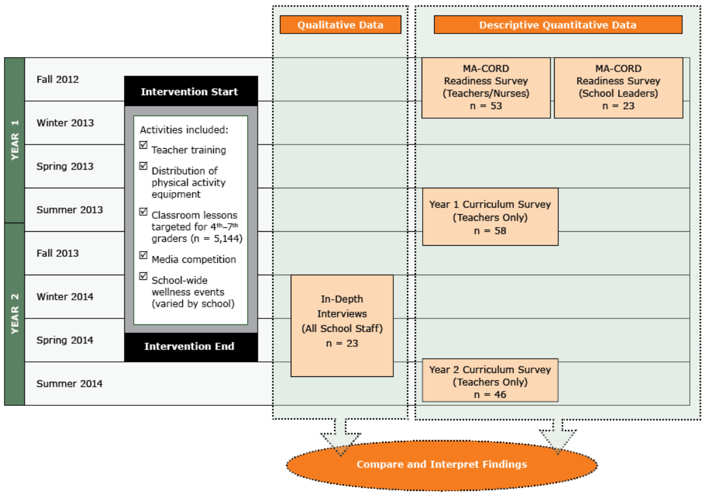

Figure 1. MA-CORD school sector implementation data used in a convergent parallel mixed methods design. The MA-CORD intervention occurred over a 2-year period and was evaluated using both quantitative and qualitative measures.

For both in-depth interviews and readiness surveys we used a convenience sample of school leaders (eg, principals, community coordinators, wellness champions) and staff members (eg, teachers, school nurses) in MA-CORD schools in Community 1 (n = 6) and Community 2 (n = 22). End-of-year curriculum surveys were collected from eligible teachers. The number of eligible teachers varied slightly by year in Community 1 (n = 7 in year 1; n = 6 in year 2) and Community 2 (n = 117 in year 1; n = 122 in year 2). Interviewees from each community were principals and superintendents (n = 5), wellness champions and school nurses (n = 11), and teachers eligible to offer the curricula (n = 7).

Two anonymous surveys were administered at baseline to assess stakeholder readiness for implementing MA-CORD (Figure 1). In addition, 2 anonymous surveys were administered to teachers at the end of each academic year to assess the delivery of the MA-CORD intervention. These surveys were administered online via Qualtrics Insight (Qualtrics) or pen-to-paper (Appendix A, Appendix B). In-depth interviews were conducted by telephone with school leaders and staff members in year 2 to assess implementation of MA-CORD activities. Study procedures were approved by the human subjects committees of the Massachusetts Department of Public Health, Harvard T.H. Chan School of Public Health, Massachusetts General Hospital, and Harvard Pilgrim Health Care Institute in June 2012 (#331765).

Measures

Readiness surveys. Two measures of organizational readiness for change were used to measure program acceptability. The first, provided to school leaders, contained items adapted from an existing tool (12) and assessed school and district readiness for adoption and leadership support for MA-CORD. The second survey given to school staff (eg, teachers, nurses) contained items adapted from an existing readiness-for-change scale for employees within an organization (13,14) to assess staff engagement and support for MA-CORD.

Curriculum surveys. Curriculum surveys collected at the end of years 1 and 2 assessed appropriateness (eg, lessons perceived as positive addition to curriculum), feasibility, perceived implementation cost (eg, perceived competence to teach curriculum, perceived effort to obtain materials to complete lessons), implementation fidelity (eg, proportion of MA-CORD lessons taught), and sustainability (eg, plans to continue offering the lessons in the following year).

In-depth interviews. Using semi-structured interview guides, participants were asked about appropriateness of MA-CORD, barriers and facilitators to adoption, implementation fidelity, perceived intervention cost, and changes in activities over time. To examine sustainability of MA-CORD activities, participants were also asked about intervention reach based on links to activities in their school and community.

Internal records. For each community, we obtained a census roll of superintendents, principals, school nurses, school coordinators, wellness champions, and eligible teachers. These records were updated regularly on the basis of reports from internal research group meetings (eg, staff layoffs, medical leave) or delays in intervention activities (eg, snow days). Sign-in sheets indicated the number of teachers who completed the MA-CORD curriculum training.

Data analysis

We used SAS 9.3 (SAS Institute) to generate descriptive statistics including means, standard deviations, and frequencies for survey and internal record data. Interviews were digitally recorded, transcribed verbatim, and analyzed using NVivo 10 (QSR International). A coding scheme was developed based on a conceptual framework (9) and piloted with 5 transcripts among 3 coders to ensure internal consistency (Appendix C). Transcripts were double coded using the constant comparative method (15) to identify emergent themes, and discrepancies were discussed through peer review to clarify coded passages and resulting themes. Finalized themes within implementation outcome categories were coded and summarized within and across both MA-CORD communities (Appendix D). Qualitative and quantitative data were triangulated across outcomes to identify factors that influenced implementation.

Results

Table 1 summarizes characteristics of communities, schools, students and staff. Quantitative and qualitative measures were used to assess outcomes based on the taxonomy for implementation research outcomes of Proctor et al (9) (Table 2). MA-CORD implementation barriers and facilitators were assessed during year 2 using in-depth interviews and summarized based on implementation outcomes (Table 3).

Acceptability. Before the intervention, leaders in both districts reported high levels of support for MA-CORD (Table 2**)**. Among school staff members, scores for organizational commitment, motivation, and confidence in their school's ability to support MA-CORD were lower in Community 2 than Community 1. In interviews, staff members in Community 2 discussed concerns about changing administrative priorities and focusing on standardized testing, which competed with outside activities. Acceptability facilitators were preexisting wellness activities related to nutrition and physical activity, parental involvement, and strong principal support.

Adoption. Teachers in both communities participated in MA-CORD curriculum training (C1:100%; C2:72%) and in a curriculum survey in year 1, which assessed initial adoption (C1:100%; C2:44%). Most teachers reported teaching at least one lesson during both year 1 (C1:100%, C2:60%) and year 2 (C1:100%; C2:75%) (Table 2). During interviews, participants from Community 2 described difficulty coordinating afterschool schedules of teachers for training sessions. Teachers in both communities described motivated wellness champions as a driving force behind adoption of MA-CORD lesson plans.

Appropriateness. In interviews, teachers and staff members in both communities reported that MA-CORD training and curricula were appropriate for their students and teaching priorities. In curriculum surveys, teachers in both communities unanimously agreed (n = 35, 100%) that the lessons were a positive addition to their curriculum.

Feasibility. Although teachers in both communities reported being able to obtain necessary lesson materials (>80%), fewer teachers in Community 2 reported feeling competent to teach the content (Community 2, 57% vs Community 1, 86%). In interviews, participants across both communities identified competing priorities for teachers' time as barriers to administering classroom lessons. Standardized tests, statewide campaigns (anti-bullying curriculum), and general burnout were cited as barriers to the staff teaching lessons on wellness or being involved in wellness activities.

Implementation fidelity. In year 1, teachers in Community 1 nearly met the teaching goal of 6 MA-CORD lessons per year (mean, 5.8: standard deviation [SD], 2.7); Community 2 reported fewer lessons (mean, 3.6; SD, 2.5) (Figure 2). In year 2, mean lessons taught dropped slightly for Community 1 and increased for Community 2. In Community 2, administrative changes, including a new superintendent, principal turnover, and district-wide teacher layoffs, were described in interviews as barriers to implementation fidelity.

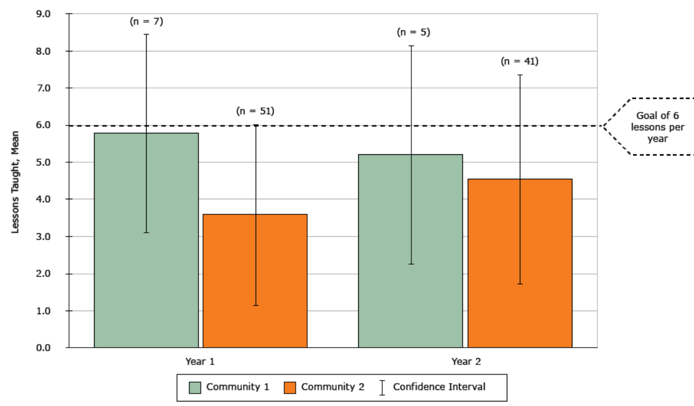

Figure 2. MA-CORD Implementation Fidelity: Curriculum lessons taught by 4th, 5th, 6th, and 7th grade school teachers, Massachusetts, 2012–2014. Using end-of-year surveys, teachers reported the number of lessons taught from the MA-CORD curricula, which were adapted from "Eat Well and Keep Moving" and "Planet Health" (Appendix A).

Perceived implementation cost. In surveys, school leaders in both communities were neutral or agreed that their schools had resources to support MA-CORD and could manage risks associated with implementing the intervention. In interviews, leaders and staff members in both communities reported satisfaction with the availability of supplies and resources needed to implement activities. Community 2 staff members reported receiving physical activity play equipment as a major benefit of MA-CORD participation.

Reach. On the basis of the number of 4th through 7th grade students eligible to receive the intervention; (Community1: 1,486; Community 2: 3,658) (Table 1) and the percentage of eligible teachers who completed trainings (Community 1, 100%; Community 2, 72%) (Table 2), we estimate that 1,486 students in Community 1 (100%) and 2,626 students in Community 2 (72%) were reached by the intervention. In interviews, leaders and staffs in both communities reported classroom activities effectively tied into larger school and city-wide campaigns, thus increasing student and family awareness.

Sustainability. In end-of-year curriculum surveys in year 2, most teachers in Community 1 (100%, n = 5) and Community 2 (76%, n = 29) reportedly planned to continue teaching MA-CORD lessons. In interviews, staff members described health teachers as strong implementers of the curriculum. One principal made MA-CORD activities part of teachers' professional evaluation, ensuring MA-CORD lessons would be sustained through supervisory accountability. Barriers to long-term sustainability were teacher turnover, lack of ongoing leadership from principals, or lack of active wellness champions.

Discussion

Our study describes barriers and facilitators to implementing a school-based obesity intervention in 2 low-income communities. MA-CORD was adopted at a rate comparable to similar classroom-based lifestyle interventions (16–18) in districts facing competing priorities. Understanding factors facilitating implementation is necessary to develop targeted technical assistance and resources for successful implementation. Our findings provide insight into benefits of pre-intervention assessment of staff readiness and selection of ideal teachers and curricula to ensure activities are integrated and sustained in schools. Our study yielded 4 key lessons learned:

Lesson 1: Assess organizational readiness of all staff members. Strong leadership support for MA-CORD existed in both communities at baseline, but implementers (ie, teachers, nurses) in Community 2 reported lower perceived readiness to implement MA-CORD than did implementers in Community 1. In fact, proportionally fewer teachers in Community 2 engaged in training, taught lessons, completed curriculum surveys, or planned to sustain lessons post-intervention. These teachers described administrative shifts and staff turnover (45% of schools in Community 2 received new principals), in contrast with administratively stable Community 1, which also had a history of parent involvement and wellness activities before MA-CORD.

Health education teachers administered lessons in Community 1, whereas a mix of health education teachers and classroom teachers in Community 2 administered them. In low-resourced communities with few health education teachers, additional strategies to identify motivated teachers or parents could be beneficial. Lack of parental involvement is reported as a barrier to implementation in school-based obesity prevention projects serving low-income children (19,20). Interviewees suggested parents could support teachers delivering MA-CORD lessons by bringing healthy snacks to taste-test or by planning school wellness events. In future projects, school leaders should consider collaboratively addressing barriers to implementation by increasing parental involvement before launching intervention activities.

Lesson 2: Identify and support passionate wellness champions. Using school wellness champions was one of the strongest reported facilitators of MA-CORD implementation, consistent with previous research indicating the use of outside staff to implement an intervention significantly reduced its likelihood of being sustained (21). We found that champions who were health education teachers or nurses reported the highest satisfaction with their role because it fit well with their job description. In Community 2, busy principals and classroom teachers served as wellness champions, but some colleagues reported waning support from them because of shifting administrative priorities over time.

Although some schools may not have health education teachers or nurses who can take on additional roles, investigators may increase engagement and buy-in from champions by using strategies adapted from workplace wellness programs: ongoing training, recognition, and incentive programs linked with key intervention outcomes (22,23). Wellness champions who efficiently train and motivate busy teachers to adopt new classroom activities play a critical role in implementation success. These champions are also likely to support overall district and school-level wellness policy implementation.

Lesson 3: Build on existing curricula combined with incentives. Tailored messaging and print materials are valuable contributors to successful obesity-related intervention outcomes in school-based settings (24). In our study, teachers consistently conveyed satisfaction with the lesson plans and print materials adapted from existing interventions. For example, one *Eat Well and Keep Moving* lesson titled "Sugar Water: Think about Your Drink," contained activities crossing various core curricula (eg, multiplication to find grams of sugar in soda, interpreting a soda can label). Obesity prevention lessons that fulfill multiple core classroom subjects support adoption and sustainability of intervention activities in schools (18). Curriculum delivery was maximized by incentivizing aspects of program participation with grant funding. Teachers were compensated for attending MA-CORD training sessions after school or they attended sessions during the school day, which probably contributed to greater than 70% teacher participation in both communities. As an additional incentive, some schools received play equipment such as balls and hula hoops, which promoted active indoor play during winter months and supported the intervention's physical activity goal.

Lesson 4: Sustainability is maximized through ongoing training and institutional adoption. Teachers who continued to teach MA-CORD lessons beyond year 1 of the intervention described having a wellness champion who offered ongoing support through formal and informal training. Both in our study and elsewhere, staff turnover is a barrier to intervention sustainability in schools, because repeated training is expensive and difficult to coordinate across campuses (25–27). However, we identified sustainable strategies, which included incorporating the curricula into lesson plans that continued year-to-year (eg, math lessons, writing), acknowledging MA-CORD activities in performance evaluations, and schoolwide policies supporting messages taught during lessons (eg, no sugary drinks on campus). Additionally, online training modules are being considered as a low-cost way to train a school's staff on health topics (28) and could be a way to overcome issues related to staff turnover. One study found no significant difference in adoption of an after-school nutrition and physical activity intervention when the staff were trained online versus face-to-face (29).

As in other process analyses, our study's findings rely on self-report from a convenience sample (17). In one community, nearly half of eligible teachers did not complete follow-up curriculum surveys, reflecting possible unmeasured levels of implementation in nonparticipating schools. Because student-level data were not collected because of privacy restrictions, we based our estimate of reach on the number of eligible students and percentage of eligible teachers who attended MA-CORD trainings. Although small sample sizes limited our ability to generalize beyond our population, using mixed methods offered detailed context, which may be useful for others working to implement similar programs in resource-poor schools. Because long-term follow-up data beyond the intervention period were not available, we could not assess the intervention's long-term sustainability.

To improve child health and maximize limited resources, there remains a need for continued collection and publication of both quantitative and qualitative process evaluation data describing school-based obesity prevention interventions. Sharing null findings, barriers, and implementation failure is critical to refining and promoting best practices in implementation to identify strategies to encourage sustainable changes in schools.

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Tables

Table 1. Characteristics of Communities, Schools, Students, and Staff Members Participating in the MA-CORD Intervention, Massachusetts, 2012–2014

Characteristic	Community 1	Community 2
Community		
Population total (30), **n**	40,318	95,072
Race/ethnicity (30), **%**		
White	68.2	67.9
Hispanic	21.6	16.7
African American	5.1	6.4
Multi-race, Non-Hispanic	3.7	5.7
Asian	3.6	0.9
Average per capita income (30), **$**	22,620	21,056
Persons below poverty level (30), **%**	20.6	23.5
School		
Schools eligible to participate in MA-CORD[a] , n	6	22
Elementary schools	4	19
Middle schools	3	3
Health education staff		
Schools with nurses, n	6	25
Schools with a health education teacher, n (% of schools)	6 (100.0)	3 (13.6)
District-wide staff retention rates, n (% of schools)		
Superintendent	1 (100.0)	0 (0.0)
Principals	7 (87.5)	19 (79.2)
Teachers	315 (92.9)	777 (90.0)
Teacher		
Total eligible to teach MA-CORD curricula, n		
Year 1	7	117
Year 2	6	122
Female, % of eligible teachers (31)	81.3	81.4
Race/ethnicity, % of eligible teachers (31)		
White	90.5	90.7
Hispanic	6.8	2.5

Abbreviation: MA-CORD: Massachusetts Childhood Obesity Research Demonstration Project.
[a] Community 1 consisted of 6 schools, but 1 school served kindergarten through eighth-grade students and was counted as both an elementary and a middle school.
[b] Students enrolled in fourth, fifth, sixth, and seventh grade were eligible to receive the curricula used in MA-CORD.
[c] Defined as being eligible for either free or reduced price lunch, transitional aid to families, or the Supplemental Nutrition Assistance Program based on family household income.
[d] Intervention readiness surveys were distributed to MA-CORD school leaders and staff members (Table 2); participants were not identified by school.
[e] School principals, superintendents, intervention coordinators, and MA-CORD wellness champions.
[f] In-depth qualitative interviews conducted during year 1 of the intervention with school leaders (superintendent, principals, wellness champions), teachers, and nurses.

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Table 1. Characteristics of Communities, Schools, Students, and Staff Members Participating in the MA-CORD Intervention, Massachusetts, 2012–2014

Characteristic	Community 1	Community 2
African American	2.0	5.7
Multi-race, Non-Hispanic	0.2	0.6
Asian	0.5	1.3
Student		
Total eligible to receive MA-CORD curricula [b] (31), **n**	1486	3658
Race/ethnicity, % of students (31)		
White	38.2	49.2
Hispanic	46.6	31.1
African American	5.8	11.7
Multi-race, Non-Hispanic	5.7	6.1
Asian	5.5	0.8
Low-income[c] (31)	76.9	73.4
Engagement in Process Evaluation		
Surveys of intervention readiness[d]		
Leaders[e], n	5	18
Teachers or nurses, n	4	49
Qualitative interviews, n		
Schools represented in qualitative interviews, n (% of schools)[f]	5 (83.3)	11 (50.0)
Leaders[e], n	4	2
Teachers or nurses, n	7	10
Year-end teacher curriculum surveys, n (% of teachers)		
Year 1	7 (100)	51 (43.6)
Year 2	5 (83.0)	41 (33.6)

Abbreviation: MA-CORD: Massachusetts Childhood Obesity Research Demonstration Project.
[a] Community 1 consisted of 6 schools, but 1 school served kindergarten through eighth-grade students and was counted as both an elementary and a middle school.
[b] Students enrolled in fourth, fifth, sixth, and seventh grade were eligible to receive the curricula used in MA-CORD.
[c] Defined as being eligible for either free or reduced price lunch, transitional aid to families, or the Supplemental Nutrition Assistance Program based on family household income.
[d] Intervention readiness surveys were distributed to MA-CORD school leaders and staff members (Table 2); participants were not identified by school.
[e] School principals, superintendents, intervention coordinators, and MA-CORD wellness champions.
[f] In-depth qualitative interviews conducted during year 1 of the intervention with school leaders (superintendent, principals, wellness champions), teachers, and nurses.

Table 2. Outcomes of an Implementation Assessment of MA-CORD School-Based Intervention[a], Massachusetts, 2012–2014

Measures	Community 1	Community 2
Acceptability[b]		
Beliefs of school leaders[c,d], mean (standard deviation)		
Commitment to prevent or reduce childhood obesity in the community	4.9 (0.2)	4.7 (0.2)
Compatibility of program with organization's approach	4.2 (0.8)	4.3 (0.5)
Timing of implementation was good	4.3 (0.7)	4.0 (0.6)
Intervention will distract from other organizational priorities	2.4 (0.7)	1.7 (0.5)
Beliefs of school staff members[d,e], mean (standard deviation)		
Commitment of staff to implementation	4.2 (0.5)	3.8 (0.9)
Motivation of staff for implementation	4.3 (0.5)	3.6 (0.8)
Confidence of staff to implement tasks smoothly	4.0 (0.8)	3.6 (0.9)
Confidence of staff to handle implementation challenges	4.3 (0.5)	3.6 (0.8)
Confidence of staff members that organization can support them during transition to intervention	4.3 (0.5)	3.6 (0.8)
Adoption[f]		
Teacher adoption of MA-CORD lessons, n (% of teachers)		
Eligible teachers completed MA-CORD curriculum training in year 1[g]	7 (100.0)	84 (71.8)
Taught any MA-CORD lessons in year 1[h]	7 (100.0)	28 (59.6)
Taught any MA-CORD lessons in year 2[i]	5 (100.0)	39 (75.0)
Appropriateness[j]		
"Lessons I taught were a positive addition to my curriculum" (Agree or strongly agree)[i]	7 (100.0)	28 (100.0)
Feasibility[k]/Perceived Implementation Cost[l]		
Beliefs of MA-CORD eligible teachers, n (%)		
"I felt competent to teach the content" (agree or strongly agree)[i]	6 (85.7)	25 (56.8)
"Overall, the effort required to obtain needed materials not provided [by MiM Kids] was acceptable"[i]	4 (80.0)	29 (90.6)
Beliefs of school leaders[c,d], mean (standard deviation)		

Abbreviations: MA-CORD, Massachusetts Childhood Obesity Research Demonstration Project; MiM KIDS, Mass in Motion KIDS intervention.
[a] The community-level name for the intervention that was part of the larger MA-CORD project was MiM KIDS.
[b] Acceptability is the initial perception of the intervention's fit.
[c] Data obtained from survey of leaders in the school sector (administrators, principals, school wellness champions) using an adapted version of the Adoption Decision Questionnaire: Community 1 (n = 5), Community 2 (n = 18).
[d] Response options ranged from 1 (strongly disagree) to 5 (strongly agree).
[e] Data obtained from survey of staff members in the school sector (teachers, school nurses) using an adapted version of the Organizational Readiness for Change Questionnaire: Community 1 (n=4), Community 2 (n = 49).
[f] Adoption in initial participation.
[g] Based on sign-in sheets and internal records.
[h] Data obtained from year 1 curriculum survey of staff members eligible to teach MA-CORD curriculum: Community 1 (n = 7), Community 2 (n = 51).
[i] Data obtained from year 2 curriculum survey of staff members eligible to teach MA-CORD curriculum: Community 1 (n = 5), Community 2 (n = 41).
[j] Appropriateness is the perception of MiM Kids as being good for teachers/children
[k] Feasibility is the actual fit/compatibility of conducting MiM Kids activities in a school setting.
[l] Perceived implementation cost refers to the resources required to conduct activities (eg, financial, time, parent support).
[m] Implementation fidelity is the quantity and quality of MiM Kids activities conducted.
[n] Compared with goal of 6 MA-CORD lessons taught per year.
[o] Reach is the impact of MiM Kids on students, parents, staff, and community.
[p] Sustainability is the continuation/institutionalization of MiM Kids activities.

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Table 2. Outcomes of an Implementation Assessment of MA-CORD School-Based Intervention[a], Massachusetts, 2012–2014

Measures	Community 1	Community 2
Organization has resources necessary for implementation	3.5 (0.8)	3.8 (0.8)
Organization can manage risks associated with implementation	3.7 (1.0)	3.7 (0.5)
Implementation Fidelity[m]		
Lessons taught from MA-CORD curriculum in year 1 (mean, SD)[n]	5.8 (2.7)	3.6 (2.5)
Lessons taught from MA-CORD curriculum in year 2 (mean, SD)[n]	5.2 (3.0)	4.5 (2.8)
Reach[o]		
Estimated number of students who received MA-CORD curriculum[h] (31)	1,486	2,262
Sustainability[p]		
Teachers sustaining MA-CORD curriculum, n (%)		
Plan to teach curriculum after year 1 (yes vs no/undecided)[h]	7 (100.0)	40 (83.3)
Plan to teach curriculum after year 2 (yes vs no/undecided)[i]	5 (100.0)	29 (76.3)

Abbreviations: MA-CORD, Massachusetts Childhood Obesity Research Demonstration Project; MiM KIDS, Mass in Motion KIDS intervention.
[a] The community-level name for the intervention that was part of the larger MA-CORD project was MiM KIDS.
[b] Acceptability is the initial perception of the intervention's fit.
[c] Data obtained from survey of leaders in the school sector (administrators, principals, school wellness champions) using an adapted version of the Adoption Decision Questionnaire: Community 1 (n = 5), Community 2 (n = 18).
[d] Response options ranged from 1 (strongly disagree) to 5 (strongly agree).
[e] Data obtained from survey of staff members in the school sector (teachers, school nurses) using an adapted version of the Organizational Readiness for Change Questionnaire: Community 1 (n=4), Community 2 (n = 49).
[f] Adoption in initial participation.
[g] Based on sign-in sheets and internal records.
[h] Data obtained from year 1 curriculum survey of staff members eligible to teach MA-CORD curriculum: Community 1 (n = 7), Community 2 (n = 51).
[i] Data obtained from year 2 curriculum survey of staff members eligible to teach MA-CORD curriculum: Community 1 (n = 5), Community 2 (n = 41).
[j] Appropriateness is the perception of MiM Kids as being good for teachers/children
[k] Feasibility is the actual fit/compatibility of conducting MiM Kids activities in a school setting.
[l] Perceived implementation cost refers to the resources required to conduct activities (eg, financial, time, parent support).
[m] Implementation fidelity is the quantity and quality of MiM Kids activities conducted.
[n] Compared with goal of 6 MA-CORD lessons taught per year.
[o] Reach is the impact of MiM Kids on students, parents, staff, and community.
[p] Sustainability is the continuation/institutionalization of MiM Kids activities.

Table 3. Barriers and Facilitators to Implementation of the MA-CORD School-Based Intervention Based on In-Depth Interviews of School Administrators, Teachers, and Nurses (n = 23)[a], Massachusetts, 2013–2014

Implementation Outcome Constructs	Facilitators[b]	Barriers[b]
Acceptability[c]	Principal is a champion for health activities	Pressure of standardized testing or academic demands in district
	Existing wellness initiatives and policies (C1)	New superintendent and administrative turnover (C2)
	School nurses and health education teachers found the project fit well within their work tasks	
Adoption[d]	Rapport between wellness champions and the staff	Weather interrupting trainings (C2)
		Lack of time for teachers to attend trainings
		Teachers not informed about intervention (C2)
Appropriateness[e]	Training and curricula were well-received	Concerns about messages that children do not have control over (eg, safe outdoor play, sleep environments)
	Message appropriate for students	
	Teachers liked being part of a larger movement across schools	
Feasibility[f]/implementation fidelity[g]	A champion at the school who maintains enthusiasm	Lack of time for teachers to teach lessons
	Using students to engage other students	Competing priorities with other schoolwide campaigns
	Technical assistance to change policies in the school	Principal and teacher turnover (C2)
Perceived implementation cost[h]	Providing physical activity equipment to schools (C2)	Inadequate printing resources to provide materials for conducting lessons
Reach[i]	School-wide integration of messaging	Limited collaboration between some sectors
	Linkages with other school health priorities	
	Media coverage	
	Children bringing messages home from school	
Sustainability[j]	Health education teachers implementing curriculum	Staff turnover
	Enjoyable activities that are adopted long-term	Lack of ongoing leadership
	Intervention involvement acknowledged in teacher evaluations	

Abbreviations: C1, Community 1; C2, Community 2; MA-CORD Project, Massachusetts Childhood Obesity Research Demonstration Study.
[a] Based on sample of 11 school staff members in Community 1 and 12 school staff members in Community 2.
[b] Themes reported in both communities unless otherwise specified.
[c] Acceptability: Initial perception of intervention fit.
[d] Adoption: Initial participation.
[e] Appropriateness: Perception of Mass in Motion [MiM] Kids being good for teachers/children (MiM KIDS was the community-level name for the intervention that was part of the larger MA-CORD project).
[f] Feasibility: Actual fit/compatibility of conducting MiM Kids activities in school setting.
[g] Implementation Fidelity: Quantity and quality of MiM Kids activities conducted.
[h] Perceived implementation cost: Resources required to conduct activities.
[i] Reach: Impact of MiM Kids on students, parents, staff, and community.
[j] Sustainability: Continuation/institutionalization of MiM Kids activities.

Appendix A. – Questionnaires Used in Process Evaluation of School Intervention

This file is available for download as a Microsoft Word file at https://www.cdc.gov/pcd/issues/2017/docs/16_0381AppendixA.docx. [DOCX - 132KB]

Appendix B. – Interview Guides

This file is available for download as a Microsoft Word file at https://www.cdc.gov/pcd/issues/2017/docs/16_0381AppendixB.docx. [DOCX - 27KB]

Appendix C. – Interview Coding Scheme

This file is available for download as a Microsoft Word file at https://www.cdc.gov/pcd/issues/2017/docs/16_0381AppendixC.docx. [DOCX - 23KB]

Appendix D. – Key Illustrative Quotes Obtained From Qualitative Interviews of School Staff Members Participating in MA-CORD in Massachusetts, 2012–2013 (n = 23)

This file is available for download as a Microsoft Word file at https://www.cdc.gov/pcd/issues/2017/docs/16_0381AppendixD.docx. [DOCX - 26KB]

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ORIGINAL RESEARCH

Geographic Association Between Income Inequality and Obesity Among Adults in New York State

Daniel Kim[1]; Fusheng Wang, PhD[1]; Chrisa Arcan, PhD, MHS, MBA, RD[2]

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PEER REVIEWED

Abstract

Introduction
In addition to economic factors and geographic area poverty, area income inequality — the extent to which income is distributed in an uneven manner across a population — has been found to influence health outcomes and obesity. We used a spatial-based approach to describe interactions between neighboring areas with the objective of generating new insights into the relationships between county-level income inequality, poverty, and obesity prevalence across New York State (NYS).

Methods
We used data from the 2015 American Community Survey and 2013 obesity estimates from the Centers for Disease Control and Prevention for NYS to examine correlations between county-level economic factors and obesity. Spatial mapping and analysis were conducted with ArcMap. Ordinary least squares modeling with adjusting variables was used to examine associations between county-level obesity percentages and county-level income inequality (Gini index). Univariate spatial analysis was conducted between obesity and Gini index, and globally weighted regression and Hot Spot Analysis were used to view spatial clustering.

Results
Although higher income inequality was associated with lower obesity rates, a higher percentage of poverty was associated with higher obesity rates. A higher percentage of Hispanic population was associated with lower obesity rates. When tested spatially, higher income inequality was associated with a greater decrease in obesity in southern and eastern NYS counties than in the northern and western counties, with some differences by sex present in this association.

Conclusion
Increased income inequality and lower poverty percentage were significantly linked to lower obesity rates across NYS counties for men. Income inequality influence differed by geographic location. These findings indicate that in areas with high income inequality, currently unknown aspects of the environment may benefit low-income residents. Future studies should also include environmental factors possibly linked to obesity.

Introduction

Economic factors have been linked to numerous health outcomes, including obesity (1). However, research on area income inequality — the extent to which income is distributed unevenly across a population — and obesity rates is limited and inconsistent, because income inequality is a contextual variable specific to geographic scale and is differentially associated with social conditions. The relationship between income inequality and obesity changes by geographic area and is not fully understood.

In the United States, obesity is related to poverty, low individual income, and food-insecurity (1). A study that used data from the 2003–2008 National Health and Nutrition Examination Survey showed that at the tract and county levels, high degrees of income inequality was correlated with low obesity rates (2), suggesting that community affluence has a positive effect on residents' lifestyles. Similarly, city-level and tract-level income inequality was negatively associated with body weight in Los Angeles county in 2000–2001 (3). A study using the Behavioral Risk Factor Surveillance System (BRFSS) found that a high prevalence of income inequality was associated with reduced odds of obesity among non-Hispanic white women (4). To our knowledge, previous studies have not used spatial regression methods to examine the relationship between area income inequality and obesity rates. To address this research gap, we used spatial analysis to examine associations between small-area income inequality and obesity among adults in

New York State (NYS). We hypothesized that income inequality would have an inverse relationship with obesity rates and that a geographic difference exists between the two.

Methods

Data sources

Our study used a cross-sectional design of publicly available data sources to create estimates related to NYS residents. Data from the American Community Survey (ACS) (https://www.census.gov/programs-surveys/acs) were used for all independent variables, including area poverty prevalence and area income inequality. ACS is an annual survey conducted by the US Census Bureau throughout the United States and provides annual estimates of a series of monthly samples of people living in housing units, such as houses or apartments, and in institutional and noninstitutional group quarters, such as correctional facilities, mental hospitals, college dormitories, military barracks, and shelters. The Census Bureau uses several data collection methods (internet, mailed paper questionnaire, telephone, personal visit) to ensure representation of the US population. The ACS survey is mandatory by law, resulting in an extremely high response rate. Participants were excluded for refusal to participate based on legal or other reasons, insufficient data, inability to locate participants, temporary absences from their place of residence, and language barriers. ACS is conducted in English, meaning that results cannot be retrieved if interpreters are unavailable. Our study used ACS 5-year estimates (2011–2015), representing 790,051 observations. Even at a 99.5% confidence interval, the necessary sample size to ensure correct estimates for the NYS population was 38,341, less than the number of participants in the ACS survey.

County-level income inequality was measured by the Gini coefficient, or Gini index, which represents income dispersion across an area, assigning values from 0 to 1: the higher the number, the greater an area's income inequality. The numerator of the coefficient is the area between the Lorenz curve of the distribution and the uniform distribution line; the denominator is the area under the uniform distribution line. We converted this ratio into an index by multiplying each value by 100. Gini index was the only variable not separated by sex. In the ACS data set, racial groups were recorded as counts and were converted to percentages by dividing the counts for each racial group by the total estimated number of people in each county. We used the Gini index in this study because it is the most commonly used measure of income inequality; however, we acknowledge the existence of other measures, such as Atkinson's measures, Theil's T, and Theil's L, and that our results may not necessarily have held if these other measures were used instead of the Gini index (5,6).

The dependent variable, obesity prevalence, was drawn from the Centers for Disease Control and Prevention (CDC) statistical estimates (7,8). These were based on the Census Bureau's Population Estimates Program and the 2013 BRFSS (9), which was conducted via telephone interview. However, these estimates also include statistical adjustments designed to reduce the random sampling's inherent randomness (7). Obesity was defined as a body mass index (BMI, kg/m^2) of 30 or greater and was measured by physical examinations at the county level.

Statistical methods

We examined the association between county-level independent variables and obesity prevalence with ArcMap (Esri) by using ordinary least squares (OLS). OLS is a variation of linear regression, a statistical method that examines associations between multiple independent variables and a single dependent variable; once the assumptions are satisfied, the regression output indicates the strength of the association between the dependent variable and each of the independent variables. These assumptions, include linear parameters, random sampling, no multicollinearity, no autocorrelation, a conditional mean of zero, and normally distributed error terms; all of them were satisfied, meaning that our OLS models are efficient and represent a linear unbiased estimator of variable coefficients.

Final models included county-level Gini index, poverty percentage (defined as having an income below the Federal Poverty Level), adjusted for median age, percentage African-American, percentage Hispanic, percentage married, and percentage with at least a high school education. Statistical significance was set at $P < .05$. Interactions between the sex ratio with each of the other independent variables were tested. Because we found significant interactions between sex and the Gini index, analyses were conducted separately by sex. After these analyses, we found that coefficients and *P* values did not differ by sex; therefore we performed the analysis with both sexes combined.

Two spatial tests, geographically weighted regression (GWR) and Getis-Ord GI* Hot Spot Analysis (Esri), were used to add a different dimension to our analysis. GWR created a separate ordinary least squares (OLS) model for every county while considering spatial factors, such as the distances and OLS models of neighboring counties. GWR measured relationships that vary across space, whereas OLS linear regression assumes these relationships apply equally over an entire geographic area (9). We performed univariate GWR with Gini index as our independent variable, with both Gini index and obesity prevalence first matched to counties in a NYS ArcMap shapefile.

Hot Spot Analysis was conducted on the GWR regression results; this test determines whether the different coefficients of the Gini index variable for each county that GWR returned are randomly dispersed, or whether unusually high or unusually low values are clustered together. Hot Spot Analysis tests for clusters of similar values in a set of spatial data, indicating when similar values are close to one another. The method is specific, enabling us to detect possible local spatial associations whereas other methods, such as Moran's I, does not (10).

Although standard OLS regression makes one model for the entire state, giving an overall sense of a variable's effect on obesity rates, GWR combined with Hot Spot Analysis provides information about the degree of effect a variable has in different areas. This allowed for observation of differences in the effect of income inequality on obesity prevalence across NYS.

Results

The median age in our data set of the NYS population was 38.1 years; 48.5% were men, 15.6% were black, 18.4% were Hispanic, 44.5% were married, and 85.6% were high school graduates. During the time that these data were collected, the response rate varied by county; however, for NYS, the overall response rate of housing units was 93.3%, and the overall response rate of group quarters was 95.2%.

The OLS regression showed that among all adults, a higher county-level Gini index (or higher inequality) (β, −0.37; $P = .01$) and a higher percentage of Hispanic population (β, −0.22; $P = .009$) was significantly associated with a lower obesity rate. In contrast, a higher percentage of county-level poverty (β, 0.42; $P = .004$) and higher percentage of being married (β, 0.22; $P = .03$) was associated with a higher obesity rate (Table 1). Then in separate analyses, the same significant associations were observed among men and women with the exception of marital status, which was significant among men (Table 2) but not among women (Table 3). We used Hot Spot Analysis to test for spatial autocorrelation, and none was found. Variance inflation factor values of all variables were measured, with none exceeding 5, a benchmark for moderate multicollinearity.

The GWR analysis showed that a 1% increase in income inequality was associated with a greater decrease in obesity prevalence in southern NYS than in the western state for both sexes. The effect of the Gini index on obesity prevalence was highest in southern and eastern NYS, but showed a downward trend toward the north and west. These associations were stronger among men (Figure 1) than among women (Figure 2), just as the OLS models predicted.

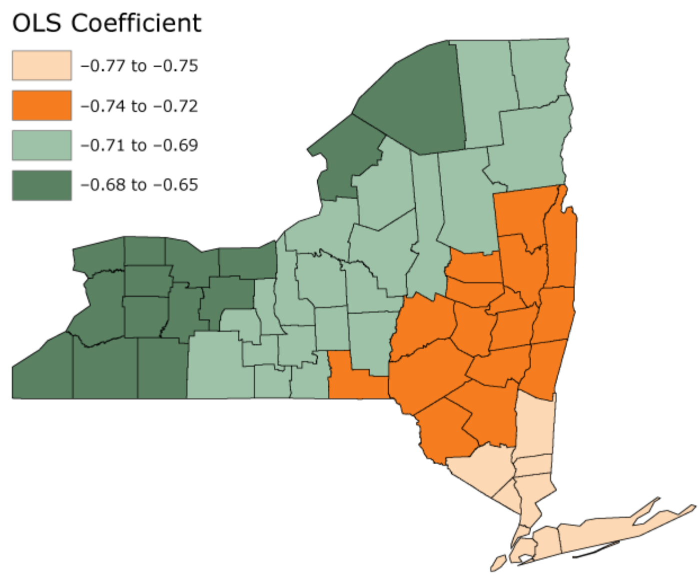

Figure 1. Results of geographically weighted regression (GWR) tests for men, mapping the individual ordinary least squares (OLS) coefficient constructed by GWR to each county in New York State. Data are from the American Community Survey and from CDC County Data Indicators estimates (11).

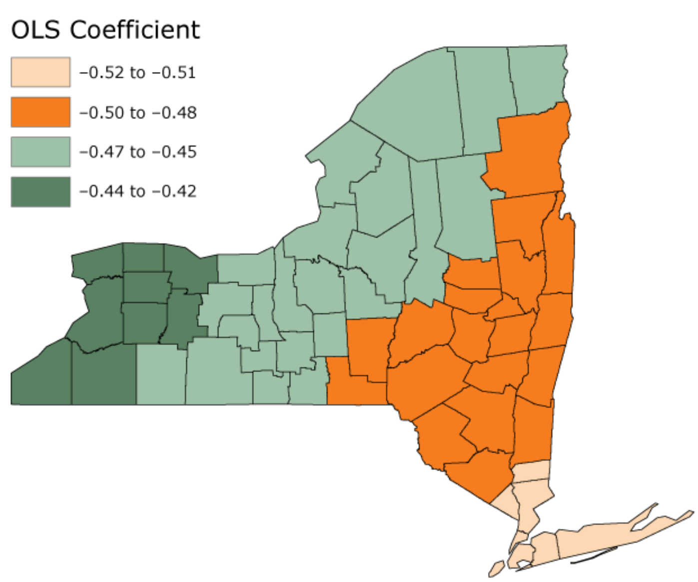

Figure 2. Results of geographically weighted regression (GWR) tests for women, mapping the individual ordinary least squares coefficient constructed by GWR to each county in New York State. Data are from the American Community Survey and from CDC County Data Indicators (11).

Hot Spot Analysis tests confirmed GWR results: a large area exists in the southeast where the effect of the Gini index is unusually high compared with its surrounding areas, and a large area in the west where this effect is unusually low compared with neighboring areas. From the results of the GWR and Hotspot tests, we observed a connection between the differing effects of income inequality (Gini index) and its relation to geographical direction in NYS. Moving east the absolute effect of income inequality on obesity increased, whereas moving west it, decreased, which the Hot Spot test confirmed.

Discussion

Our study examined associations between obesity prevalence and county-level income inequality and poverty percentage among adults in NYS. As we hypothesized, income inequality was inversely associated with obesity prevalence, and a difference in the geographical effect on income inequality and obesity was observed. Our findings using spatial analyses can help public health officials and lawmakers to tailor health initiatives to different geographical areas, thereby improving the sustainability of these initiatives on the well-being of the population.

The negative correlation of income inequality with obesity is not unilateral; a study of 21 developed countries showed that income inequality was positively correlated with obesity prevalence in men and women (12). Social inequalities were found to have a greater effect on obesity in women in a study of 11 member countries of the Organization for Economic Cooperation and Development (OECD), which include the United States (13). Our study found that income inequality had a greater effect on obesity among men than among women. These conflicting findings may be due to the use of different types of measurements, the inclusion of different countries in the studies, and the geographic area studied, such as NYS. The area level studied was shown to have differing effects of income inequality on other health outcomes (14).

Country-level studies examining national data suggested a detrimental effect of high income inequality to mean BMI and prevalence of obesity (15). A study of 68 countries noted that obesity prevalence was greater among women than among men in countries with a high Gini index (16). Another study using national data from the Behavioral Risk Factor Surveillance System found little to no association between income inequality and obesity in race–sex stratified groups in metropolitan areas (4). Similarly, using national data from Spain's 2001 National Health Survey, a study found no association between income inequality and BMI (17). A multinational study associated high income inequality at the national level with increases in obesity prevalence; this association disappeared when the United States and Mexico were excluded from their model (18). In contrast, a study using county and tract data found an association between income inequality and BMI similar to our findings, leading us to think that differences in the overall geographical area measured may contribute to differences in the associations between income inequality and obesity.

When considering poverty, our study agrees with similar studies conducted among populations of adult men and women in various countries. A study of Canadian men and women found that rich men and poor women were more likely to be obese (19). Although that study did not measure individual income, poverty percentage was positively associated with obesity among women. Low area socioeconomic status, low-cost food stores, low education attainment, and individual income have been associated with high obesity rates in adults living in Seattle, Washington, and Paris, France (20). In England, a study of adults aged 18 to 75 showed that social and economic gradients existed for obesity in both sexes, with lower socioeconomic status associated with higher rates of obesity, and that this trend had not changed significantly in more than a decade (21).

A study that examined Gini index in adults at the US county and tract levels showed that the addition of potential confounders changed the degree of the association between income inequality and obesity, because area level factors such as neighborhood environment (eg, availability of parks and recreation, healthy food), and local policies may have an effect on residents' weight status (2). One study of US counties showed that geographical differences in obesity rates can be explained through physical activity and food environments, along with settlement patterns and transportation habits (22). However, this may be due to other factors; income inequality has been associated with low rates of physical activity, which may contribute in part to our findings (23). Future studies may test these correlations by including potential factors as mediators, especially in an area-based study that takes into account context factors, such as distance from parks or other neighborhood services or conditions (23).

County-level poverty was positively associated with obesity in our study. A study of 1,150 children that used data from the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development found that poverty in very early life was associated with obesity in adolescence (24). Some studies differentiated socioeconomic differences by sex, such as one that used data from the 2001–2009 Korea National Health and Nutrition Examination Survey to study Korean adults (25). That study found that lower education was associated with higher obesity rates in women, and higher income was related to higher obesity rates in men. Another study that looked at several US counties found a positive relationship between poverty and obesity (1), suggesting that the positive relationship could have been due to lower physical activity rates of people living in poor counties, which introduces another possible variable in the relationship between county-level poverty and obesity rates.

Studies looking at the relationship between poverty and obesity, have used the term "poverty-obesity paradox" to indicate the positive relationship often found between poverty and obesity. Similar results were observed among the elderly by using data from the Survey of Health, Ageing, and Retirement and from the English Longitudinal Study of Ageing (26). Another study indicated a relationship between food insecurity and obesity through resource scarcity, suggesting that obesity is a response to a threatened food supply (27).

Our study has numerous strengths, including the use of OLS regression and the relatively high number of counties that NYS has compared with other states. The data used were CDC estimates derived from statistical estimates that sought to minimize error, and from ACS data, which is a conglomerate of half a decade of data collected from a high number of interviews. Another strength of our study is the use of GWR and Hot Spot Analysis to determine obesity prevalence geographically, a combined approach that has not often been tried in the literature, allowing for spatial analysis. These results are also highly generalizable. This study was conducted with large data sets, improving the generalizability of the findings. A similar approach can be conducted for the entire United States as needed.

Our study also had limitations. The study's cross-sectional design limited our ability to infer causality. Also, some of the variables in the BRFSS dataset are self-reported and may be subject to desirability or recall bias (28).

In conclusion, we found that income inequality was inversely associated with obesity prevalence in NYS counties, although this effect differed by sex. Also, the effect of income inequality differed geographically; income inequality was weaker in western NYS and stronger in the east. This trend did not differ by sex. Poverty percentage, however, was positively associated with obesity. Future studies can use spatial-based multiple regression models by introducing potential area-level factors that may contribute to the differing geographical effects of income inequality on obesity. The findings can help design effective programs that will be tailored to address the unique needs of the geographic locations, thus improving the sustainability of health outcomes.

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Tables

Table 1. Effects of Income Inequality[a], Poverty Percentage, and Sociodemographic Variables on Obesity at the County Level Among Adults in New York State[b]

Variable	β Coefficient	Standard Error	*P* Value[c]
Intercept[d]	16.91	21.06	.43
Gini index	−.37	.14	.01
Poverty[e], %	.42	.14	.004
Median age	.09	.10	.36
African-American, %	.14	.10	.14
Hispanic, %	−.22	.09	.009
Married, %	.22	.10	.03
High school graduate, %	.08	.16	.64

[a] Calculated by Gini index drawn from 5-year estimates of the American Community Survey for 2015.
[b] Based on an ordinary least squares multivariable linear regression model. Poverty percentage and sociodemographic variables were drawn from 5-year estimates of the American Community Survey for 2015. The dependent variable, obesity percentage, is based on 2013 CDC County Data Indicators (https://www.cdc.gov/diabetes/data/countydata/countydataindicators.html) estimates based on the BRFSS (Behavioral Risk Factor Surveillance System) survey (9).
[c] *P* values were calculated by using the ordinary least squares statistical test. Significance was set at $P < .05$.
[d] The intercept of the OLS regression model. Defined, in this case, as the expected value of obesity prevalence if all independent variables used in the equation are set to 0.
[e] Defined as percentage of population with annual incomes below the Federal Poverty Level.

Table 2. Effects of Income Inequality[a], Poverty Percentage, and Sociodemographic Variables on Obesity at the County Level Among Adult Men in New York State[b]

Variable	β Coefficient	Standard Error	*P* Value[c]
Intercept[d]	35.68	15.89	.03
Gini index	−.41	.13	.004
Poverty[e], %	.31	.14	.03
Median age	.04	.10	.68
African-American, %	.07	.09	.48
Hispanic, %	−.26	.08	<.001
Married, %	.21	.08	.01
High school graduate, %	−.04	.13	.76

[a] Calculated by Gini index drawn from 5-year estimates of the American Community Survey for 2015.
[b] Based on an ordinary least squares multivariable linear regression model. Poverty percentage and sociodemographic variables were drawn from 5-year estimates of the American Community Survey for 2015. The dependent variable, obesity percentage, is based on 2013 CDC estimates based on the BRFSS (Behavioral Risk Factor Surveillance System) survey (9).
[c] *P* values were calculated by using the ordinary least squares statistical test. Significance was set at $P < .05$.
[d] The intercept of the OLS regression model. Defined, in this case, as the expected value of obesity prevalence if all independent variables used in the equation are set to 0.
[e] Defined as percentage of population with annual incomes below the Federal Poverty Level.

Table 3. Effects of Income Inequality[a], Poverty Percentage, and Sociodemographic Variables on Obesity at the County Level Among Adult Women in New York State[b]

Variable	β Coefficient	Standard Error	*P* Value[c]
Intercept[d]	19.82	22.92	.39
Gini index	−.34	.15	.03
Poverty, %[e]	.38	.13	.004
Median age	.08	.10	.40
African-American, %	.18	.10	.07
Hispanic, %	−.20	.09	.03
Married, %	.15	.10	.14
High school graduate, %	.05	.18	.80

[a] Calculated by Gini index drawn from 5-year estimates of the American Community Survey for 2015.
[b] Based on an ordinary least squares multivariable linear regression model. Poverty percentage and sociodemographic variables were drawn from 5-year estimates of the American Community Survey for 2015. The dependent variable, obesity percentage, is based on 2013 CDC estimates based on the BRFSS (Behavioral Risk Factor Surveillance System) survey (9).
[c] *P* values were calculated by using the ordinary least squares statistical test. Significance was set at $P < .05$.
[d] The intercept of the OLS regression model. Defined, in this case, as the expected value of obesity prevalence if all independent variables used in the equation are set to 0.
[e] Defined as percentage of population with annual incomes below the Federal Poverty Level.

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ORIGINAL RESEARCH

Longitudinal Analysis of Nut-Inclusive Diets and Body Mass Index Among Overweight and Obese African American Women Living in Rural Alabama and Mississippi, 2011–2013

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PEER REVIEWED

Abstract

Introduction

Nuts, when eaten alongside other nutritionally rich foods, may decrease obesity and related chronic disease risks, which are high among African American women in the rural South. We monitored changes in nut intake, other obesity-related foods (fruits, vegetables, red or processed meats, added sugars), and body mass index (BMI) over a 2-year weight loss intervention among 383 overweight and obese African American women in rural Alabama and Mississippi.

Methods

Two dietary recalls were administered at 4 points over 24 months. Mann–Whitney tests compared differences in median food group intake between nut consumers and non-nut consumers, and *t* tests identified BMI differences between groups. Mixed linear models tested the relationship between nut intake and intake of the select food groups, and between nut intake and BMI over time.

Results

Overall nut consumers ate more fruits and vegetables and less red meat than non-nut consumers. Nut consumers had lower BMI values than non-nut consumers. Weight loss by the end of the intervention was significant for nut consumers but not for non-nut consumers, even after accounting for kilocalorie consumption and physical activity engagement.

Conclusion

Nut consumption is associated with consumption of other nutritionally rich foods and lower BMI among African American women in rural Alabama and Mississippi. Future interventions should target increasing daily nut intake, decreasing added sugar intake, and identifying strategies to encourage positive dietary changes to continue after an intervention.

Introduction

African American women in the rural southeastern United States have the highest rates of obesity and obesity-related diseases in the country (1,2). Eighty percent of African American women in the United States are either overweight or obese (3). This disparity may be the result of various influences (eg, environmental, cultural, behavioral) associated with low diet quality, resulting in high rates of obesity and chronic diseases (4,5).

African Americans in the rural South tend to consume a traditional "Southern" diet that contains large amounts of red or processed meats, salty snacks, and added sugar (6,7), which increase obesity and chronic disease risks (6). However, although these foods are in the diet, many protective plant foods such as collard greens, apples, green beans, and nuts are abundant in southern regions and are included in Southern cuisine (8–12). Nuts in particular may facilitate weight loss, and dietary patterns that include them generally result in lower rates of obesity and chronic disease risks (13–16). What is unknown is whether the consumption of nuts alongside other protective foods over time enhances synergistic health benefits (17) or whether the incorporation of nuts into a traditional Southern diet increases obesity risk. Weight loss interventions in this community are challenging because of high attrition rates, low weight loss maintenance, and failure to tailor dietary recommendations on the basis of foods already in the diet (18).

The objective of this study was to examine the longitudinal relationship between nut intake and other healthful foods (eg, fruits and vegetables) and foods whose intake is related to obesity and chronic disease (eg, red or processed meats, added sugars) in a 2-year weight-loss intervention among African American women in rural Alabama and Mississippi. We examined changes in body mass index (BMI, measured as weight in kg divided by height in m^2) between nut and non-nut consumers. We hypothesized that nut consumers would eat more fruits and vegetables, have lower BMI values, and lose more weight than non-nut consumers.

Methods

We used secondary data from the Deep South Network for Cancer Control (DSN). DSN is an ongoing collaboration among university researchers, public health practitioners, and volunteers who live and work in target communities. From its inception in 2000, the aim of DSN has been to eliminate cancer disparities, particularly in rural communities of Alabama and Mississippi (19). For this study, analyses were performed on a subgroup of 383 overweight and obese African American women who participated in a 2-year DSN weight loss intervention from 2011 through 2013.

Eight rural counties, evenly distributed between Alabama and Mississippi, were selected for the intervention. Participants lived or worked in one of these counties. Selected counties have limited access to health care and high poverty and cancer rates (19). Half of the counties, evenly distributed between states, received the group weight loss intervention, and the other counties received community strategies along with the weight loss intervention. The community strategies included grants to fund farmers' markets and produce stands in the community. The research protocol was approved by the institutional review board at the University of Alabama at Birmingham, and all participants provided written informed consent.

Recruitment and exclusion criteria

Recruitment for the parent study was conducted from January 2011 through September 2013 by study staff who lived in the communities of study. Participants were recruited through networking, word of mouth, and announcements in churches, health departments, schools, and other local facilities. People who were eligible self-identified as African American; lived, worked, or attended school in a participating community; were aged 30 to 70 years; had a measured BMI of 25 or greater; reported no history of weight loss surgery, eating disorder, recent cardiac event, or mobility impairment; and reported being a nonsmoker. Women were excluded at the baseline assessment if they had uncontrolled blood pressure (systolic blood pressure ≥160 mm Hg or diastolic blood pressure ≥100 mm Hg) or fasting blood glucose of 126 mg/dL or higher. Data from participants of the parent study who provided at least 2 dietary recalls over the study period (n = 383) were used for this study (Figure).

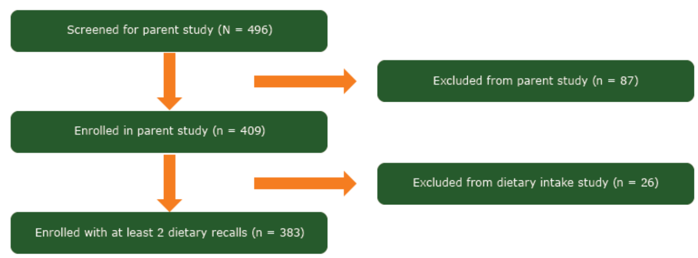

Figure. Study cohort enrollment diagram for 383 overweight and obese African American women enrolled in a weight loss intervention in rural Alabama and Mississippi, 2011–2013.

Demographic information and body mass index

Participants completed baseline demographic surveys that included questions about their age, employment status, annual household income, education level, and marital status. Trained staff members measured height and weight at baseline and at 6, 12, and 24 months. Height and weight were measured with a portable stadiometer (SECA 2-in-1 model no. 8761321004; seca GmBh & Co KG). Height was measured to the nearest 0.1 cm, and weight to the nearest 0.1 kg with light clothing and without shoes. BMI was calculated from height and weight measurements (20).

Intervention

The weight loss intervention was conducted during a 2-year period and included the first 6 months of intensive evidence-based education about obesity and chronic disease prevention as the initial study phase. By county, participants met once per week and were educated by trained volunteers about the role of healthy habits, including diet and regular physical activity, in promoting weight loss and preventing chronic disease. Participants were introduced to various weight loss strategies including reducing daily calorie intake, adhering to an exercise regimen, and preparing healthy meals. The weekly intervention meetings included discussions about participant successes and challenges to achieving their health goals, and participants received group support. The intensity of the intervention was gradually decreased, and in the following 6 months groups met twice per month (3 months), then monthly (3 months) to discuss maintenance of healthy habits learned in the program. During the second year (maintenance phase), group meetings were discontinued, and participants received monthly telephone calls from lay peer coaches to discuss maintenance of the healthy habits.

Dietary intake data collection

Dietary data were collected by using the Automated Self-Administered 24-Hour Dietary Recall (ASA24). ASA24 is a web-based tool that guides participants through recording all foods eaten on a previous day (21). ASA24 uses the Automated Multiple Pass Method (AMPM), which is an evidence-based approach intended to improve the accuracy of food intake recording in 24-hour dietary recalls (21,22). AMPM uses multiple probes throughout the recall to prompt users to remember all foods eaten in the previous day, including commonly forgotten foods. Because of limited computer access, participants completed the recalls with trained staff members by telephone and in person.

Dietary information was collected at baseline and at 6, 12, and 24 months. Each answer was entered into ASA24 at the time of interview. At each point, trained staff collected 1 weekday recall in person and 1 weekend recall by telephone. The rationale for 1 in-person and 1 telephone call was logistical. Because research study staff traveled to local communities (up to 4 hours away) to collect a weekday recall, capturing the weekend recall via telephone eliminated the need for participants and staff members to return to the assessment location for a single assessment. Visual cue cards were provided to participants preceding interviews to help them identify common household measurements, such as teaspoons and cups. The validity of the telephone method of administration for recalls has been established. Research indicates that the estimation of energy intakes was as effective in the telephone method as in the in-person method (22). Dietary recalls were collected from 383 participants during the 2-year study period.

Dietary intake nutrient analysis and physical activity

The ASA24 database was linked with the MyPyramid Equivalents Database (MPED) from the US Department of Agriculture. MPED standardizes the quantities of reported food groups (23). In MPED, protein foods, such as red meat and processed meats, were measured in ounces. Nuts, including peanuts, tree nuts, and seeds, were measured in ounce equivalents (oz eq), where 0.5 oz of nuts is nutritionally equivalent to 1 oz of lean meat. Fruits and vegetables were measured in cup equivalents (cup eq) of whole fruit (not including juice) and total vegetables, and added sugars were calculated in teaspoon equivalents (tsp eq).

Nut consumers were identified by points in time and overall. At each point, nut consumers were identified as participants who consumed nuts, whereas non-nut consumers were participants who did not consume nuts at that point. Overall nut consumers were defined as participants who ate nuts during at least 1 of the 4 points, whereas non-nut consumers did not.

Participants completed surveys that asked 2 questions about the number of days per week they engaged in physical activity (moderate and/or vigorous physical activity) at each of the 4 points. Moderate physical activity was defined as "physical activity that causes some increase in breathing or heart rate" (eg, brisk walking, bicycling, vacuuming, gardening). Vigorous activity was defined as "physical activity that causes large increase in breathing or heart rate" (eg, running, aerobics, heavy yard work) (24).

Statistical methods

Four dietary recall points at 6-month intervals over a 24-month period were examined to reflect changes in dietary intake over time. Participation rate and the proportion of nut to non-nut consumers overall and at each point were calculated. Participants who completed dietary recalls for at least 1 of the 4 points were included in the analysis. The linear mixed models accounted for missing data and drop-out patterns by adjusting for random variables and time-varying covariates, such that an unequal number of observations across participants did not negatively affect the results (25).

The food groups and components that were examined included nuts, fruits, vegetables, red meat, processed meat, and added sugars. These food groups were chosen on the basis of their association with obesity, obesity-related chronic diseases, or both (15,26–28). To account for underlying data distribution, we calculated median intake of nuts and of these food groups or components of interest at each point. We used Mann–Whitney tests to compare differences in median food group intake at each point between groups. After the Johnson SI transformation was applied to BMI, *t* tests were used to examine differences in mean BMI between groups at each point.

Mixed linear models were used to examine the relationship between nut intake and the intake of the select food groups and components over time using a factorial design. In this model, nut intake at baseline and at 6, 12, and 24 months (points 1, 2, 3, and 4, respectively) was the independent variable and the food groups and components at baseline and at 6, 12, and 24 months were the dependent variables. The model also accounted for the variability within and between participants. The relationship between nut intake and BMI over time was also identified by using interaction testing. Both mixed models were adjusted for age, annual household income, education level, and mean daily kilocalorie intake. The relationship between nut intake and BMI was further adjusted for number of days per week of moderate and vigorous physical activity reported. The slopes were tested to determine the presence of a significant change in the association between nut intake and intake of select food groups and components and BMI over time. All statistical tests were conducted using JMP Pro 12 (SAS Institute, Inc), and *P* values of .05 or less were considered significant.

Results

Seventy percent of the 383 participants were overall nut consumers, and approximately 38% of participants consumed nuts at each point (Table 1). Nut consumers and non-nut consumers were similar at baseline in BMI, age, annual household income, and education level (Table 2).

Food consumption differences between nut and non-nut consumers

Overall nut consumers had significantly higher intakes of fruits and vegetables and lower intakes of red meat than did non-nut consumers (Table 3). However, nut consumers and non-nut consumers reported similar dietary trends at baseline and at 24 months (Table 3). At 24 months, nut consumers consumed significantly less median daily sugar than they did at baseline (4.7 less tsp eq/d, $P < .001$; 1.6 less tsp eq/1,000 kcal/d, $P = .004$). When accounting for kilocalories consumed, however, there were no significant differences in median nut, fruit, vegetable, or red meat intake between baseline and 24 months. Results were similar for non-nut consumers, who also reported consuming less added sugar at 24 months than they did at baseline (2.7 less tsp eq/d, $P < .001$; 0.8 less tsp eq/1,000 kcal/d, $P = .01$). They also reported significantly lower processed meat intake between baseline and 24 months ($P = .02$). However, there was no change in median fruit, vegetable, or red meat intake between baseline and 24 months. There was no difference in added sugar intake between nut consumers and non-nut consumers when comparing baseline and 24 months ($P = .30$).

Similar results were observed when conducting longitudinal analyses of food group and component intake over time in nut consumers and non-nut consumers separately. When adjusting for kilocalories consumed, there were no changes in red or processed meat intake over time in either group, and non-nut consumers did not change their fruit or vegetable intake over time. However, nut consumers increased their fruit ($P = .009$) and vegetable ($P = .01$) intake over time. Furthermore, the decrease in daily added sugar intake per 1,000 kcal over time was significant for both nut consumers ($P = .004$) and non-nut consumers ($P = .01$). The change from baseline to 24 months in total daily added sugar intake ($P = .07$) and daily added sugar intake per 1,000 kilocalories ($P = .57$) did not differ between groups enough to attain significance. When adjusting for age, annual household income, and education level, both nut consumers and non-nut consumers significantly decreased their mean daily kilocalorie consumption throughout the intervention ($P < .001$ for both groups).

Longitudinal relationship between nut intake and BMI

Overall nut consumers had significantly lower BMI values than did non-nut consumers over the study period ($P < .001$, Table 3) and at each point (baseline, $P = .04$; 6 months, $P = .009$; 12 months, $P = .003$; 24 months, $P < .001$). Nut consumers at each point had lower BMI values than did non-nut consumers (Table 3). In the longitudinal analysis, BMI values of all participants decreased over the 2-year period ($P = .002$), although this result was significant in nut consumers ($P = .01$) but not in non-nut consumers ($P = .63$). For nut consumers, this finding remained after the model was adjusted for age, annual household income, and education level ($P < .001$) and for number of days per week of exercise ($P < .001$) and mean daily kilocalories consumed ($P = .05$).

Discussion

We monitored changes in dietary intake over a 2-year weight loss intervention in 383 overweight and obese African American women in rural Alabama and Mississippi. Specifically, we wanted to identify whether or not nut consumption was accompanied by a higher intake of other protective plant foods and the association between nut intake and BMI.

Our main finding was that, even when adjusting for confounders, nut consumption was consistently associated with lower BMI over time. A possible explanation for this is that nut consumers ate more plant foods and less red meat than did non-nut consumers. Diets that emphasize nuts, fruits, and vegetables and limit red meat are protective against obesity and chronic diseases (13). Even though median nut intake among nut consumers remained stable over the intervention, the overall diet of nut consumers may have contributed to weight management. One previous study found lower BMI values in individuals who consumed nuts long-term compared with those who did not, despite the amount consumed (29). These results coincide with our findings and suggest that a small amount of nut intake may be associated with significant weight management benefits if consumed over a long period. Nut consumers also significantly reduced their added sugar intake from baseline to 24 months, which may have further assisted with weight loss (28).

An area of concern observed in this study was that some of the positive dietary behaviors noted in both nut consumers and non-nut consumers did not persist to the end of 24 months. It is common for African Americans in the South to fall short of federal recommendations for intake of fruits and vegetables (30). Previous lifestyle interventions in African American communities have described similar challenges in participants maintaining healthy behaviors after an intervention (18). Because food choices in African American communities are closely linked to cultural traditions, adhering to a pattern that excludes cultural foods that are less nutritious may be challenging, even for those who desire to lose weight (4). Positive dietary changes must remain after an intervention period for participants to continue to experience the health benefits gained during the intervention.

A strength of this study was that it used a large sample size, which was also homogeneous in race, weight status, geographic location, and sex. Therefore, results provide a reliable examination of nut-inclusive diets among overweight and obese African American women who participated in the DSN study in the rural South. One weakness included reliance on self-reported data, such as dietary intake and physical activity. However, these were the most economically feasible approaches for this study. Caution should be used when generalizing the findings to women of other races, age groups, and regions of the country.

The impact of future weight loss interventions in this community could be enhanced by encouraging increased nut intake and decreased added sugar intake and by introducing low-calorie substitutions for popular Southern foods such as red and processed meats. Interventions may be able to encourage long-term dietary changes by focusing on maintaining a group or family support system after the intervention. Participants may be trained as leaders to teach community members the material learned in the intervention. An ongoing system of community involvement may encourage more widespread and long-term positive changes after the intervention. Future studies may also examine the effect of nut consumption on metabolic processes among women in this population.

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Tables

Table 1. Dietary Recall[a] Participation Among 383 Overweight or Obese African American Female Nut Consumers and Non-Nut Consumers in Rural Alabama and Mississippi, 2011–2013

Time	Participation Rate[b]	Nut Consumers[c]	Non-Nut Consumers[d]
	Proportion (%)		
Overall	383 of 383 (100)	267 of 383 (70)	116 of 383 (30)
Baseline	382 of 383 (99.7)	160 of 382 (42)	222 of 382 (58)
6 Months	328 of 383 (86)	119 of 328 (36)	209 of 328 (64)
12 Months	287 of 383 (75)	116 of 287 (40)	171 of 287 (60)
24 Months	232 of 383 (61)	79 of 232 (34)	153 of 232 (66)

[a] Dietary recalls were administered using the web-based Automated Self-Administered 24-Hour (ASA24) recall system.
[b] Women who participated in the dietary recall analysis portion of an intervention of the Deep South Network for Cancer Control.
[c] Participants were classified as nut consumers if they reported consuming nuts on at least 1 of the 4 dietary recall points.
[d] Participants were classified as non-nut consumers if they did not report consuming nuts on at least 1 of the 4 dietary recall points.

Table 2. Baseline Demographic Characteristics of 383 Overweight or Obese African American Female Weight Loss Participants in Rural Alabama and Mississippi, 2011–2013

Baseline Description[a]	Total	Nut Consumers	Non-Nut Consumers
BMI, mean (SD), kg/m^2	38.6 (8.1)	38.0 (7.5)	39.1 (8.6)
Age, mean (SD), y	47 (10)	47 (11)	46 (10)
Annual household income, $			
<10,000	73 (19)	23 (15)	50 (23)
10,000–19,999	87 (23)	41 (26)	46 (21)
20,000–29,999	80 (21)	33 (21)	47 (22)
30,000–39,999	57 (15)	22 (14)	35 (16)
40,000–49,999	32 (9)	18 (11)	14 (6)
≥50,000	36 (10)	18 (11)	18 (8)
Don't know/unsure	11 (3)	3 (2)	8 (4)
Missing	6 (1)	2 (1)	4 (2)
Education level			
Less than high school	22 (6)	5 (3)	17 (8)
High school graduate/GED	129 (34)	51 (32)	78 (36)
Some post high school	71 (19)	31 (20)	40 (18)
College graduate or more	152 (41)	70 (45)	82 (38)
Don't know/unsure	1 (0)	0 (0)	1 (0)
Missing	7 (2)	3 (2)	4 (2)

Abbreviations: BMI, body mass index; GED, general educational development; SD, standard deviation.
[a] There were no significant differences in BMI, age, income, or education between nut consumers and non-nut consumers at baseline (P = .19, P = .32, P = .27, and P = .06, respectively). Values are presented as no. (%), unless otherwise indicated.

Table 3. Difference in Food Group/Component Consumption and BMI Between 383 Overweight and Obese African American Nut Consumers and Non-Consumers in Rural Alabama and Mississippi, at Baseline, 6 Months, 12 Months, and 24 Months, 2011–2013

Food Group/Component	All Participants	Nut Consumers	Non-Nut Consumers	*P* Value[a]
	Median (25th–75th Percentile)/Median Per 1,000 kcal			
Nuts, oz equivalent				
Overall	—	0.4 (0.1–1.2)/0.3	—	—
Baseline	—	0.4 (0.1–1.0)/0.3	—	—
6 Months	—	0.5 (0.2–1.5)/0.4	—	—
12 Months	—	0.4 (0.1–1.3)/0.3	—	—
24 Months	—	0.5 (0.2–1.0)/0.3	—	—
Adjusted *P* value (per 1,000 kcal)[b]	—	.19	—	—
Whole fruit, cup equivalent				
Overall	0.4 (0–1.0)/0.3	0.4 (0–1.1)/0.4	0.2 (0–0.9)/0.2	<.001
Baseline	0.2 (0–0.9)/0.2	0.6 (0.1–1.0)0.3	0.1 (0–0.7)/0.1	<.001
6 Months	0.5 (0–1.4)/0.5	0.6 (0.2–1.6)/0.5	0.5 (0–1.3)/0.4	.09
12 Months	0.4 (0–1.1)/0.3	0.5 (0.1–1.4)/0.4	0.4 (0–1.0)/0.3	.01
24 Months	0.3 (0–1.0)/0.2	0.4 (0–1.3)/0.4	0.2 (0–0.9)/0.2	.17
Adjusted *P* value (per 1,000 kcal)[b]	.005	.009	.20	.22[c]
Vegetables, cup equivalent				
Overall	1.1 (0.7–1.6)/0.8	1.2 (0.7–1.7)/0.8	1.0 (0.6–1.5)/0.8	<.001
Baseline	1.1 (0.7–1.6)/0.7	1.2 (0.8–1.7)/0.7	1.0 (0.7–1.5)/0.7	.04
6 Months	1.2 (0.7–1.8)/0.9	1.3 (0.8–1.8)/0.9	1.2 (0.7–1.8)/0.9	.25
12 Months	1.1 (0.7–1.6)/0.5	1.2 (0.7–1.6)/0.8	1.1 (0.6–1.6)/0.8	.44
24 Months	1.1 (0.6–1.6)/0.8	1.1 (0.6–1.6)/0.8	1.0 (0.6–1.5)/0.8	.46
Adjusted *P* value (per 1,000 kcal)[b]	.009	.01	.38	.11[c]
Red meat, oz				
Overall	0.7 (0–1.8)/0.5	0.6 (0–1.7)/0.4	0.9 (0–2.0)/0.6	.01
Baseline	0.9 (0.1–2.0)/0.6	0.9 (0–2.0)/0.4	0.1 (0.2–2.0)/0.7	.07
6 Months	0.5 (0–1.5)/0.3	0.4 (0–1.2)/0.2	0.5 (0–1.8)/0.4	.11
12 Months	0.6 (0–1.9)/0.5	0.6 (0–1.7)/0.5	0.6 (0–1.9)/0.5	.28
24 Months	0.6 (0–1.8)/0.6	0.3 (0–1.5)/0.3	0.7 (0–1.8)/0.6	.41
Adjusted *P* value (per 1,000 kcal)[b]	.83	.43	.82	.43[c]
Processed meat, oz				
Overall	0.2 (0–0.9)/0.2	0.2 (0–0.9)/0.2	0.3 (0–0.9)/0.2	.59
Baseline	0.4 (0–1.1)/0.3	0.4 (0–1.0)/0.2	0.4 (0–1.1)/0.3	.43

Abbreviations: — , does not apply; BMI, body mass index; SD, standard deviation.
[a] *P* values were determined by Mann–Whitney tests and compare differences in food intake between nut and non-nut consumers at each of the 4 time points.
[b] *P* values were determined by linear mixed models and compare changes in food group intake over time in all participants, nut consumers, and non-nut consumers while adjusting for daily kilocalorie consumption.
[c] *P* values were determined by linear mixed models and compare differences in dietary changes over time between nut and non-nut consumers while adjusting for daily kilocalorie consumption.
[d] *P* values were determined by *t* tests and compare BMI differences between nut and non-nut consumers at each time point.

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Table 3. Difference in Food Group/Component Consumption and BMI Between 383 Overweight and Obese African American Nut Consumers and Non-Consumers in Rural Alabama and Mississippi, at Baseline, 6 Months, 12 Months, and 24 Months, 2011–2013

Food Group/Component	All Participants	Nut Consumers	Non-Nut Consumers	*P* Value[a]
	Median (25th–75th Percentile)/Median Per 1,000 kcal			
6 Months	0.2 (0–0.8)/0.1	0 (0–0.7)/0	0.3 (0–0.9)/0.2	.09
12 Months	0.2 (0–0.9)/0.1	0.3 (0–0.9)/0.2	0.2 (0–0.9)/0.1	.77
24 Months	0 (0–0.8)/0	0 (0–0.9)/0	0.04 (0–0.8)/0.04	.98
Adjusted *P* value (per 1,000 kcal)[b]	.18	.71	.07	.14[c]
Added sugar, tsp equivalent				
Overall	9.4 (4.9–14.7)/7.2	9.6 (4.9–14.9)/7.4	9.0 (4.5–14.5)/7.0	.16
Baseline	12.0 (7.5–17.6)/8.1	13.0 (8.7–20.0)/8.2	10.8 (6.6–16.7)/7.8	.005
6 Months	8.4 (3.7–13.4)/6.3	9.5 (5.8–14.0)/6.7	7.3 (2.9–13.0)/6.1	.003
12 Months	8.7 (4.3–14.3)/6.6	8.8 (4.4–14.8)/6.6	8.3 (4.2–14.1)/6.7	.48
24 Months	8.2 (4.4–12.8)/6.8	8.3 (4.4–13.2)/6.6	8.1 (4.3–12.4)/7.0	.51
Adjusted *P* value (per 1,000 kcal)[b]	<.001	.004	.01	.57[c]
Body mass index, kg/m^2, mean (SD)				
Overall	38 (8)	37 (7)	40 (9)	<.001[d]
Baseline	39 (8)	38 (7)	39 (9)	.33[d]
6 Months	37 (8)	36 (7)	38 (8)	.25[d]
12 Months	37 (8)	36 (7)	38 (8)	.009[d]
24 Months	38 (8)	37 (7)	38 (8)	.07[d]

Abbreviations: — , does not apply; BMI, body mass index; SD, standard deviation.
[a] *P* values were determined by Mann–Whitney tests and compare differences in food intake between nut and non-nut consumers at each of the 4 time points.
[b] *P* values were determined by linear mixed models and compare changes in food group intake over time in all participants, nut consumers, and non-nut consumers while adjusting for daily kilocalorie consumption.
[c] *P* values were determined by linear mixed models and compare differences in dietary changes over time between nut and non-nut consumers while adjusting for daily kilocalorie consumption.
[d] *P* values were determined by *t* tests and compare BMI differences between nut and non-nut consumers at each time point.

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ORIGINAL RESEARCH

Health Care Disparities Between Men and Women With Type 2 Diabetes

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PEER REVIEWED

Abstract

Introduction
Regular medical checkups indicate a patient's level of adherence to health care treatment, and the frequency of cancelled appointments or no-shows can indicate adherence. This study investigated the use of health care services by men and women and its impact on the control of their type 2 diabetes.

Methods
This study observed 100 patients with type 2 diabetes aged 45 years or older who lived in Ventura County, California, during January 1, 2015, to January 31, 2016. The data were collected by Magnolia Family Medical Center. A Pearson χ^2 test compared differences between men and women in whether they received a glycated hemoglobin A_{1c} (HbA_{1c}) test in previous 6 months, a low-density lipoprotein cholesterol test in previous year, and a retinal examination in previous year. A Wilcoxon signed-rank test compared attendance to medical appointments and HbA_{1c} values for men and women.

Results
Women had a higher rate of scheduling, cancelling or rescheduling, and showing up to their medical appointments than did men, and men had a higher median HbA_{1c} value than did women; all the Wilcoxon signed-rank tests showed a significant difference ($P < .001$). None of the χ^2 tests were significant.

Conclusion
Although men and women had similar health care services for diabetes, men had less control of their disease and took less advantage of medical appointments than did women.

Introduction

The prevalence of type 2 diabetes increased from 1980 through 2014 (1). Dieting, exercising, attending regular medical check-ups, and screenings may prevent or control such disease (2). Regular medical checkups indicate a patient's level of adherence to health care treatment, and the frequency of cancelled appointments or no-shows can indicate adherence. Several screenings, such as retinal examinations and laboratory work for glycated hemoglobin A_{1c} (HbA_{1c}) and low-density lipoprotein (LDL) cholesterol, are recommended for proper diabetes care and disease prevention (3).

HbA_{1c} measurements are used to observe the patient's blood glucose level. The higher the HbA_{1c}, the more sugar is found attached to the red blood cells; HbA_{1c} should be less than 5.7% (3). People with diabetes have an HbA_{1c} of 6.5% or higher (3). LDL cholesterol is a measurement of low-density lipid to determine the risk of developing heart disease. Patients are at a higher risk of heart diseases if they have diabetes and have high levels of LDL cholesterol (3). A retinal examination, or a funduscopy, checks for eye diseases. Uncontrolled diabetes can lead to diabetic retinopathy (3). According to American Diabetes Association's *Standards of Medical Care in Diabetes*, HbA_{1c} measurements should be done at least once every 6 months, LDL cholesterol measurements should be done at least once every 5 years, and retinal examinations should be done at least once every 2 years (3). If patients are taking statins to lower blood pressure, the frequency of LDL cholesterol measurements depends on the physician and patient (3). Patients with any levels of diabetic retinopathy should have retinal examinations at least once every year (3).

Proper treatments are done after an individual has had diabetes diagnosed. Preventing or slowing the progression of such disease depends ultimately on the patient. This is a health issue because a disease can progress without early detection, proper diagnosis, treatment, and full commitment of the patient.

Several factors in a person's life can create difficulties in diabetes prevention and control, including the level of adherence to recommended schedules of medical care services. Shalev et al and Krämer et al have found significant difference between men and women and their use of medical care (4,5). However, both studies were generalizable to individuals outside of the United States. Vaidya et al found that women used preventive care more frequently (6); however, they did not observe patients already diagnosed with diabetes. Bertakis et al found that women used health care services more often than did men (7). However, that study examined data on all health care services, including those that may not pertain to men.

The objective of my study was to determine whether differences exist between men and women in the control of diabetes and the use of medical appointments.

Methods

The study cohort was patients with type 2 diabetes aged 45 years or older who lived in Ventura County, California, and were regularly checked for diabetes care at Magnolia Family Medical Center. I obtained the data from Magnolia Family Medical Center with the approval of the medical director. The Quality Improvement and Research: Spreading Effective and Efficient Diabetes Care (QIR/SEED) department of Magnolia Family Medical Center collected data from the clinic's electronic health records system, Cerner (Cerner Corporation), through Cerner's Explorer Menu application. The Explorer Menu application produced a report of patients with a Systematized Nomenclature of Medicine–Clinical Terms (SNOMED–CT) problem code of 197763012, which was a diagnostic code for diabetes mellitus 2 in Cerner. The application was then used to identify all patients with that SNOMED-CT code who were aged 45 years or older and who came into the clinic with an appointment during January 1, 2015, to January 31, 2016. The report included data on patient demographics, diagnoses, history, primary care provider name, and appointments.

With the report generated by the Explorer Menu, QIR/SEED collected data on patients who had diagnoses of hypertension or hyperlipidemia and who did not have anemia. QIR/SEED screened out patients who were not regular patients of Magnolia Family Medical Center and who were seen only for a nonprovider appointment. Because of the time involved in gathering information for each patient, the first 50 men and 50 women who fit the criteria from a stratified random sample were included in the study. The study focused on the 100 patients' medical activities from January 1, 2015, to January 31, 2016.

Demographic variables analyzed were age (45–54, 55–64, and ≥65 years), race/ethnicity (Asian, black/African American, other or more than 1 race, white Hispanic, and white non-Hispanic), and sex. The racial/ethnic distribution of this sample was compared with that of Ventura County, which is 84.5% white Hispanic and non-Hispanic (8). Patient appointment data analyzed were the number of no-shows, number of cancelled or rescheduled appointments, and total number of appointments. Show-up rates were calculated by subtracting the number of no-shows from the number of total appointments. Laboratory data for HbA_{1c} and LDL cholesterol were reviewed and noted as to whether they were outdated, up to date, or not done. Retinal examination status was noted as to whether the examinations were outdated, up to date, could not be performed, or the patient had never had one. If the patient did not get their HbA_{1c} test done within 6 months of their last HbA_{1c} test during the study period, their HbA_{1c} status was recorded as outdated. Similarly, retinal examinations and LDL cholesterol tests that were not done within 1 year from the last examination during the study period were recorded as outdated. The number of canceled and rescheduled appointments were recorded to observe the patients' commitment to medical appointments concerning diabetes. The number of no-shows is the number of times a patient had an appointment and failed to show up. The total number of appointments scheduled included no-shows and kept appointments during the study's timeframe.

Patients' names, addresses, medical record numbers, date of birth, and any identifying factors were excluded from the data analyzed. Medical record numbers were changed to a random value from 1 to 100 to protect the patients' identities. Factors such as insurance coverage, transportation, jobs, and family commitments were not considered in the study because they are extrinsic factors. Also not recorded was time since a patient received a diagnosis of diabetes. Medication adherence was measured through the patients' verbal responses to their physician's questions about whether or not they were taking their medications; to avoid the limitations associated with self-reported data, data on medication adherence were excluded from the study. A letter of exemption from National University's institutional review board was obtained to investigate these data.

RStudio (RStudio) was used to analyze and interpret the data. In RStudio, box plots were produced to check for outliers and visualization of any possible differences. The box plots were also used for analyzing the distribution of the data set. A Pearson χ^2 test compared differences between men and women in whether they received an HbA_{1c} test in previous 6 months, an LDL cholesterol test in previous year, and a retinal examination in previous year. The χ^2 test was also used to examine whether these variables were dependent on each other. A Wilcoxon signed-rank test was performed on sex versus total appointments scheduled, appointments cancelled or rescheduled, rate of showing up, and HbA_{1c} values. The Wilcoxon signed-rank test was also used to observe any differences between the medians for men and women. The level of significance used for both the χ^2 test and Wilcoxon signed-rank test was $\alpha = .05$.

Results

Of 100 patients in this study, 7 were Asian, 2 were black/African American, 45 were white non-Hispanic, 32 were white Hispanic, and 3 were other or more than 1 race. Only data on the white non-Hispanic and white Hispanic groups were analyzed because the other 3 groups had small numbers. This racial/ethnic distribution is similar to that of the Ventura County population. Eighty-eight percent of the white non-Hispanic group had an outdated HbA_{1c} test, 45.1% had an outdated LDL cholesterol test, and 66% had an outdated retinal examination. In the white Hispanic group, 86.5% had an outdated HbA_{1c} test, 56.8% had an outdated LDL cholesterol test, and 68.6% had an outdated retinal examination.

Of the 100 patients, 36% were aged 45 to 54 years (21 men and 15 women), 44% were aged 55 to 64 years (23 men and 21 women), and 20% were aged 65 years or older (6 men and 14 women). The range for HbA_{1c} values for women was 5.2 to 12, with an outlier of 12. The range for HbA_{1c} values for men was 5.8 to 12, with no outliers. The range of total appointments for women was 15 to 118 and for men was 6 to 58; for women, 118 was an outlier, and for men 58 was an outlier. The range of values for showing up to an appointment for women was 16 to 116 and for men was 6 to 58; for women, 116 was an outlier, and for men 58 was an outlier. The range of values for cancelled or rescheduled appointments for women was 5 to 57 and for men was 3 to 19; 57 was an outlier for women, and there was no outlier for men.

During January 1, 2015, to January 31, 2016, most men (76%) and most women (70%) had had at least 1 HbA_{1c} test done within 6 months (Table). HbA_{1c} tests were outdated for 18% of men and 30% of women. Most men (90%) and most women (84%) had had an LDL cholesterol test within the previous 6 months; 8% of women and 10% of men had an outdated LDL cholesterol test. At least 1 retinal examination had been recorded in the past year for 62% of men and 56% of women; 18% of the men and 16% of the women had not had a retinal examination in the past year. Sixteen percent of men and 26% of women had an outdated retinal examination. No significant associations were found between sex and whether or not patients received any of these services within the designated time frame.

Men had a higher HbA_{1c} median than did women (Table). The median of appointments that men showed up for was 14.0, while for women the median was 23.5 ($P < .001$). Women had a higher median of cancelled or rescheduled appointments than men did ($P < .001$) and a higher median number of total appointment than men did ($P < .001$). Therefore, differences between use of appointments by men and women and their median HbA_{1c} values were significant (Table).

Discussion

This study found a difference in the control of diabetes as well as the use of medical appointments between men and women. Similar results were observed in studies by Bertakis et al, Legato et al, Grant et al, and Singh-Manoux et al (7,9–11). Each study suggested a difference between the prevalence of diseases, including diabetes, between men and women. Comparable to the findings of Shalev et al, the results of this study also found that women had more scheduled appointments than did men (4).

Men and women at Magnolia Family Medical Center were provided similar health care services and recommendations; such services included getting retinal examinations, complying with schedules for receiving laboratory tests, and showing up to their medical appointments. However, women had better control of their blood glucose levels. Thus, making sure both sex groups had up-to-date blood work and retinal examinations did not guarantee that both sex groups had similar diabetes control.

My study has a few strengths. For instance, the study solely focused on a population with a medical condition; thus, the study was specific. I did not collect the data; hence, no researcher-generated data-collection biases could affect the outcome. The study also had a long time frame of 1 year. Data were not collected from surveys, but rather through physician documents, laboratory reports, retinal examination reports, and scheduling reports. Thus, no biases could result from patient self-report or me.

This study also has limitations. The data collected were from a clinic; therefore, some outliers were found. Clinic providers had different data entry techniques; thus, some data may not have been collected. Because the data were collected through a computerized system that generated reports entered by people, data entry errors and other human errors limit the accuracy of the data. The study did not include data on the length of time that patients had had a diabetes diagnosis, and the findings are pertinent only to the population of patients with diabetes at Magnolia Family Medical

Center. Another limitation was the population size. The study examined data only for patients with type 2 diabetes who had hypertension or hyperlipidemia and who were taking similar medications. The study focused only on patients regularly seen by their primary care provider in Magnolia Family Medical Center. A bigger population size should be considered for future studies. The study was also biased toward recording appointments made with Magnolia Family Medical Center only. Other clinic appointments should be recorded for future studies.

Conclusions drawn from this observation are generalizable only to the population in the study. This study solely observed individuals with type 2 diabetes and focused on the population with diabetes at 1 clinic in Ventura County, California. The observations did not show an association between regular checkups and a decreased gap between proper diabetes care in both sex groups. Although the medical treatments of the men did not differ from those of the women, men had less control of their disease; thus, sex-specific medical treatments and health education should be investigated. Moreover, when treating men with type 2 diabetes, a care provider and health professional must stress the importance of controlling blood glucose levels and health care utilization. Further studies should also investigate what causes men to have less control of their blood glucose levels. For a generalizable study, factors such as medication adherence, types of insurance and coverage, the length of time since type 2 diabetes was diagnosed, age at which type 2 diabetes was diagnosed, and race/ethnicity should be included. Other extrinsic factors should be included because they may influence behaviors related to keeping appointments and compliance with medical treatments.

Overall, men were found to have lower rates of cancelling or rescheduling a medical appointment; however, they also had a lower rate of showing up to their appointments. Regardless of men and women having similar rates of getting their blood work and screening for retinal examinations, men were still found to have a significantly higher HbA_{1c} median compared with women. Therefore, even when both sex groups were provided similar health care services for diabetes, men still had less control of their diabetes. This study will contribute to improving care for diabetes patients and will encourage care managers to work closely with their patients.

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Table

Table. Use of Health Care Services Among 100 Patients With Diabetes Aged 45 Years or Older Regularly Seen at Magnolia Family Medical Center, Ventura County, California, January 1, 2015, to January 31, 2016

Variable	Population	Sex		*P* Value[a]
		Male	Female	
HbA_{1c} value, median	7.2	7.4	6.8	<.001[a]
Total no. of appointments, median	21.5	16.0	25.5	<.001[a]
No. of appointments showed up for, median	18.5	14.0	23.5	<.001[a]
No. of cancelled or rescheduled appointments, median	7.0	6.0	11.5	<.001[a]
Had HbA_{1c} test within previous 6 months, n (%)				
Yes	73 (73)	38 (76)	35 (70)	.99[b]
Not done	3 (3)	3 (6)	0	
No	24 (24)	9 (18)	15 (30)	
Had low-density lipoprotein cholesterol test within previous year, n (%)				
Yes	87 (87)	42 (84)	45 (90)	.54[b]
Not done	4 (4)	3 (6)	1 (2)	
No	9 (9)	5 (10)	4 (8)	
Had retinal examination within previous year, n (%)				
Yes	59 (56)	31 (62)	28 (56)	.63[b]
Not done	17 (17)	9 (18)	8 (16)	
Not applicable[c]	3 (3)	2 (4)	1 (2)	
No	21 (21)	8 (16)	13 (26)	

Abbreviation: HbA_{1c}, glycated hemoglobin A_{1c}.
[a] Based on Wilcoxon signed-rank test where α = .05.
[b] Based on Pearson χ^2 test of association where α = .05.
[c] Patients not able to obtain a retinal examination because of blindness or surgery (which would mean the patient's care was being handled by an ophthalmologist and the patient would most likely have received a retinal examination).

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ORIGINAL RESEARCH

Education, Income, and Employment and Prevalence of Chronic Disease Among American Indian/Alaska Native Elders

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PEER REVIEWED

Abstract

Introduction
Chronic disease studies have omitted analyses of the American Indian/Alaska Native (AI/AN) population, relied on small samples of AI/ANs, or focused on a single disease among AI/ANs. We measured the influence of income, employment status, and education level on the prevalence of chronic disease among 14,632 AI/AN elders from 2011 through 2014.

Methods
We conducted a national survey of AI/AN elders (≥55 y) to identify health and social needs. Using these data, we computed cross-tabulations for each independent variable (annual personal income, employment status, education level), 2 covariates (age, sex), and presence of any chronic disease. We also compared differences in values and used a binary logistic regression model to control for age and sex.

Results
Most AI/AN elders (89.7%) had been diagnosed with at least one chronic disease. AI/AN elders were also more than twice as likely to have diabetes and more likely to have arthritis. AI/AN elders with middle-to-low income levels and who were unemployed were more likely to have a chronic disease than were high-income and employed AI/AN elders.

Conclusion
Addressing disparities in chronic disease prevalence requires focus on more than access to and cost of health care. Economic development and job creation for all age cohorts in tribal communities may decrease the prevalence of long-term chronic diseases and may improve the financial status of the tribe. An opportunity exists to address health disparities through social and economic equity among tribal populations.

Introduction

Chronic diseases are the leading causes of death and disability in the United States, and nearly half of adults are diagnosed with one or more chronic conditions (1). Many of these conditions are disproportionally prevalent among American Indian/Alaska Natives (AI/ANs) (2,3). The prevalence of chronic conditions among AI/ANs results in low life expectancy (4,5), and AI/ANs are more likely than all other races in the United States to die of heart disease, diabetes, chronic lower respiratory disease, cirrhosis, stroke, pneumonia, kidney disease, and hypertension (4,6).

AI/ANs are more likely than their peers to be at risk for chronic disease as a result of income, education level, employment status, and health behaviors (7,8). One in 4 AI/ANs live in poverty, and tribal communities report the lowest employment rate nationally. The median annual personal income for AI/ANs is far below the national average (7,8). During 2001 and 2002, AI/AN elders (aged ≥55 y) were at greater risk for chronic disease than their non-Hispanic white peers when social status and health behaviors were examined (9). However, the study with these findings relied on a small sample (3,5), was conducted before the Patient Protection and Affordable Care Act and the US recession, and did not explore subgroups in the AI/AN elder population. Other national surveys on the prevalence and risk factors of chronic disease had a small sample of AI/ANs, were disease-specific, omitted analyses of the AI/AN population, or had cell sizes that were too small to report (9–11).

The objective of this national analysis was to identify which social factors, if any, influence the prevalence of chronic diseases among AI/AN elders (aged ≥55 y). We assessed the association of self-reported income, employment status, and education level on the prevalence of chronic disease among 14,632 AI/AN elders from 2011 through 2014.

Methods

The US Department of Health and Human Services' Administration for Community Living funds the National Resource Center on Native American Aging (NRCNAA). Data used in this study were taken from the NRCNAA's 2011–2014 Survey of Elders, which has been administered every 3 years since 2001.

Survey

NRCNAA faculty developed the paper survey to assist tribes, villages, and homesteads nationally in creating a record of the health and social needs of their elders. The results satisfy the requirement for Title VI Nutrition and Caregiving Grant under the Administration for Community Living. Self-reported data are collected every 3 years on general health status; activities of daily living; vision, hearing, and dental care screenings; health care access; tobacco and alcohol use; weight and nutrition; social support and housing; demographic characteristics; and social functioning. Survey measures mirror those of nationally administered questionnaires to allow for comparison to the US population (12). Data for this study were taken from Cycle V, which covers self-reported health status for AI/AN elders from 2011 through 2014. The University of North Dakota's institutional review board approved the survey and the proposed method of research; the Official Tribal Council for each participating tribe provided approval through a tribal resolution for the study.

The survey is administered via a Scantron form (Scantron Corporation) on which respondents fill in circles that correspond to the most appropriate responses. The survey also has several write-in responses that are input through image reader technology. Surveys are scanned in-house by NRCNAA staff. To build tribal capacity and improve trust among participants, trained members of the tribe administered the paper surveys to participating elders, reading the questions and filling in the corresponding answers on the form. These individuals were not paid by the NRCNAA directly, but many were employees of the Title VI program. The participating elders were allowed to skip questions they were not comfortable answering. Participating tribes returned all completed surveys to the NRCNAA research team.

All survey data are owned by the tribes. The NRCNAA houses the data, but staff report only in aggregate and under tribal approval. Tribal-specific reports are shared with Title VI directors, who then provide the data to members of the community and to community health groups (to include local public health units). NRCNAA staff and faculty (including authors) include both non-Natives and enrolled members of federally recognized tribes.

Study population

Tribes participating in the Title VI Nutrition and Caregiving Grant were recruited through the Title VI tribal directors, although we invited all tribes to participate. The 2011–2014 survey cycle included tribally affiliated elders aged 55 years or older. Participants represented all US regions, and 262 (of 566) federally recognized tribes. Within each tribe, researchers identified a simple random sample based on the total number of elders enrolled. The prestudy calculation of required sample size was determined by applying a formula to each tribe. The formula was applied to each of the 262 tribes independently to ensure that the sample obtained was representative of that tribe and not an aggregate representation of all participating tribes collectively. This method allowed results that were representative and generalizable to their population to be shared with each tribe and not to all participating tribes.

Individuals were included in the study if they were aged 55 years or older, an enrolled member of a federally recognized tribe, and eligible to accept services under the Title VI Nutrition and Caregiving Grants. The survey had a 68.5% response rate (14,632 of 21,361 respondents).

Measures

Independent variables were employment status (employed, unemployed/retired); education level (no education or less than a high school diploma, high school graduate, any education beyond high school); and annual personal income (<$15,000 [low]; $15,000–$49,999 [middle]; ≥$50,000 [high]). Income level was listed categorically in the survey instrument. We controlled for age (55–64 y, 65–74 y, ≥75 y) and sex (male/female). The dependent variable was diagnosis of any chronic disease. Participants replied to the question, "Has a doctor ever told you that you had any of the following diseases (please mark all that apply)?" The presence of chronic disease was assessed with 10 conditions: arthritis, congestive heart failure, stroke, asthma, cataracts, high blood pressure, osteoporosis, depression, diabetes, and cancer. We included cataracts in our analysis because literature on the elderly population more commonly refer to this vision impairment as a chronic condition, and the World Health Organization indicates it as a priority eye disease (13,14). Furthermore, diabetes is associated with the development of cataracts.

Statistical analysis

We used SPSS (IBM Corporation) to compute summary statistics to identify characteristics of the study population. To determine the prevalence of chronic disease, we created a binary variable to include respondents with at least one of the 10 identified chronic conditions and those without. We converted age from a ratio to a categorical variable, a method most commonly used in health research (15), and converted education level from a 0 to 17 scale to a 3-point scale. We determined the percentage of participants with and without chronic conditions within each category of the independent variables. We computed cross-tabulations for each independent variable and presence of any chronic disease and used a binary logistic regression model ($P \leq .05$). In the regression model, researchers controlled for age (categorically), and sex (male/female).

Results

Respondents were mostly female (62.3%), unemployed/retired (69.4%), aged 55 to 64 years (40%), and middle income (56.1%) and had completed some education beyond high school (38.7%). Most AI/AN elders (89.7%) had been diagnosed with at least one of 10 chronic diseases; 69.8% had 2 or more chronic conditions, and 45.2% had 3 or more. The most common chronic diseases among AI/AN elders were high blood pressure (58.9%), diabetes (53.9%), and arthritis (47.2%) (Table 1).

The prevalence of having one or more chronic diseases was significantly higher among female (91.1%) than male (87.5%) elders; among elders aged 65 to 74 years and aged 75 years or older than those aged 55 to 64 years; among low-income and middle-income elders than high-income elders; among unemployed (92.4%) than employed (83.9%) elders; and among elders who had not completed high school than those with a high school diploma and those with education beyond high school (all $P \leq .05$) (Table 2).

When we controlled for age and sex, middle-income AI/AN elders were 1.3 times as likely as high-income AI/AN elders to be diagnosed with one or more chronic diseases (Table 3). Employed AI/AN elders were less likely than unemployed AI/AN elders to be diagnosed with one or more chronic diseases. When we controlled for age and sex, educational attainment did not have a significant influence on the likelihood that an AI/AN elder would be diagnosed with at least one chronic disease (Table 3).

Discussion

AI/AN elders have a higher prevalence of chronic disease than other races in the US population yet are largely overlooked in research and in proposed federal, social, and tribal interventions. We identified the influence of social variables on the health status of AI/AN elders and found that 89.7% of elders surveyed from 2011 through 2014 had at least one chronic disease. Comparatively, the National Council on Aging, using 2015 Medicaid and Medicare data, reported that 80% of older adults of all races had at least one chronic condition (16,17).

High blood pressure, diabetes, and arthritis were the 3 leading chronic conditions for AI/AN elders. The frequency of hypertension among AI/AN elders (58.9%) nearly mirrored the national average (58%) (16,17). However, other chronic conditions among AI/AN elders occurred at double the national average. Specifically, 54% of the AI/AN elders reported diabetes, compared with only 27% of the US population aged 65 years or older. Roughly 31% of all US adults aged 65 or older were diagnosed with arthritis in 2015, compared with 47.2% of AI/AN elders (16,17).

Federal, state, community, and tribal interventions and policies must explore the prevalence of chronic conditions by race, rather than solely examine general prevalence of chronic disease. Data for AI/AN elders and for the general US elder population identify the prevalence of similar chronic diseases, but special attention must be paid to AI/AN elders. The significant disparity among diseases (eg, diabetes) may also indicate that programs designed to reduce the prevalence of that disease among the general US elder population are not effective, are not reaching tribal populations, or both. As public health units become increasingly responsible for the prevention of chronic disease, these data may be used to develop interventions that are population-specific for each chronic condition.

We established the prevalence of chronic disease among AI/AN elders and then identified demographic categories with higher prevalence of chronic disease. As in national trends, female AI/AN elders were significantly more likely than male AI/AN elders to have a chronic condition (18–21). Approximately 91% of AI/AN female elders had at least one chronic disease, compared with 87.5% of AI/AN male elders. As age increased among elders, so did the likelihood of having a chronic condition, which mirrors national trends (21).

The prevalence of chronic disease among AI/ANs who were employed was significantly lower than for those who were unemployed; similarly, those with high income were less likely than middle-income and low-income elders to have a chronic condition. These trends were also reported by the National Center for Health Statistics for the general US population in 2013 (15). Cost of care is the most common reason patients with chronic conditions delay treatment or prevention (regardless of income or employment status) (22). Therefore, there is heightened concern for the AI/AN elder population, as most were unemployed and middle-income to low-income and less likely to then afford health care services both on and off of the reservation.

Although the Indian Health Service (IHS) provides care at reduced cost to AI/ANs on the reservation, access to that care is limited because IHS consistently is underfunded (23,24). During 2009 and 2010, Indian health expenditures per capita were one-third of the expenditures for Medicare, and they were lower per capita than those for veterans, Medicaid patients, and participants in the Federal Employees Health Benefits Program (25). AI/ANs also have high uninsured rates, making it more difficult to access care outside of IHS, especially for those who are low-income (23). These issues of access to affordable care likely contribute to the increased prevalence of chronic disease among AI/AN elders who are low-income and unemployed.

To prevent chronic diseases and improve the health status of those with chronic diseases, communities and programs can investigate job creation for AI/AN elders. Elders may also require resources like transportation and job training. Economic development and job creation for all age cohorts in tribal communities will benefit long-term chronic disease prevalence and can improve the financial status of the tribe.

Results also indicate a need to identify solutions that are focused more on population health than on access to or cost of care. Communities have developed programs that rely on collaboration between public health units, at-risk tribal populations, and local health care systems to address prevention and early detection services (26–29). As public health units take on a larger responsibility for population health, this data can and is being used to target population subgroups in the AI/AN population who have an increased prevalence of chronic conditions. Tribal public health units can identify subgroups (eg, women) that have a higher prevalence of certain chronic conditions and provide education and prevention that is specific to them (26). Likewise, as AI/ANs seek information, prevention, and treatment outside of IHS, local public health units need to recognize that AI/AN elders that use their services likely have multiple chronic conditions. Shaw et al discussed health literacy and the need for communities and public health units to understand the socioeconomic and cultural differences of at-risk populations (29). Programs exist that effectively incorporate cultural traditions in public and tribal health services (10,27,29,30). These models can improve the health of tribal communities and their elders.

This study has several limitations. First, the national definition of elderly is typically aged 65 or older. We assessed chronic disease among AI/AN elders aged 55 or older. This decision was in response to the lower average life expectancy of AI/ANs compared with that of the general US population. However, doing so made it difficult to compare AI/AN elders' prevalence of chronic disease to the prevalence of disease among all older people in the United States with any certainty. This limitation, however, provides a conservative measure of chronic disease among AI/ANs elders, recognizing that research indicates a higher prevalence among older cohorts. Omitting respondents aged 55 to 64 years would have resulted in higher prevalence rates for the AI/AN population.

The self-reported diagnosis of a chronic disease may also be problematic. There is risk of both underreporting and overreporting. Elders may not want to identify with a given disease or may have low health literacy and misunderstand or forget a diagnosis. Elders may also self-diagnose and indicate a chronic disease that has not been clinically diagnosed. Finally, the results addressed AI/ANs as one collective people, although AI and AN populations experience vastly different health barriers, practice different traditions, and vary in some health outcomes. The decision to speak to the AI/AN elder population collectively was made to ensure a large enough sample to generalize for tribal populations and to have large enough cell sizes to conduct both a factor analysis and cross-tabulations. Future research may investigate the 2 populations independently to determine whether differences in the prevalence of chronic disease exist. In addition, the variable "employment" previously omitted a distinction between "retired" and "unemployed," limiting respondents to indicate only "yes, employed full-time"; "yes, employed part-time"; or not employed. Future cycles of the survey will now include "retired" and "unemployed" as separate categories, which will allow for more granularity in the discussion of chronic disease among people who are not employed.

We found a higher overall prevalence of chronic disease among AI/AN elders compared with the older US population and substantially higher rates of both diabetes and arthritis among AI/AN elders. Finally, we found that a significantly higher prevalence of chronic disease exists among AI/AN elders who are unemployed and middle-income or low-income. These findings call for economic and social interventions outside those typically related to access to care. These results may be used to develop public health and community programs and interventions at the tribal level dedicated to improving the health of AI/AN elders, especially those with hypertension, arthritis, or diabetes, and those who are middle- to low-income or unemployed. An opportunity exists to address health disparities through social and economic equity among tribal populations.

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Tables

Table 1. Percentage of American Indian/Alaska Native (AI/AN) Elders With Diagnosed Chronic Disease (N = 14,632), by Demographic Category, Survey of Elders, 2011–2014

Demographic Characteristic	HBP	Diabetes	Arthritis	Cataracts	Depression	Asthma	Osteoporosis	Cancer	CHF	Stroke
Overall	58.9	53.9	47.2	22.5	15.0	13.7	10.8	9.0	8.9	7.7
Sex[a]										
Male	59.6	52.9	40.0	19.1	11.4	9.4	3.9	10.0	10.1	8.3
Female	58.6	54.6	51.5	24.5	17.1	16.3	14.9	8.3	8.2	7.3
Age, y[a]										
55–64	54.5	49.7	43.0	12.5	17.4	14.8	8.7	6.4	5.7	5.5
65–74	61.3	57.3	48.4	24.3	13.9	13.7	10.9	9.4	9	8.2
≥75	62.8	55.9	52.5	36.4	12.5	11.6	13.9	12.6	14.2	10.7
Annual personal income, $[a]										
<15,000 (Low)	58.3	57.5	49.6	21.7	16.2	14.6	11.2	7.8	8.7	8.6
15,000–49,999 (Middle)	59.8	53.3	46.6	23.0	14.4	13.5	10.7	9.5	9.3	7.5
≥50,000 (High)	55.3	44.8	37.5	18.6	11.4	11.1	9.5	10.7	6.1	3.6
Employment status[a]										
Unemployed or retired	61.9	57.3	51.7	26.6	17.0	14.5	12.5	10.2	10.9	9.5
Employed	53.1	47.1	36.6	13.3	10.4	12.0	6.6	6.4	4.5	3.5
Education level[a]										
Less than a high school diploma	62.2	57.1	52.2	27.5	15.4	14.1	10.9	8.7	11.1	9.5
High school graduate	58.8	52.7	45.8	20.5	13.3	11.7	9.7	8.2	8.3	7.4
Education beyond high school	56.6	52.7	44.8	20.7	16.2	15.0	11.6	9.8	8.0	6.7

Abbreviations: CHF, congestive heart failure; HBP, high blood pressure.
[a] Significant at $P \leq .05$.

Table 2. Demographic Characteristics of American Indian/Alaska Native Elders With and Without a Diagnosed Chronic Disease (N = 14,632), Survey of Elders, 2011–2014

Demographic Characteristic	With Chronic Disease (n = 13,123[a])	No Chronic Disease (n = 1,509[a])
	% (No.)	
Sex		
Male	87.5 (4,768)	12.5 (681)
Female	91.1 (8,212)	8.9 (807)
Age, y		
55–64	85.5 (5,003)	14.5 (848)
65–74	91.6 (4,849)	8.4 (445)
≥75	93.8 (3,271)	6.2 (216)
Annual personal income, $		
<15,000 (Low)	90.6 (4,392)	9.4 (455)
15,000–49,999 (Middle)	90.0 (6,655)	10.0 (737)
≥50,000 (High)	84.6 (794)	15.4 (144)
Employment status		
Employed	83.9 (3,459)	16.1 (666)
Unemployed or retired	92.4 (8,623)	7.6 (712)
Education level		
Less than a high school diploma	92.2 (3,787)	7.8 (319)
High school graduate	88.8 (4,192)	11.2 (529)
Education beyond high school	88.7 (4,942)	11.3 (630)

[a] Subcategorical totals may not sum to values for n because of missing data. Percentages for each subcategory omit missing data.

Table 3. Binary Logistic Regression Models for Presence of Chronic Disease Among American Indian/Alaska Native Elders (N = 14,632), by Income, Employment Status, and Education Levels, Controlling for Age and Sex, Survey of Elders, 2011–2014

Variable	B (Standard Error)	Wald χ^2	*P* Value[a]	Exp(B)
Income, $				
≥50,000 (High)[b]	–	11.90	.003	–
15,000–49,999 (Middle)	0.261 (0.105)	6.18	.01	1.298
<15,000 (Low)	0.060 (0.117)	0.27	.60	1.062
Education				
Education beyond high school[b]	–	7.18	.03	–
High school graduate	−0.088 (0.072)	1.49	.22	0.916
Less than a high school diploma	0.143 (0.087)	2.72	.10	1.154
Employed	−0.715 (0.071)	100.29	<.001	0.489
Age, y				
≥75[b]	–	49.69	<.001	–
65–74	−0.157 (0.101)	2.44	.12	0.854
55–64	−0.568 (0.098)	33.57	<.001	0.566
Female sex	0.449 (0.062)	51.87	<.001	1.566

[a] *P* values calculated using Wald χ^2 test.
[b] Reference group; cells with a dash indicate that the value was not calculated.

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ORIGINAL RESEARCH

Falls and Fall-Related Injuries Among US Adults Aged 65 or Older With Chronic Kidney Disease

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PEER REVIEWED

Abstract

Introduction
Falls are among the leading causes of injury and death among adults aged 65 or older. People with chronic kidney disease (CKD) are at increased risk of falling and of having a serious injury from falls. However, information is limited about risk factors for falls and fall-related injuries among people with CKD.

Methods
We performed a secondary analysis of 157,753 adults (6.1% with CKD) aged 65 or older surveyed in the 2014 Behavioral Risk Factor Surveillance System.

Results
People with CKD were at increased risk of falls (odds ratio [OR] = 1.81; 95% confidence interval [CI], 1.63–2.01) and fall-related injuries (OR = 1.50; 95% CI, 1.27–1.78) even after adjusting for differences in demographic characteristics, health conditions, and lifestyle factors ($P < .05$ for all). Among people with CKD, women, people diagnosed with diabetes, diabetes duration, and arthritis were all significant predictors of falls and fall-related injuries ($P < .05$ for all). Lifestyle factors, such as engaging in recent exercise (adjusted odds ratio [AOR] = 0.68; 95% CI, 0.56–0.81) and limited physical function (assessed as difficulty in climbing stairs) (AOR = 2.84; 95% CI, 2.30–3.44), were most closely associated with falls and fall-related injuries.

Conclusion
Adults aged 65 or older with CKD were at increased risk of falling and of suffering an injury as a result of a fall compared with adults in the same age range without CKD. Potentially modifiable factors such as physical function and recent exercise were most closely related to reduced risk for falls and fall-related injuries and may be an appropriate target for fall prevention and rehabilitation programs in people with CKD.

Introduction

Falls are among the leading causes of injury and death among US adults aged 65 or older (1). Nearly one-third of adults in this age group report a fall every year (2), and the annual cost of falls in the United States is approximately $31 billion (3). Numerous risk factors for falls have been identified, including frailty and chronic diseases (4).

Chronic kidney disease (CKD) is common among adults aged 65 and older with an estimated prevalence of 14.8% in the US population (5). People with CKD in this age group have a greater risk of falling than those without CKD (4). Furthermore, poor kidney function is a risk factor for falling (6) and for poor outcomes from falls, such as fractures (7). People with CKD may be more likely to fall and to experience a serious injury from falls; however, information is limited on the prevalence and predictors of falls in adults aged 65 or older with CKD (8).

Previous studies have identified age, sex, frailty, and diabetes as risk factors for unintentional falls (8). However, published data have limitations. For example, previous studies primarily used convenience samples from small clinics or health care facilities, assessed falls without exploring fall-related injuries, and often did not focus on older adults. Thus, these studies provided limited assessments of health, lifestyle, and demographic factors that may influence prevalence of falls or CKD. The limited samples in these previous studies, although providing valuable information, have led to conflicting results in relation to many risk factors. For example, some studies of people with CKD found that men were at increased risk of falling (9), whereas others found that women were more likely to fall (10,11). Thus, the purpose of this study was to assess the prevalence of CKD and falls in a large national sample of US adults aged 65 or older and to explore the association between falls, CKD, health risk factors, and demographic characteristics.

Methods

Study design and participants

We conducted a secondary analysis of data from the 2014 Behavioral Risk Factor Surveillance System (BRFSS). BRFSS is conducted annually by the Centers for Disease Control and Prevention (CDC) to measure behavioral and health risk factors and diseases in US adults. BRFSS is a telephone survey that uses random-digit dialing to randomly select civilian noninstitutionalized adults aged 18 or older. In 2014, BRFSS data were collected from adults across all 50 states and the District of Columbia. BRFSS uses a complex multistage sampling procedure and design weights to adjust for the unequal probability of being selected, for noncoverage, and for nonresponses. This is to ensure the creation of equal population estimates for each geographic region. The combined landline and cellular telephone median weighted response rate was 47.0% (landline telephones, 48.7%; cellular telephones, 40.5%). The BRFSS questionnaire consists of 3 parts: 1) core questions, which are a standard set of questions that all participating states and territories must administer; 2) optional modules; and 3) state-added questions, that is, questions on specific topics that states can choose to include in response to state-specific health concerns. Additional details about BRFSS survey methods, sampling, and response rates are available (12). Because BRFSS is approved by CDC's institutional review board (IRB) and because our study used de-identified publicly available data, did not recruit human subjects, and had no direct contact with study participants, no additional approval was required from the authors' IRBs.

Measures

Demographic characteristics and chronic kidney disease. We included all adults aged 65 or older who participated in the 2014 BRFSS (N = 157,753). BRFSS also collected data on participants' sex, race, marital status, employment, and education through structured and closed-format questions; we used these demographic variables for our analysis. BRFSS 2014 asked respondents about history of diagnosis of various chronic conditions including CKD with response options of yes, no, or don't know. The CKD diagnosis question was, "Has a doctor, nurse, or other health professional ever told you that you have kidney disease (excluding kidney stone, bladder infection, or incontinence)?" (12). Respondents were categorized into 2 groups based on a history of CKD to assess differences in demographic characteristics and lifestyle factors (ie, CKD group vs non-CKD group).

Health, lifestyle, and disease conditions. Study participants were asked if they had ever been diagnosed with arthritis, diabetes, or cancer (with response options of yes, no, or don't know). Response options to questions on current smoking, heavy drinking, difficulty walking, and health coverage were yes or no. Body mass index (BMI) (weight in kg/height in m^2) was computed on the basis of self-reported height and weight. A single item assessed participants' current general health (with response options of excellent, very good, good, fair, and poor) (12). For prevalence of falls and fall-related injuries, the 2014 BRFSS asked 2 questions: 1) In the past 12 months, how many times have you fallen and 2) how many of these falls caused an injury. The responses were categorized as no for 0 events and yes for 1 or more falls or fall-related injury events (12). CKD and non-CKD groups were compared for differences in these health and disease variables.

Data analysis

We first computed descriptive statistics (eg, percentages, frequencies) for all study variables and measures (ie, demographics, lifestyle behaviors, and chronic conditions). Using χ^2 tests we explored the differences in these variables between respondents with a history of CKD versus those without. Second, we used the binary variable history of CKD (yes vs no) as an independent variable to predict the odds of falls and fall-related injuries. In multivariate logistic regression analysis, falls and fall-related injuries were used as an outcome, with CKD as a predictor, and we computed adjusted odds for falls and fall-related injuries after adjusting for demographic characteristics of study participants, their lifestyle and health behaviors, and history of comorbid conditions that may be associated with falls or CKD. All analyses were performed by using the complex sample survey data analysis procedures in SPSS version 24 (IBM Corp). Statistical significance was set a priori at $P < .05$.

Results

Most study participants were white (79%), female (56%), retired (72%), and married or living with a partner (56%). Slightly more than a quarter of the participants were obese (28%), reported difficulty in walking (27%), and had poor or fair health (26%). In relation to falls, almost a third of participants (29%) had a fall in the past 12 months, and 10% had a serious injury resulting from the fall. Less than a tenth of participants reported a history of CKD (6.1%). A comparison of adults aged 65 or older with and without CKD revealed differences based on demographic characteristics, lifestyle behaviors, and comorbid conditions between adults with and without CKD (Table 1).

In a logistic regression analysis (Table 2), we found that people with CKD were more likely to report having falls (OR = 1.81; 95% CI, 1.63–2.01), even after adjusting for demographics, lifestyle behaviors, and comorbid conditions (adjusted odds ratio [AOR] = 1.26; 95% CI, 1.13–1.47). Moreover, 37.4% of those who fell had a fall-related injury, with injuries occurring more frequently among people with CKD (OR = 1.50; 95% CI, 1.27–1.78), even after adjusting for demographic characteristics, lifestyle behaviors, and comorbid conditions (AOR = 1.23; 95% CI, 1.04–1.40).

Among patients with CKD, men were significantly less likely than women to fall (AOR = 0.79; 95% CI, 0.65–0.93) and have fall-related injuries (AOR = 0.59; 95% CI, 0.44–0.80), after adjusting for race and age (Table 3). Having a diagnosis of diabetes was associated with an increased likelihood of falling (AOR = 1.25; 95% CI, 1.02–1.53), and the length of time since diabetes diagnosis was associated with both falls and fall-related injuries. People with CKD and arthritis were more likely to fall (AOR = 1.79; 95% CI, 1.46–2.20) and have fall-related injuries (AOR = 1.54; 95% CI, 1.06–2.24), whereas people with cancer were more likely to have a fall-related injury only (AOR = 1.50; 95% CI, 1.04–2.15). Lifestyle factors such as engaging in recent exercise (AOR = 0.68; 95% CI, 0.56–0.81) and limited physical function (assessed as difficulty in climbing stairs) (AOR = 2.84; 95% CI, 2.30–3.44) were most strongly associated with both falls and fall-related injuries.

Discussion

We used secondary data from the 2014 BRFSS to study the relationship between falls in noninstitutionalized adults with and without CKD. After accounting for multiple demographic characteristics, lifestyle factors, and chronic disorders, people with CKD aged 65 and older had a higher prevalence of falls and fall-related injuries than those without CKD. Among people with CKD, multiple lifestyle factors (eg, not currently engaging in physical activity, difficulty climbing stairs) and comorbid conditions (diabetes, diabetes duration, cancer, and arthritis) were found to significantly influence the probability of falls and fall-related injuries. Factors related to exercise and physical function were most closely related to falls and fall-related injuries, suggesting that these may be potential targets of fall-prevention strategies in older adults with CKD.

Our findings are consistent with previous reports that found that patients with CKD (4) and those who have advanced to end-stage kidney disease (ESKD) (10,11,13) are at increased risk of falling. Numerous physiological changes associated with CKD, such as uremic neuropathy and muscle wasting and weakness may explain the increased risk of falling. Furthermore, changes in bone and mineral metabolism leading to weak, brittle bones may lead to an increased propensity for fall-related injuries in people with CKD, especially those with ESKD (12). The increased risk of falls and fall-related injuries is a significant finding because of its strong relationship with poor clinical outcomes (13,14).

Previous studies of people with CKD identified numerous risk factors for falls, including age, sex, body weight, and education (8). However, these studies were primarily of small prospective cohorts and produced conflicting results in relation to some risk factors, such as sex. In our study, we used a large sample of US adults aged 65 and older and found that women with CKD were more likely than men to fall or have a fall-related injury. This is similar to the overall population of adults in the age group from BRFSS in which women were also found to be at greater risk of both falls and fall-related injuries than men (1). Furthermore, we did not find some previously identified demographic factors, such as BMI and education, to be significant predictors of falls in our study sample.

Previous studies also identified diabetes, a leading cause of CKD, as a risk factor for falls among people with CKD (14). Peripheral diabetic neuropathy is a common complication associated with poor glycemic control and can lead to balance and gait impairment, especially in activities such as walking, climbing, and descending stairs. (15). We previously reported greater gait impairments in CKD patients undergoing hemodialysis who also had diabetes compared with those who did not have diabetes (16). Despite these observations, previous studies of fall risk have not accounted for the duration of diabetes. In our study, we found that people with CKD aged 65 or older who were diagnosed with diabetes before age 65, and therefore would have likely lived with diabetes for longer than those diagnosed after 65, were more likely to suffer a fall or fall-related injury. This finding suggests that, similar to the non-CKD populations (17), the physiological changes associated with diabetes that lead to increased injury risk may take time to manifest and that early prevention and management of diabetes may reduce the risk of falls and fall-related injuries in older adults.

Although not as common as diabetes, cancer and arthritis increase fall risk in the general population and are common chronic disorders among people with CKD (4,18,19). In our study, we found that among people aged 65 and older, having cancer and CKD did not increase the risk of falling but did increase the likelihood of suffering a fall-related injury. This increase in injury risk may be due in part to the effect of cancer treatments on bone strength (20).

Factors related to poor health, reduced physical functioning, and chronic diseases had the largest influence on the probability of both falls and fall-related injuries. For example, a diagnosis of arthritis was associated with an increased likelihood of having both a fall and a fall-related injury. Frailty, a condition consisting of fatigue, weakness, and reduced physical activity, is a strong predictor of falls in both the elderly population and in people with CKD who have advanced to ESKD (9). A common strategy to prevent falls is improving strength and balance. We found that difficulty climbing stairs, a task that requires strength and balance (21), was most closely related to falls and fall-related injuries among people with CKD. Furthermore, the absence of exercise in the past month was also a strong predictor of falls and fall-related injuries. Physical function and exercise are potentially modifiable, cost effective, and evidence-based strategies available to enhance mobility. Our study suggests that as in other populations, exercise programs that target strength and balance may be an effective strategy for preventing falls and fall-related injuries among people with CKD, but prospective trials are needed (22).

Our study has several limitations. First, the BRFSS questionnaire relies on self-reported health and lifestyle factors. Self-reporting may have limitations such as recall bias, social desirability, and over- or underestimation of health-related variables. Second, this study was cross-sectional, and we cannot establish cause and effect relationships between variables. Third, BRFSS is a closed-format survey, limiting internal validity. Also, few BRFSS items measured CKD and falls, resulting in improper estimation of the nature and extent of CKD and falls. Finally, CKD is a complex phenomenon with a multitude of influences on disease causation and prognosis. Variables that may influence CKD outcome or progression were not captured (eg, diet and nutritional status). People with CKD may not always be available to answer questionnaires such as BRFSS (eg, because of cognitive disabilities or hospitalization), limiting the external validity of our results and the ability to generalize our findings to all elderly adults with CKD. Despite these limitations, our study has several strengths. To our knowledge, this is the largest survey to examine risk factors for falls and fall-related injuries among people aged 65 and older with CKD. Furthermore, this study analyzed several demographic factors and lifestyle behaviors, which adds to the body of knowledge pertaining to CKD and falls in older adults.

The results of our study show that people with CKD have a higher likelihood of falling and having fall-related injuries. However, potentially modifiable factors such as recent exercise and difficulty climbing stairs were most closely related to falls and fall-related injuries. These findings suggest that among elderly people with CKD, as among other elderly populations at risk for falls, poor physical function and balance may be appropriate targets of multifactorial fall-prevention strategies.

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Tables

Table 1. Participant (N = 157,753) Characteristics, Study of Falls and Fall-Related Injuries Among US Adults Aged 65 or Older With Chronic Kidney Disease (CKD), Behavioral Risk Factor Surveillance System, 2014[a]

Variable	Total, N (%)	CKD, N (%), 9,116	No CKD, N (%), 147,893
Demographic Characteristics			
Sex			
Male	59,746 (44)	3,547 (45)	55,924 (44)
Female	98,007 (56)	5,569 (55)	91,969 (56)
Race[b]			
White	132,276 (79)	7,431 (75)	124,845 (79)
African-American	9,323 (9)	699 (12)	8,624 (9)
Other	3,957 (4)	254 (4)	3,703 (3)
Multiracial	2,129 (1)	167 (1)	1,962 (1)
Hispanic	6,583 (8)	406 (8)	6,177 (8)
Marital status[b]			
Married/ living with a partner	76,769 (56)	4,065 (52)	72,433 (56)
Separated/divorced	23,031 (14)	1,430 (15)	21,475 (13)
Widowed	49,687 (27)	3,154 (31)	46,236 (26)
Never married	7,212 (4)	419 (3)	6,750 (4)
Employment[b]			
Employed for wages	15,544 (10)	501 (5)	15,043 (10)
Self-employed	8,707 (5)	316 (3)	8,391 (5)
Retired	112,707 (72)	6,695 (74)	106,012 (72)
Other (unable to work, out of work, student, homemaker)	18,567 (13)	1,535 (18)	17,032 (13)
Education[b]			
≤High school graduate	65,267 (48)	4,005 (50)	61,262 (48)
>High school but <college graduate	40,050 (28)	2,445 (30)	37,605 (28)
≥College graduate	50,533 (23)	2,601 (19)	47,932 (24)
Physical Function, Health, and Lifestyle Factors			
General health[b]			
Excellent	20,506 (12)	335 (4)	20,143 (13)
Very good	47,064 (28)	1,353 (14)	45,587 (29)
Good	51,967 (33)	2,835 (31)	48,881 (33)
Fair	26,449 (18)	2,654 (31)	23,609 (17)
Poor	10,972 (8)	1,895 (20)	8,940 (7)
Access to health care			
Yes	154,846 (98)	8,976 (98)	145,870 (99)

[a] Not all BRFSS respondents answered the question about CKD. Percentages may not total 100% because of missing values. Percentages are rounded to the nearest whole number.
[b] Significant differences between groups (P < .05).

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Table 1. Participant (N = 157,753) Characteristics, Study of Falls and Fall-Related Injuries Among US Adults Aged 65 or Older With Chronic Kidney Disease (CKD), Behavioral Risk Factor Surveillance System, 2014[a]

Variable	Total, N (%)	CKD, N (%), 9,116	No CKD, N (%), 147,893
No	1,789 (2)	124 (2)	1,665 (1)
Current smoker	12,736 (9)	650 (7)	12,086 (9)
Heavy drinker (men >2 drinks/day; women >1 drink/day)	5,900 (4)	219 (3)	5,681 (4)
Difficulty walking/climbing stairs[b]	40,615 (27)	4,471 (52)	36,198 (26)
Engaged in any exercise in past month[b]	108,953 (69)	5,189 (56)	103,764 (69)
Obese (BMI ≥30)[b]	39,566 (28)	3,162 (38)	36,404 (27)
Chronic conditions in addition to CKD (ever diagnosed)			
Diabetes[b]	32,429 (23)	3,591 (43)	28,838 (22)
Cancer	27,133 (17)	2,441 (29)	24,692 (16)
Arthritis[b]	84,017 (53)	6,344 (72)	77,673 (52)
Had ≥1 falls in past year[b]	43,885 (29)	3,529 (41)	40,356 (28)
Had fall-related injury in past year[b]	16,062 (10)	1,566 (16)	14,496 (10)

[a] Not all BRFSS respondents answered the question about CKD. Percentages may not total 100% because of missing values. Percentages are rounded to the nearest whole number.
[b] Significant differences between groups (*P* < .05).

Table 2. Probability of Falls and Fall-Related Injuries, Among US Adults (N = 157,753) Aged 65 or Older With Chronic Kidney Disease (CKD) (N = 9,116) and Without CKD (N = 147,893), Behavioral Risk Factor Surveillance System, 2014[a]

Predictors	OR (95% CI) Falls	OR (95% CI) Fall-Related Injury
Model 1. Compares CKD group vs non-CKD group	1.81 (1.63–2.01)[b]	1.50 (1.27–1.78)[b]
Model 2. Comparison in Model 1 adjusted for demographic characteristics from Table 1	1.75 (1.58–1.94)[b]	1.46 (1.24–1.72)[b]
Model 3. Comparison in Model 1 adjusted for physical function, health, and lifestyle factors from Table 1	1.36 (1.21–1.53)[c]	1.26 (1.08–1.44)[c]
Model 4. Comparison in Model 1 adjusted for chronic conditions from Table 1	1.53 (1.38–1.70)[b]	1.42 (1.20–1.69)[b]
Model 5. Comparison in Model 1 adjusted for demographic characteristics and physical function, health, and lifestyle characteristics from Table 1	1.32 (1.18–1.48)[c]	1.25 (1.06–1.49)[c]
Model 6. Comparison in Model 1 adjusted for demographic, physical function, health/lifestyle characteristics and chronic conditions	1.26 (1.13–1.47)[c]	1.23 (1.04–1.40)[c]

Abbreviations: CI, confidence interval; OR, odds ratio.
[a] Not all participants responded to the question about CKD.
[b] Indicates $P < .001$.
[c] Indicates $P < .01$.

Table 3. Predictors of Falls and Fall-Related Injuries in People With Chronic Kidney Disease, Behavioral Risk Factor Surveillance System, 2014

Predictors	AOR (95% CI)[a] Falls	AOR (95%CI)[a] Fall-Related Injury
Men versus women	0.79 (0.65–0.93)[b]	0.59 (0.44–0.80)
Married/ living with a partner versus other[c]	0.96 (0.78–1.17)	0.90 (0.69–1.08)
Education		
≤High school graduate	1 [Reference]	1 [Reference]
>High school but <college graduate	1.37 (0.98–1.76)	1.17 (0.81–1.72)
≥College graduate	1.01 (0.83–1.22)	0.72 (0.54–0.90)[b]
Any exercise last month, yes versus no	0.68 (0.56–0.81)[b]	0.70 (0.60–0.93)[b]
Difficulty climbing/walking stairs, yes versus no	2.84 (2.30–3.44)[b]	1.70 (1.27–2.30)[b]
Obese or overweight versus normal weight[d]	0.87 (0.67–1.12)	0.86 (0.60–1.27)
Heavy drinker versus others[e]	1.54 (0.89–2.98)	1.19 (0.93–2.07)
Current smoker versus others[f]	1.21 (0.85–1.71)	1.08 (0.90–1.44)
Has diabetes versus does not have diabetes	1.25 (1.02–1.53)[b]	1.07 (0.81–1.44)
Diabetes diagnosed ≤64 y versus diagnosed ≥65 y	1.45 (1.04–2.02)[b]	1.62 (1.08–2.53)[b]
Arthritis history, yes versus no	1.79 (1.46–2.20)[b]	1.54 (1.06–2.24)[b]
Cancer history, yes versus no	1.03 (0.81–1.30)	1.50 (1.04–2.15)[b]

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.
[a] Indicates adjustments made for race and age. The outcome is falls and fall-related injuries in the past 12 months (yes vs no).
[b] Indicates $P < .01$.
[c] Includes widowed, divorced, separated, and never married.
[d] People with BMI ≥25 were categorized as overweight or obese, and people with BMI from 18.5 to <25 were categorized as normal weight.
[e] Men who regularly consume more than 2 drinks per day and women who regularly consume more than 1 drink per day. Others were those who consumed fewer drinks or did not drink alcohol at all.
[f] Includes nonsmokers and former smokers.

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ORIGINAL RESEARCH

Patterns of Screen Time Among Rural Mexican-American Children on the New Mexico-Mexico Border

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PEER REVIEWED

Abstract

Introduction

The prevalence of obesity is 26% among Hispanic children and teenagers and 47% among Hispanic adults. One contributor to obesity is sedentary behavior, such as using electronic screen devices (ie, screens). Low-income and Hispanic youths spend more time using such devices than other youths.

Methods

We interviewed 202 parents of Mexican-origin children aged 6 to 10 years in 2 rural communities near the US–Mexico border to determine screen use among children. We tested for associations between covariates and heavy screen use (≥4 hours/day) and calculated adjusted odds ratios (AORs) to identify independent, modifiable risk factors for such use.

Results

More than two-thirds (68.3%) of households had an annual income of less than $24,000, 89.1% spoke primarily Spanish, and 92.1% had internet access. The percentage of children with heavy screen use was 14.9% on weekdays and 25.2% on weekends. Smartphones were used by 62.4% of children, desktops or laptops by 60.9%; homework was the most common reason for use of these devices. One in 3 children used them for social media. Increased odds of heavy screen use were associated with having a television on while the child ate (weekday AOR = 3.02; 95% confidence interval [CI], 1.08–8.45 and weekend AOR = 2.38; 95% CI, 1.04–5.40) and using electronics to entertain (weekend AOR = 2.94; 95% CI, 1.15–7.51). More than 3 family meals per week (AOR = 0.40; 95% CI, 0.17–0.94 compared with ≤3 meals) and 2 or 3 family activities per week (AOR = 0.33; 95% CI, 0.12–0.87 compared with ≤1 activity) were associated with decreased odds of heavy weekend use.

Conclusion

Even in low-income, Spanish-speaking communities, children have access to electronic devices, social media, and the internet, and a substantial fraction of them are heavy users. Efforts to reduce screen time might focus on understanding and changing the social norms that promote it.

Introduction

In 2015–2016, Hispanic adults had a higher age-adjusted rate of obesity (47.0%) than non-Hispanic white (37.9%) or non-Hispanic black (46.8%) adults in the United States (1). Moreover, the prevalence of obesity in 2015–2016 among children and teenagers aged 2 to 19 years was 25.8% among Hispanics, 22.0% among non-Hispanic blacks, and 14.2% among non-Hispanic whites (1). The 2015 Youth Risk Behavior Survey showed that 16.2% of Hispanic and 13.3% of non-Hispanic white ninth-graders in New Mexico were obese, while an additional 16.8% of Hispanic and 15.5% of non-Hispanic white ninth-graders were overweight. Obesity rates in both populations are increasing (2).

Behaviors that contribute to obesity among children and teenagers include sedentary behavior and the consumption of excessive calories (3–5). Sedentary behavior is defined as any waking behavior that has a low level of energy expenditure (<1.5 metabolic equivalents) while in a sitting, reclining, or lying posture (6). The component of such behavior that is studied most often is screen time. Screen time is time spent on screen-based behaviors (6), such as watching television, playing video games, and using computers, smartphones, or other electronic devices with screens. Use of devices with screens other than televisions has increased dramatically in the United States in recent years (7).

Perhaps one reason the rate of obesity is higher among Hispanic children and teenagers than among their non-Hispanic counterparts is that the former spend more time using electronic screen devices (8). For example, in the 2015 New Mexico Youth Risk Behavior Survey, 27.3% of Hispanic and 21.7% of non-Hispanic white ninth-graders spent 3 hours or more watching television each weekday (2). And in the 2015 New Mexico Youth Risk and Resilience Survey in the largely Hispanic county of Otero, in the US–Mexico border region, 27.7% of middle-school students (sixth- to eighth-graders) watched 3 hours or more of television, and 28.5% used computers or video games for 3 hours or more on weekdays (9). Consistently, low-income and racial/ethnic minority children and teenagers report more time using electronic devices for recreational purposes than do their non-Hispanic white counterparts (8). Other demographic groups associated with greater screen time include boys, older children, younger mothers, and less-educated parents (7,8,10). Little is known about screen time in Hispanic subpopulations, especially Hispanic children in elementary school. Studying screen time in younger children is important because risk factors for obesity can begin to operate as early as infancy (11).

The *Salud Para Usted y Su Familia* (Health for You and Your Family) project (12) is studying the determinants of obesity among Mexican American children in rural, low-income border communities in New Mexico. As a first step in designing an intervention to reduce the risk for childhood obesity in these communities, we collected data on the prevalence of risk factors, including screen time. The main objective of this study was to describe the demographic correlates of heavy screen use among Mexican American children in 2 small, rural communities on the New Mexico–Mexico border. A secondary objective was to assess the association of selected modifiable household norms with heavy screen use.

Methods

From July through December 2016, we conducted a cross-sectional survey of 202 mothers or primary caregivers of Mexican-origin children aged 6 to 10 years (in grades kindergarten through 4) in 2 *colonias* (rural communities that lack adequate water, sewer, or decent housing) (13). We recruited study participants from the unincorporated community of Chaparral (population, 14,631) in Otero County and Doña Ana County and the village of Columbus (population, 1,244) in Luna County (14). Chaparral and Columbus are 20 and 3 miles from the Mexican border and 84% and 88% Hispanic, respectively (14).

We hired and trained *promotores de salud* (promoters of health), bilingual indigenous community health workers, as promotor–researchers to recruit participants and collect data for the project (15,16). Promotor–researchers recruited a convenience sample from their communities by approaching potential respondents door-to-door and at schools, school bus stops, shopping centers, and community events. When 2 parents were available, mothers were preferred as participants. Promotor–researchers determined eligibility by administering a 9-item questionnaire. Eligibility criteria included having lived in the community for at least 1 year, being the primary caregiver for a Mexican American child aged 6 to 10 years, and living with a spouse or partner who shared childcare responsibilities. Mexican origin was defined as Mexican nativity in the child or 1 or more of the child's biological parents or grandparents.

Our goal was a sample size of 200, 100 from each community. Promotor–researchers approached 1,093 individuals, of whom 1,091 (99.8%) completed the questionnaire. Among these, 260 (23.8%) were eligible. The modal reason for ineligibility was not having a child aged 6 to 10 years. Among eligible respondents, 202 (77.7%) signed informed consent agreements, and all those who signed completed interviews.

Promotor–researchers administered the informed consent and the study instruments in English or Spanish, depending on the respondent's preference. The primary study instrument, an 88-item survey, took 45 minutes and was conducted at the time of recruitment or later at a convenient location. Study participants received a $5.00 gift card.

We asked participants with 2 or more children aged 6 to 10 years to choose 1 child and answer survey questions with that 1 reference child in mind. Interviewers prompted participants to respond about that child with phrases such as, "Going back to the child you were thinking about . . .."

Variables

The 88 survey questions covered a range of factors associated in the literature with childhood obesity, including demographic variables, diet, and physical activity. It also included factors associated with screen time: 1) internet access; use of smartphones, computers or laptops, and other electronic devices among children, mothers, and fathers; 2) household norms related to screen use (Box); and 3) reasons for use and types of electronic devices used by all children in the household.

Box. Household Norms Related to Screen Use as Defined by the Questions Below.

- Is the TV on when your child eats?
- When eating together as a family, is there anyone who uses electronics (cell phone, games, etc.)?
- During a normal week, how often does your family eat a meal together?
- When your child misbehaves, do you ever take away his/her outdoor play time?
- When your child misbehaves, do you ever take away his/her electronics?
- Does it ever seem the only way to keep your child entertained is to encourage his/her use of TV, tablet, video games, or other electronics?
- How many times a week does your family do active things together?

We defined screen time as the number of hours per day that the child used electronic screen devices at home. Mothers were asked, "How many **hours** does your child spend at home on a normal day **during the week** using electronics (TV, videogames, computer games, cell phone)?" and "How many **hours** does your child spend at home on a normal day **on the weekend** using electronics (TV, videogames, computer games, cell phone)?" Possible responses were none, 1 or 2 hours, 3 hours, or 4 hours or more. The 2 outcome variables were heavy screen use on weekdays and heavy screen use on weekends. We defined heavy screen use as 4 hours or more per day (17).

Analysis

To assess which variables should be included in a multivariate analysis, we first conducted individual tests of association between the outcome variables and potential risk factors. We used χ^2 and Fisher exact tests for unordered categorical variables and Cochran–Armitage tests for trend for ordered variables. Variables were included in the multivariate model if 1) the variable was associated ($P < .25$) in the weekday or weekend analysis, or 2) the variable was associated with screen time in the literature (ie, child's age, child's sex, maternal education, and income/Medicaid status). Internet access met the first criterion, but it was excluded because none of the heavy users lacked internet access. Weekday and weekend use were fit by using separate models.

Analysis was conducted by using SAS version 9.4 (SAS Institute Inc). The institutional review boards of the institutions with which the authors are affiliated reviewed and approved the study protocol.

Results

Among the 202 children in the study, 117 (57.9%) were aged 6 to 8 and 85 (42.1%) were aged 9 or 10 (Table 1). Mean age was 8.1 years (standard deviation, 1.4 y). Among the parent respondents, 192 (95.0%) were female, 144 (71.3%) were born in Mexico, 181 (89.6%) had a high school education or less, and 143 (70.8%) had 5 or more members in their household. Among the 202 study households, 99 of 145 (68.3%) had a total monthly income of less than $2,000 (excluding "don't know" responses); 180 (89.1%) had a member who receives Medicaid, and 180 (89.1%) spoke primarily Spanish. The children used Spanish-language electronic devices exclusively in 46 (22.8%) households; most used English exclusively or English and Spanish. Most (n = 108 [53.5%]) households had cell phone plans, and 92.1% had internet access.

Approximately one-quarter (53 of 202; 26.2%) of children used screens for more than 2 hours per day during the week at home, and 30 (14.9%) were heavy weekday users. On weekends, 84 (41.6%) children used screens for more than 2 hours per day, and 51 (25.2%) were heavy weekend users. Screen time was greater on weekend days ($P = .002$). Heavy use during weekdays or weekends was not significantly associated with child's age, child's sex, or any other demographic characteristic except household size (Table 1). We found a trend toward less screen use on weekends as household size increased. We also found that a greater percentage of children in Columbus (32.0%) than in Chaparral (18.6%) were heavy weekend users.

The unadjusted analysis of 7 household norms (Table 2) found that norms encouraging screen use were common. Six of 7 norms qualified for inclusion in the adjusted analysis, but we included all 7 norms. In the adjusted analysis (Table 3), no demographic variables other than household size were associated with screen time. Larger households were less likely to report heavy weekend screen use. In contrast, 4 of 7 norms were associated with heavy weekday use, heavy weekend use, or both. Most (59.9%) families had the television on while the child ate, a practice associated with heavy screen use both on weekdays (AOR = 3.02; 95% confidence interval [CI], 1.08–8.45) and weekends (AOR = 2.38; 95% CI, 1.04–5.40) (Table 3). Three of 4 families ate meals together more than 3 times per week, and heavy weekend screen use among children in these families was less prevalent than in families who ate meals together 3 times or fewer per week (AOR = 0.40; 95% CI, 0.17–0.94). Parents who used television or electronics for entertaining their child reported heavy weekend use more than twice as often (AOR = 2.94; 95% CI, 1.15–7.51) as parents who did not. Finally, families who were physically active together 2 or 3 times per week were associated with less weekend screen time than families active together at most 1 time (0 or 1) per week (AOR = 0.33; 95% CI, 0.12–0.87).

Parents reported multiple reasons why children (as a group) in their households used desktops or laptops and smartphones on weekdays (Figure 1). Two-thirds of all users used these devices for homework. Just more than half of all users used them for games and for internet/YouTube. No single reason for use was significantly associated with heavy weekday or heavy weekend use.

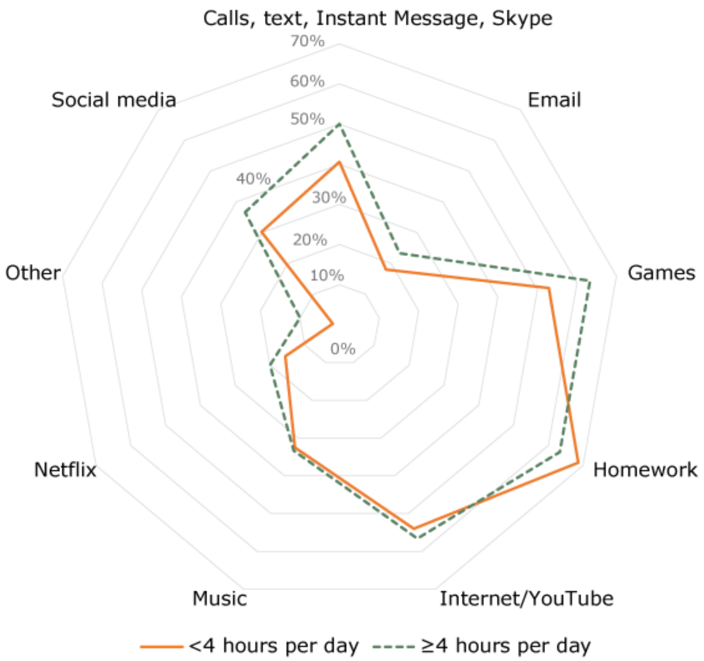

Figure 1. Frequency of reasons for use of smartphones, desktops, or laptops by children on weekday in study households, according to level of use in the reference child, Chaparral and Columbus, New Mexico, 2016. Parents could indicate more than 1 reasons for use; thus, percentages do not sum to 100.

Among devices used by all children in study households, smartphones (62.4%) and desktop or laptops (60.9%) were dominant (Figure 2). Only 8.9% of children used none of the devices listed. No devices were significantly associated with heavy weekday or weekend screen time.

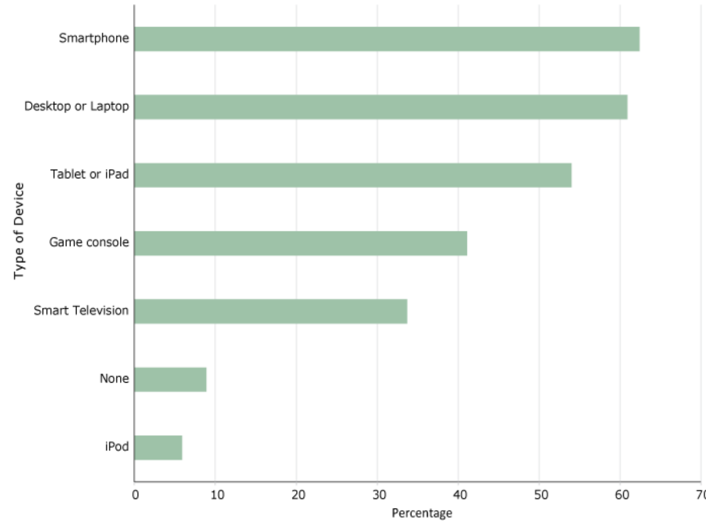

Figure 2. Frequency of use of types of electronic devices by children in study households, Chaparral and Columbus, New Mexico, 2016.

Among mothers, 89.2% used smartphones, 25.0% used desktops or laptops, and 7.3% used game consoles. Paternal patterns of use were similar. Parental patterns of use were not significant predictors of heavy screen use among children.

Discussion

This study found that in 2 rural communities in New Mexico near the Mexico border, most families had cell phones and access to the internet in 2016. Among these families, one in 4 had a child aged 6 to 10 years who spent 2 hours or more per weekday using electronic devices at home, and one in 7 had a child who spent 4 hours or more per weekday using electronic devices at home. Most families reported that a television was on while children ate, and someone was using electronic devices during meals in one-quarter of the households. Social norms of television use during meals, not eating as a family frequently, encouraging children to entertain themselves with electronics, and not participating as a family in physical activities appear to be risk factors for heavy screen use in this study population.

In aggregate, the total screen time reported for many of these elementary-school–aged children exceed previous recommendations to limit screen time to 2 hours per day (18). Comparison with other populations of children is difficult because of differences in ages of study populations, outcome measures, and scope. In a population of Latino participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in Oregon, 42% of children aged 2 to 5 years spent 2 hours or more per day on noneducational screen time (19). The National Health and Nutrition Examination Survey found that 47% of children aged 2 to 15 years spent more than 2 hours per day viewing television and video and using computers (20). Among Hispanic media users aged 8 to 12 years in 2015, mean daily screen time was 5 hours and 34 minutes nationally (8). The National Survey of Children's Health (NSCH) reported weekday screen time for children who were more similar in age to those in our study population. For 2011–2012, NSCH reported that 7.8% of children aged 6 to 11 years old in New Mexico watched television or videos or played video games for 4 hours or more per weekday and that 2.9% spent 4 hours or more using computers, games, and other devices per weekday (17). Even if these percentages are summed (10.7%), the prevalence of heavy weekday screen use reported by NSCH is lower than the 14.9% reported in our study. Finally, comparison with screen time among Mexican children would be of interest, but the most comparable data available for Mexico, for children and teenagers aged 10 to 14 years, show that 27.7% have an average of more than 4 hours per day of screen time (21).

Our study suggests that it is important to measure screen time on both weekdays and weekends among school-aged children and that because weekend use is greater, measuring only weekday use might substantially underestimate total use. This finding is consistent with the findings of a 2006–2007 study of television viewing among mostly Mexican American fourth-graders in low-income schools along the Texas–Mexico border, where median television viewing was greater on weekend days than on weekdays (2.5 hours vs 1.5 hours) (22). Most studies do not distinguish between weekend use and weekday use (23).

Another study conducted in the US–Mexico border region found that parental rules or norms limiting television viewing were associated with less television viewing among children (22). This finding is consistent with our finding that having a television on during meals is associated with heavy screen use on both weekdays and weekends. Our finding on television viewing during meals is also consistent with the findings of other studies showing that children in homes where the television is on all or most of the time are more likely to have more screen time than other children have (19,24). Watching television during meals is associated with poorer diets among children (25). A study in Texas found that three-quarters of urban overweight or obese Mexican American children aged 6 to 8 years had televisions in their bedrooms (26).

For weekend use, several norms in addition to television use during meals were significant in the adjusted analysis. These same associations were suggested in weekday results but lacked significance. In general, it appears that eating meals and engaging in activities as a family limits screen time, while using electronic devices to keep children occupied increases it. Examinations of such family activities in relation to screen time were reported previously (27,28). The American Academy of Pediatrics has recommended positive parenting activities, such as playing together, as one way to decrease screen time (3).

Our study population's access to computers and internet services can be compared with such access among the Hispanic population nationally. The 2015 American Community Survey established that 68.3% of Hispanic households had desktops or laptops and 70.9% had internet service; in limited–English-speaking populations, such as the one in our study, 53.0% of households had a computer (29). In our study, 108 (53.3%) households had cell phone plans, and 186 (92.1%) had internet access.

The extent to which our study population reflects the Mexican American population living in *colonias* in New Mexico is not clear. In our study population, 68.3% of households had an annual income of less than $24,000. This percentage is comparable to the 69.1% of households of all races/ethnicities with an annual income of less than $25,000 in 2016 in Columbus, New Mexico, but it is different from the 49.5% of households with an annual income of less than $25,000 in Chaparral (12). Some aspect of how the study sample was collected might have resulted in the recruitment of families whose incomes are lower than the average income of residents in the 2 *colonias* in our study. The study's possible inclusion of low-income families who avoid participation in the census because of their undocumented status might account for this bias.

This study has several limitations. First, the study population was a convenience sample, and selection bias might have operated in the recruitment process and/or in the choice of the reference child by the parent when more than one child was eligible. No random sampling of households was considered possible in these communities. Consequently, the reported estimates might differ from those in these communities overall or in other New Mexico *colonias*. Second, parental awareness of the more socially desirable responses to questions about use of electronic devices by children might have introduced a reporting bias toward underreporting screen time or household norms that encouraged it, such as choosing the child with less screen time as the reference child. Third, the sample size was small and may have been underpowered to detect associations between household norms and children's screen time. The study's strengths were the collection of data by trained, bilingual, local promotor–researchers and the 78% participation rate. To our knowledge, ours is the first assessment of total screen time, as opposed to television viewing (23), in *colonias* along the US–Mexico border.

Although some Hispanic children of Mexican heritage live in poor, remote communities in the Southwest and their families might have limited skills in English, the assumption that their access to the internet or electronic devices is limited would be incorrect. Along with adopting an American diet and its attendant risk of obesity (30), Mexican American children whom we studied in these New Mexican communities have adopted the same levels of computer use and other electronic screen use as have non-Hispanic white children elsewhere in the United States.

Checking the epidemic of obesity among the Hispanic population in the United States in such communities will depend on making behavioral changes early in life and addressing the twin issues of diet and physical inactivity, including reducing screen time without cutting off access to screen time that might be beneficial (3). Strategies found to be effective in nonminority populations in reaching such goals need to be tested in Hispanic and other racial/ethnic minority populations.

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Tables

Table 1. Characteristics of Study Population and Their Association With Heavy Screen Use (≥4 Screen-Time Hours per Day) on Weekdays and Weekends Among Mexican-Origin Children Aged 6 to 10 Years, Chaparral and Columbus, New Mexico, 2016[a]

Characteristic	Overall, No. (%)[b] (n = 202)	Weekday (n = 30)		Weekend Day (n = 51)	
		No. (%)	*P* Value	No. (%)	*P* Value
Child's age, y					
6–8	117 (57.9)	15 (12.8)	.34[c]	27 (23.1)	.40[c]
9 or 10	85 (42.1)	15 (17.6)		24 (28.2)	
Mean	8.1	8.1	—	8.3	—
Child's sex					
Male	108 (53.5)	16 (14.8)	>.99[c]	31 (28.7)	.26[c]
Female	94 (46.5)	14 (14.9)		20 (21.3)	
Maternal age, y[d]					
20–29	51 (25.6)	10 (19.6)	.25[e]	15 (29.4)	.44[e]
30–39	95 (47.7)	14 (14.7)		17 (17.9)	
≥40	53 (26.6)	6 (11.3)		18 (34.0)	
Mean	35.7	34.2	—	37.5	—
Maternal birth country					
United States	58 (28.7)	8 (13.8)	>.99[c]	14 (24.1)	.86[c]
Mexico	144 (71.3)	22 (15.3)		37 (25.7)	
No. of years of maternal education					
1–8	45 (22.3)	7 (15.6)	.71[e]	15 (33.3)	.14[e]
9–12	136 (67.3)	21 (15.4)		32 (23.5)	
>12	21 (10.4)	2 (9.5)		4 (19.0)	
No. of household members					
3	20 (9.9)	6 (30.0)	.051[e]	11 (55.0)	.002[e]
4	39 (19.3)	6 (15.4)		11 (28.2)	
5	74 (36.6)	11 (14.9)		17 (23.0)	
≥6	69 (34.2)	7 (10.1)		12 (17.4)	
Monthly household income, $					
<1,000	41 (20.3)	9 (22.0)	.13[e]	12 (29.3)	.08[e]
1,000–1,999	58 (28.7)	9 (15.5)		14 (24.1)	
2,000–2,999	26 (12.9)	4 (15.4)		3 (11.5)	
≥3,000	20 (9.9)	1 (5.0)		3 (15.0)	
Don't know	57 (28.2)	7 (12.3)		19 (33.3)	
Household member receives Medicaid					

[a] Data collected from 88-item survey of 202 mothers or primary caregivers from July through December 2016. Participants with 2 or more children aged 6 to 10 years were asked to choose 1 child and answer survey questions with that 1 reference child in mind.
[b] Percentages may not sum to 100 because of rounding.
[c] Determined by Fisher exact test.
[d] Values do not sum to 202 because 3 respondents did not answer question.
[e] Determined by Cochran–Armitage 2-sided trend test.

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Table 1. Characteristics of Study Population and Their Association With Heavy Screen Use (≥4 Screen-Time Hours per Day) on Weekdays and Weekends Among Mexican-Origin Children Aged 6 to 10 Years, Chaparral and Columbus, New Mexico, 2016[a]

Characteristic	Overall, No. (%)[b] (n = 202)	Weekday (n = 30)		Weekend Day (n = 51)	
		No. (%)	*P* Value	No. (%)	*P* Value
No	22 (10.9)	3 (13.6)	>.99[c]	8 (36.4)	.20[c]
Yes	180 (89.1)	27 (15.0)		43 (23.9)	
Primary language in household					
Spanish	180 (89.1)	26 (14.4)	.75[c]	45 (25.0)	.80[c]
English	22 (10.9)	4 (18.2)		6 (27.3)	
Language child uses for electronics					
Spanish exclusively	46 (22.8)	9 (19.6)	.59[c]	15 (32.6)	.36[c]
English exclusively	84 (41.6)	11 (13.1)		21 (25.0)	
Both	72 (35.6)	10 (13.9)		15 (20.8)	
Internet access type					
Cell phone subscription	87 (43.1)	14 (16.1)	.21[c]	22 (25.3)	.95[c]
DSL/cable subscription	49 (24.3)	6 (12.2)		15 (30.6)	
Both cell phone and DSL/cable subscription	21 (10.4)	3 (14.3)		5 (23.8)	
Other type of internet subscription	15 (7.4)	5 (33.3)		3 (20.0)	
Access to internet without subscription	14 (6.9)	2 (14.3)		3 (21.4)	
No internet access	16 (7.9)	0		3 (18.8)	
Community of residence					
Chaparral	102 (50.5)	16 (15.7)	.84[c]	19 (18.6)	.04[c]
Columbus	100 (49.5)	14 (14.0)		32 (32.0)	
Total	202 (100.0)	30 (14.9)	–	51 (25.2)	–

[a] Data collected from 88-item survey of 202 mothers or primary caregivers from July through December 2016. Participants with 2 or more children aged 6 to 10 years were asked to choose 1 child and answer survey questions with that 1 reference child in mind.
[b] Percentages may not sum to 100 because of rounding.
[c] Determined by Fisher exact test.
[d] Values do not sum to 202 because 3 respondents did not answer question.
[e] Determined by Cochran–Armitage 2-sided trend test.

Table 2. Household Norms and Their Association With Heavy Screen Use (≥4 Screen-Time Hours per Day) on Weekdays and Weekends Among Mexican-Origin Children Aged 6 to 10 Years, Chaparral and Columbus, New Mexico, 2016[a]

Household Norm	Category	Overall, No. (%) (n = 202)	Weekday (n = 30)		Weekend Day (n = 51)	
			No. (%)	*P* Value[b]	No. (%)	*P* Value[b]
Is the TV on when your child eats?	No	81 (40.1)	6 (7.4)	.02	13 (16.0)	.01
	Yes	121 (59.9)	24 (19.8)		38 (31.4)	
When eating together as a family, is there anyone who uses electronics (cell phone, games, etc.)?	No	153 (75.7)	20 (13.1)	.25	37 (24.2)	.57
	Yes	49 (24.3)	10 (20.4)		14 (28.6)	
During a normal week, how often does your family eat a meal together?	≤1	18 (8.9)	2 (11.1)	.03	5 (27.8)	.08
	2 or 3	32 (15.8)	10 (31.3)		13 (40.6)	
	>3	152 (75.2)	18 (11.8)		33 (21.7)	
When your child misbehaves, do you ever take away his/her outdoor play time?	No	108 (53.5)	14 (13,0)	.44	28 (25.9)	.87
	Yes	94 (46.5)	16 (17.0)		23 (24.5)	
When your child misbehaves, do you ever take away his/her electronics?	No	17 (8.4)	2 (11.8)	>.99	1 (5.9)	.08
	Yes	185 (91.6)	28 (15.1)		50 (27.0)	
Does it ever seem the only way to keep your child entertained is to encourage his/her use of TV, tablet, video games, or other electronics?	No	172 (85.1)	22 (12.8)	.09	37 (21.5)	.006
	Yes	30 (14.9)	8 (26.7)		14 (46.7)	
How many times a week does your family do active things together?	≤1	80 (39.6)	15 (18.8)	.48	29 (36.3)	.01
	2 or 3	65 (32.2)	8 (12.3)		10 (15.4)	
	>3	57 (28.2)	7 (12.3)		12 (21.1)	
Total	—	202 (100.0)	30 (14.9)	—	51 (25.2)	—

[a] Data collected from 88-item survey of 202 mothers or primary caregivers from July through December 2016. Participants with 2 or more children aged 6 to 10 years were asked to choose 1 child and answer survey questions with that 1 reference child in mind.
[b] Determined by Fisher exact test.

Table 3. Adjusted Odds Ratios for Associations of Demographic Characteristics and Household Norms With Heavy Screen Use (≥4 Screen-Time Hours per Day) on Weekdays and Weekends Among Mexican-Origin Children Aged 6 to 10 Years, Chaparral and Columbus, New Mexico, 2016[a]

Demographic Variable or Household Norm	Adjusted Odds Ratio (95% Confidence Interval)	
	Weekday	Weekend Day
Community of residence		
Chaparral	1 [Reference]	1 [Reference]
Columbus	0.63 (0.24–1.63)	1.22 (0.56–2.65)
Child's age	1.17 (0.83–1.64)	1.24 (0.92–1.66)
Child's sex		
Male	1 [Reference]	1 [Reference]
Female	1.01 (0.41–2.48)	0.63 (0.29–1.38)
Maternal age	0.95 (0.89–1.02)	1.04 (0.99–1.10)
Years of maternal education	0.96 (0.80–1.16)	1.02 (0.88–1.17)
No. of household members	0.79 (0.57–1.10)	0.73 (0.55–0.98)
Monthly household income, $[b]		
<1,000	1 [Reference]	—
Don't know	0.67 (0.18–2.51)	—
1,000–1,999	0.92 (0.28–2.98)	—
≥2,000	0.44 (0.11–1.69)	—
Household member receives Medicaid[b]		
No	—	1 [Reference]
Yes	—	0.33 (0.10–1.03)
Television on during meals[c]		
No	1 [Reference]	1 [Reference]
Yes	3.02 (1.08–8.45)	2.38 (1.04–5.40)
Someone uses electronics while eating[c]		
No	1 [Reference]	1 [Reference]
Yes	1.32 (0.50–3.54)	1.18 (0.49–2.88)
No. of meals eaten together during the week[c]		
≤3	1 [Reference]	1 [Reference]
>3	0.44 (0.17–1.16)	0.40 (0.17–0.94)
Outdoor play time limited for misbehavior[c]		
No	1 [Reference]	1 [Reference]
Yes	1.25 (0.51–3.05)	0.85 (0.39–1.84)
Use of electronic devices limited for misbehavior[c]		
No	1 [Reference]	1 [Reference]

[a] Data collected from 88-item survey of 202 mothers or primary caregivers from July through December 2016. Participants with 2 or more children aged 6 to 10 years were asked to choose 1 child and answer survey questions with that 1 reference child in mind.
[b] Medicaid participation was used as a proxy for income in the weekend model because 28.2% of participants responded "don't know" to the income question. For the weekday model, only 3 reference children were heavy users and were not in a Medicaid household, so we chose to include household income in this model, treating the "don't knows" as a separate category and combining the $2,000-$2,999 and ≥$3,000 groups. Internet access was not included in the models because none of the heavy users were without internet access.
[c] Household norms were rephrased for this table.

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Table 3. Adjusted Odds Ratios for Associations of Demographic Characteristics and Household Norms With Heavy Screen Use (≥4 Screen-Time Hours per Day) on Weekdays and Weekends Among Mexican-Origin Children Aged 6 to 10 Years, Chaparral and Columbus, New Mexico, 2016[a]

Demographic Variable or Household Norm	Adjusted Odds Ratio (95% Confidence Interval)	
	Weekday	Weekend Day
Yes	0.78 (0.14–4.23)	5.84 (0.64–53.05)
Feels electronics are the only way to keep children entertained[c]		
No	1 [Reference]	1 [Reference]
Yes	2.17 (0.75–6.30)	2.94 (1.15–7.51)
No. of times per week family does active things together[c]		
≤1	1 [Reference]	1 [Reference]
2 or 3	0.58 (0.19–1.75)	0.33 (0.12–0.87)
>3	1.14 (0.36–3.63)	0.96 (0.38–2.46)

[a] Data collected from 88-item survey of 202 mothers or primary caregivers from July through December 2016. Participants with 2 or more children aged 6 to 10 years were asked to choose 1 child and answer survey questions with that 1 reference child in mind.
[b] Medicaid participation was used as a proxy for income in the weekend model because 28.2% of participants responded "don't know" to the income question. For the weekday model, only 3 reference children were heavy users and were not in a Medicaid household, so we chose to include household income in this model, treating the "don't knows" as a separate category and combining the $2,000-$2,999 and ≥$3,000 groups. Internet access was not included in the models because none of the heavy users were without internet access.
[c] Household norms were rephrased for this table.

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ORIGINAL RESEARCH

A Diabetic Retinopathy Screening Tool for Low-Income Adults in Mexico

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PEER REVIEWED

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Abstract

Introduction
A national diabetic retinopathy screening program does not exist in Mexico as of 2017. Our objective was to develop a screening tool based on a predictive model for early detection of diabetic retinopathy in a low-income population.

Methods
We analyzed biochemical, clinical, anthropometric, and sociodemographic information from 1,000 adults with diabetes in low-income communities in Mexico (from 11,468 adults recruited in 2014–2016). A comprehensive ophthalmologic evaluation was performed. We developed the screening tool through the following stages: 1) development of a theoretical predictive model, 2) performance assessment and validation of the model using cross-validation and the area under the receiver operating characteristic curve (AUC ROC), and 3) optimization of cut points for the classification of diabetic retinopathy. We identified points along the AUC ROC that minimized the misclassification cost function and considered various scenarios of misclassification costs and diabetic retinopathy prevalence.

Results
Time since diabetes diagnosis, high blood glucose levels, systolic hypertension, and physical inactivity were considered risk factors in our screening tool. The mean AUC ROC of our model was 0.780 (validation data set). The optimized cut point that best represented our study population ($z = -0.640$) had a sensitivity of 82.9% and a specificity of 61.9%.

Conclusion
We developed a low-cost and easy-to-apply screening tool to detect people at high risk of diabetic retinopathy in Mexico. Although classification performance of our tool was acceptable (AUC ROC > 0.75), error rates (precision) depend on false-negative and false-positive rates. Therefore, confirmatory assessment of all cases is mandatory.

Introduction

In 2016, diabetes was declared a national epidemiologic emergency in Mexico (1). In 2006, the estimated prevalence of diabetes in Mexican adults was 14.4% (2). Mortality rates attributable to this disease in Mexico are among the highest in the world (3). By 2012, 74.7% of Mexican adults with diagnosed diabetes had inadequate glycemic control (4). Diabetes is associated with the development and progression of diabetic retinopathy (5–8), a major cause of sight loss and blindness in Latin American countries (9). A population-based survey from 2010 in the state of Chiapas found that 38.9% of adults aged 50 or older with diabetes had diabetic retinopathy and 21.0% had proliferative diabetic retinopathy (10).

Long-term diabetes and hypertension are consistently associated with diabetic retinopathy (5–8,11–13). The Mexican National Nutrition Survey 2006 found that the mean time since diabetes diagnosis among adults was more than 8 years (2). In 2012, an estimated 65.6% of adults with diabetes had hypertension (14). In this context, an epidemic of diabetes complications, including diabetic retinopathy, could worsen in Mexico, and the study of screening systems for diabetic retinopathy is important.

Diabetic retinopathy ranks third in direct costs generated by diabetes complications in Mexico (15); these costs result from specialized procedures for diagnosis and treatment. A cost-benefit analysis to identify optimal cut points for identifying people who are at risk for diabetic retinopathy and who need a comprehensive ophthalmologic evaluation is an approach to developing an adequate-performance screening tool (16); however, such an approach would be complex because of the detailed cost information required.

Our objective was to develop a practical screening tool based on a predictive model and a simplification of a cost-benefit analysis to optimize cut points for early detection of diabetic retinopathy in low-income communities in Mexico.

Methods

We conducted a screening protocol for eye-related complications of diabetes from May 1, 2014, to June 30, 2016, in 3 low-income municipalities in the state of Morelos. We recruited 11,468 adults (aged ≥20 y) for a screening of chronic diseases in our mobile unit and community health centers. From these participants, we invited those with a type 2 diabetes diagnosis (n = 1,768 [15.4%]) to a comprehensive ophthalmologic evaluation. Exclusion criteria for this evaluation were signs of ocular infection or pregnancy.

Of the 1,768 participants, 538 declined to participate in the ophthalmologic evaluation, 1 person was excluded because the quality of photographs was not adequate for grading, and 229 participants did not have a photographic assessment at the time of analysis. One thousand participants (56.6%) completed the procedure. We obtained informed consent from all participants, and the protocol was approved by the ethics, research, and biosecurity committees of the Mexican National Institute of Public Health.

Data collection and definition of variables

All participants had at least 1 glycemic assessment (fasting [≥8 h] capillary or random capillary glycemia [glucometer method] or fasting venous glycemia [glucose oxidase method]). Fasting serum triglycerides, total cholesterol, and high-density lipoprotein cholesterol were assessed by enzymatic method (n = 418) and serum insulin with radioimmunoassay method (n = 112) for a portion of the sample; because of logistical and budgetary constraints, the entire sample could not be assessed for these variables.

High blood glucose was defined as a fasting glucose of 126 mg/dL or more or, if fasting glucose was unavailable, as random glucose of 200 mg/dL or more (17). Insulin resistance was classified by using a homeostasis model assessment value of 3.8 or more (18).

Hypertriglyceridemia was defined as triglycerides of 150 mg/dL or more, hypercholesterolemia as total cholesterol of 200 mg/dL or more, and hypoalphalipoproteinemia as high-density lipoprotein cholesterol of less than 50 mg/dL for women and less than 40 mg/dL for men (19,20).

Blood pressure was measured twice (interval of 30 seconds). We diagnosed high systolic/diastolic blood pressure when the average of the assessments was ≥140/≥90 mm Hg. Likewise, we recorded whether participants reported a diagnosis of hypertension (21).

Weight, height, and waist circumference were measured by trained personnel using standard protocols. Body mass index (BMI; weight in kilograms divided by height in m^2 [kg/m^2]) was calculated: overweight was defined as a BMI of 25.0 to 29.9 and obesity as a BMI of 30.0 or more (22). Abdominal obesity was defined as a waist circumference of 80 cm or more for women and 90 cm or more for men (19).

Data on sociodemographic characteristics and clinical history were collected by trained interviewers through an adapted version of the questionnaires applied in the National Health and Nutrition Survey of Mexico (23). We used the time since diabetes diagnosis as a proxy of duration of type 2 diabetes and categorized it into 4 intervals (<5 y, 5 y to <10 y, 10 y to <15 y and ≥15 y). Participants reported whether they followed diet and physical activity recommendations to control their diabetes.

We conducted a principal component analysis of 15 characteristics related to household appliances and services (eg, ownership of car, telephone, computer, vacuum cleaner, washing machine, refrigerator, pay television, internet) as a proxy for socioeconomic status (SES). Similar methods have been used (14). These characteristics had a factorial loading of 0.30 or more. The first principal component was divided into tertiles and used as a proxy for low SES, medium SES, and high SES.

Ophthalmologic evaluation

All participants were interviewed by using a validated questionnaire for ocular assessment. The following data were collected by trained technicians: best-corrected visual acuity, refractometry (by using an automated refractor [Huvitz HRK-7000]), and intraocular pressure (by using a rebound tonometer [Icare TA01i]). Afterwards, all participants received a photographic evaluation of their posterior pole (45° nonmydriatic fundus camera [DRS-Centervue]). Participants were dilated with tropicamide only if the quality of the photographs was not adequate for grading. We took 3 fields of the posterior pole using a standardized protocol. The first field centered on the optic nerve, the second field centered on the fovea, and third field was temporal to the macula but included the fovea. This protocol has an adequate level of sensitivity and specificity for grading referable stages of diabetic retinopathy (24).

All photographs were sent to Eye Knowledge Network (www.eye-knowledge.net). All cases were masked and reviewed by trained graders from the Hospital Luis Sánchez Bulnes of the Association for the Prevention of Blindness in Mexico. The cases were graded by using the Revised English Diabetic Eye Screening Program Grading System (25), which allows prompt referral of proliferative stages of diabetic retinopathy and macular edema. Diabetic retinopathy was recorded when a participant had background diabetic retinopathy, preproliferative diabetic retinopathy, or proliferative diabetic retinopathy.

Statistical analysis

We tabulated categorical variables as frequency and proportion distributions and quantitative variables as measures of central tendency (mean or median) and dispersion (standard deviation [SD] or interquartile range). We set statistical significance at an α of .05. We compared measures of central tendency according to diabetic retinopathy status of participants (has diabetic retinopathy or does not have diabetic retinopathy) by using the Student *t* test or Mann–Whitney *U* test, depending on the distribution of the quantitative variables. We used a χ^2 test or Fisher exact test to compare the prevalence of diabetic retinopathy across categories of nonquantitative variables. We conducted a descriptive analysis to compare sociodemographic and clinical characteristics and diabetic retinopathy risk factors between participants and nonparticipants.

We developed the screening tool in 3 stages: 1) we developed the theoretical predictive model, 2) we assessed the performance of the model and conducted a validation analysis, and 3) we optimized risk-score cut points for diabetic retinopathy classification.

Development of the theoretical predictive model

For multivariate analysis, we included only participants who had complete information on diabetic retinopathy status (the dependent variable), and we determined whether at least 95% of the participants provided information for each of the independent variables. If 5% or more of the participants did not provide information for an independent variable (theoretical risk factors of diabetic retinopathy), we used multiple imputation through a logistic regression model, where diabetic retinopathy, sex, age, and self-reported diabetes screening were the independent variables, to complete the information.

We generated a predictive probit model based on theoretical risk factors of diabetic retinopathy (5–8,11–13). We decided to use this model to develop our tool because of its easy interpretability as a *z* score from its linear equation and because it provides a predicted probability for the linear predictor (applying the standard normal cumulative function). Familiarity with this distribution provides a better understanding of coefficients and predicted *z* scores. The dependent variable was diabetic retinopathy, and the 4 predictors were time since diabetes diagnosis, high blood glucose, high systolic blood pressure, and physical inactivity. We estimated probabilities adjusted by covariables of having diabetic retinopathy given each risk factor category though predictive margins.

Performance assessment and validation

We used the *k*-fold cross-validation method ($k = 10$ partitions) and the area under the receiver operating characteristic curve (AUC ROC). To assess the performance of the model in training and validation data sets, we randomly divided the sample into 10 partitions. In each partition, one segment was reserved for model validation (validation data set, n ~ 10%), while the rest of the sample in this partition was used as a training subsample (training data set, n ~ 90%). We calculated the AUC ROC for each iteration and its mean for the 10 iterations.

Optimization of risk-score cut points for diabetic retinopathy classification

We developed a risk score for diabetic retinopathy based on the *z* predictor of our statistical model. In this way, the attributable score of each risk factor was equivalent to its probit coefficient.

The use of a cost-benefit analysis to select cut points implies knowledge of true and false classification costs; however, it is difficult to have such complete information. To select the optimal cut points of the *z* predictor to classify diabetic retinopathy, we decided to focus on misclassification costs only through the misclassification cost term (16). We identified points along the ROC curve that minimized the misclassification cost function for various scenarios of misclassification costs and diabetic retinopathy prevalence. The costs of true classification were assumed as null, and the examples of the variations of misclassification ratios were set according to consequences in health costs of screening for diabetic retinopathy.

We estimated sensitivity and specificity across AUC ROC and iso-cost curves, which minimized the costs of misclassification. Likewise, we estimated positive predictive values and negative predictive values.

We considered the following scenarios for the optimization of the cut points: diabetic retinopathy prevalence of 35.0%, 40.0%, and 45.0%, and the observed prevalence in our sample. We examined various ratios of cost misclassification (classification costs of false negatives divided by classification costs of false positives). We examined ratios of 1, 4, and 10, assuming that classification of a false negative would generate higher health care costs than would classification of a false positive.

The statistical analysis was conducted by using Stata version 13.1 (StataCorp LLC) and RStudio version 1.0.136 with the OptimalCutpoints package.

Results

The mean age of our sample was 57.2 y (SD, 11.0 y), and 73.0% were women. The prevalence of diabetic retinopathy was 31.7% (Table 1); 18.9% had background diabetic retinopathy, 5.7% had preproliferative diabetic retinopathy, and 7.1% of participants had active proliferative diabetic retinopathy.

The prevalence of diabetic retinopathy was significantly higher among participants with insulin resistance, high blood glucose, and hypertension than among participants without those conditions. Participants with diabetic retinopathy had significantly longer times since diabetes diagnosis, higher blood glucose levels, and higher systolic blood pressure than those without diabetic retinopathy. In contrast, the prevalence of diabetic retinopathy was lower among participants who were overweight or obese, had abdominal obesity, or used physical activity to control their diabetes than among participants without these characteristics. The prevalence of diabetic retinopathy was highest, by SES, in the lowest tertile of SES and highest, by marital status, among divorced adults (Table 1).

We found no significant differences in the distribution of sociodemographic characteristics, clinical characteristics, or diabetic retinopathy risk factors between participants and nonparticipants.

Development and cross-validation of predictive model

From all independent variables included in our model, except physical activity (data were missing for 17.0% of participants), had at least 95.0% of information. After multiple imputation analysis for physical activity, we obtained a probit model with 939 observations.

According to our multivariate analysis (Table 2), time since diabetes diagnosis was positively associated with the estimated probability of diabetic retinopathy. For example, the probability of diabetic retinopathy was 11.4% (95% confidence interval [CI], 7.9%–14.9%) when time since diabetes diagnosis was less than 5 years, whereas the probability was 56.0% (95% CI, 49.5%–62.6%) when time since diabetes diagnosis was 15 years or more. Similarly, the probability of diabetic retinopathy was higher among those with high blood glucose (35.6%) and high systolic blood pressure (37.4%) than among those without those conditions (23.9% and 29.3%, respectively). On the other hand, participants who reported using physical activity to control diabetes had a lower predicted probability of diabetic retinopathy (25.4%) than those who reported not using physical activity (34.8%).

According to the cross-validation analysis (Table 3), the diagnostic performance of our model was similar between training data sets (mean AUC ROC = 0.780) and validation data sets (mean AUC ROC = 0.778).

Risk-score cut points for diabetic retinopathy classification

According to the prevalence of diabetic retinopathy observed with misclassification ratios of 1, 4, and 10, the optimal cut points were −0.046, −0.640, and −1.209, respectively (Table 4).

Four points minimized the misclassification costs given the ROC curve of our model (Figure). The optimized cut point according to a misclassification ratio of 4 and the diabetic retinopathy prevalence observed in our sample (31.7%) was $z = -0.640$, with a sensitivity of 82.9%, a specificity of 61.9%, a positive predictive value of 50.3%, and a negative predictive value of 88.6% (Table 4).

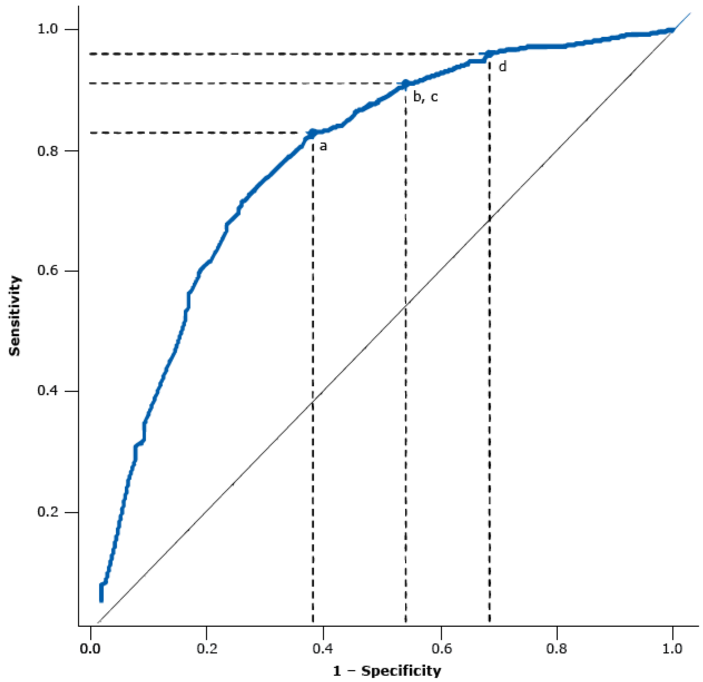

Figure. Area under the receiver operating characteristic (ROC) curve and points along the ROC curve corresponding to optimized cut points given a cost ratio (classification costs of false negatives divided by classification costs of false positives) equal to 4 and various scenarios of diabetic retinopathy prevalence: a) 31.7%, the observed prevalence in the study population; b) and c) prevalence of 35.0% and 40.0%; and d) prevalence of 45.0%.

On the basis of our data, we propose a risk-score screening tool (Box): A health care provider (can be a nonspecialized provider) asks the patient 2 questions (on time since diabetes diagnosis and use of physical activity to control diabetes) and obtains 2 measurements (blood glucose and systolic blood pressure). Each response is scored, the scores are summed, and a final score is calculated. The health care provider consults a simple chart that shows 4 levels of diabetic retinopathy prevalence, chooses the prevalence that most closely matches the prevalence of the community in which the patient resides, and then identifies the cut point that corresponds with the prevalence. If the patient has a score equal to or greater than the cut point, the patient should be directed to receive a comprehensive ophthalmologic evaluation.

Box. Proposed Screening Tool for Diabetic Retinopathy in Mexican Adults Aged ≥20 With Type 2 Diabetes, Given a Cost Ratio (Classification Costs of False Negatives Divided by Classification Costs of False Positives) of 4

Application Instructions:

1. Check one box per question.
2. Sum the corresponding scores of each checked box and then subtract 1.48.
3. Use the cut point closest to the diabetic retinopathy prevalence of the population in which you are applying this tool.
4. If the patient obtained a higher or equal score to the cut point used, the patient must be referred to specialized health services for a comprehensive ophthalmologic evaluation.

Risk Factors for Diabetic Retinopathy	Score
The information of the following 2 questions must be obtained by direct interview:	
1. How long have you been diagnosed with type 2 diabetes?	
<5 years □	0
5 to 9 years □	0.55
10 to 14 years □	1.16
≥15 years □	1.41
2. Do you use physical activity to control blood sugar?	
No □	0
Yes □ (If you checked yes for this question, you must subtract 0.33)	−0.33
The information of the following 2 questions must be obtained from measurements carried out by the interviewer:	
3. The patient had fasting capillary or venous glucose higher or equal to 126 mg/dL or random capillary glucose higher or equal to 200 mg/dL?	
No □	0
Yes □	0.41
4. The patient presented systolic blood pressure higher or equal to 140 mm Hg?	
No □	0
Yes □	0.27
Sum of scores	
Subtract	1.48
Final score	

- If prevalence of diabetic retinopathy is close to 31.7%, then cut point is −0.640
- If prevalence of diabetic retinopathy is close to 35.0%, then cut point is −1.017
- If prevalence of diabetic retinopathy is close to 40.0%, then cut point is −1.017
- If prevalence of diabetic retinopathy is close to 45.0%, then cut point is −1.190

Discussion

We developed a practical screening tool for diabetic retinopathy that could be used by nonspecialized health care personnel in low-income settings. The tool requires information on 4 risk factors. Other risk scores exist (26,27); unlike these, we optimized various cut points according to misclassification costs and diabetic retinopathy prevalence. This optimization allows the application of this tool in various contexts.

We assumed that classifying people as not having diabetic retinopathy when they actually have the condition (false negative) would result in higher long-term health care costs than would classifying them with the disease when they do not have it (false positive), because without timely diagnosis and treatment, these people are likely to progress to advanced stages of the condition. We recommend using the cut points for misclassification ratios of 4 and 10, which gives greater importance to sensitivity than to specificity. Although this recommendation substantially decreases specificity, it does not imply negative health effects, because all people with type 2 diabetes should receive an ophthalmologic evaluation when diabetes is diagnosed (17).

Although the rate of false positives generated by our tool could increase health care costs (as a result of comprehensive ophthalmologic evaluations), the application of our tool could help improve compliance with recommendations for obtaining these evaluations. In addition, the benefits of timely diagnosis and treatment could compensate for any increases in health care costs.

Although we did not have complete information for a cost-benefit analysis, we showed how results changed when the relative importance of the cost of false negatives (type 2 error) to the cost of false positives (type 1 error) varied. We set false-negative rates to be higher than false-positive rates because the health care costs resulting from delays in diagnosis and treatment of false negatives may be high in the context of the screening of diabetic retinopathy. Although the classification performance of our tool was acceptable (AUC ROC > 0.75), the precision of classification depends on the false-negative rate and false-positive rate. Therefore, confirmatory assessment of all cases is mandatory. Additionally, the negative cases identified by this tool also are at some risk of diabetic retinopathy, so periodic exploratory evaluations should be performed in all patients with diabetes.

We presented misclassification ratios only as examples: different ratios could be assumed for future research or in different contexts. Our study demonstrated a simplified approach for developing a screening tool based on a misclassification-cost criterion. Future research should focus on the assignment of costs for the 4 classification types (true positives, true negatives, false positives, and false negatives) on diabetic retinopathy screening context.

We found that systolic blood pressure and the lack of physical activity were associated with diabetic retinopathy; some studies showed that high systolic blood pressure is a potentially modifiable risk factor for diabetic retinopathy (7,12). Physical inactivity could be another important modifiable risk factor for diabetic retinopathy because it is associated with poor glycemic control (28). Our study showed that a simple question about physical activity can predict a significantly lower probability of diabetic retinopathy. Although the question cannot determine whether a person is implementing this lifestyle recommendation, it may reflect awareness and knowledge of self-care practices.

Consistent with other researchers (29,30), we observed a negative effect of obesity on diabetic retinopathy. Participants with overweight and obesity had lower levels of blood glucose and less time since diabetes diagnosis than did underweight and normal-weight participants (data not shown). We believe that the negative effect of obesity on diabetic retinopathy may be attributed to the fact that people with excess weight are experiencing an earlier stage of diabetes than people with normal or low weight.

We found a higher proportion of women (73.0%) than men in our study sample possibly because women engage in self-care practices and informal unpaid activities more than men do; this engagement may have facilitated their attendance to the recruitment process. We found a lower systolic blood pressure among women than among men (data not shown), which, given the higher proportion of women, could have underestimated the effect of systolic blood pressure in our analysis.

Our study has limitations. We did not measure HbA1c, which prevented us from adjusting our model by a variable of long-term glycemic control. However, our model adequately predicted diabetic retinopathy using parameters that are easier to measure and less expensive than an HbA1c test, which is not available at all primary health care service locations in Mexico.

An important portion of the population with type 2 diabetes may not receive a diagnosis for years (17). In Mexico, almost half of the population with diabetes is not diagnosed during routine health care, and many of them have complications that indicate many years of living with the disease (2). However, it was not possible to assess how long our study participants had been living with diabetes. Because the onset of type 2 diabetes can occur at any point during adulthood (random error), age is not the best indicator of diabetes duration. Instead of age, we used time since diagnosis as a variable for diabetes duration. Self-report of time since diabetes diagnosis may underestimate duration, but we considered it to be a nondifferential systematic error that did not affect our results. People with type 2 diabetes may recall onset of their disease inaccurately, but the inaccuracy is the same across the population of people with diabetes, and recall of onset is independent of the diabetic retinopathy condition.

The high health cost of diabetic retinopathy in Mexico is due in part to the lack of a program designed to prevent diabetes complications (15). A challenge for our team will be to develop pilot studies that evaluate the feasibility, functionality, and costs of offering our screening tool at primary health care service locations as a strategy for strengthening the system for ophthalmologic evaluation of people with diabetes.

Early detection strategies must be implemented to reduce the burden of diabetic retinopathy. Our new screening tool is a promising approach and a practical strategy with an adequate performance to detect risk of diabetic retinopathy in adults with type 2 diabetes in low-income communities in Mexico.

Notes

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Tables

Table 1. Prevalence of Diabetic Retinopathy[a] by Sociodemographic and Clinical Characteristics, and Means/Medians for Other Clinical Characteristics by Diabetic Retinopathy[a] Status of Study Population in 3 Low-Income Municipalities, Mexico, 2014–2016

Characteristics	Total (N = 1,000)	Has Diabetic Retinopathy, % (n = 317)	Does Not Have Diabetic Retinopathy, % (n = 683)	*P* Value[b]
Overall	1,000	31.7	68.3	
Sex[c]				
Female	730	30.6	69.4	.20
Male	270	34.8	65.2	
Socioeconomic status[c,d]				
Low	332	35.5	64.5	.04
Middle	332	32.8	67.2	
High	331	26.6	73.4	
Marital status[c]				
Single	100	20.0	80.0	.01
Married	675	31.6	68.4	
Divorced	77	41.6	58.4	
Widowed	133	35.3	64.7	
Can speak an indigenous language[c]				
Yes	47	34.0	66.0	.71
No	949	31.5	68.5	
Education[c]				
None	162	34.6	65.4	.06
Some elementary school	454	33.5	66.5	
Some junior high school	237	32.9	67.1	
Some high school	82	23.2	76.8	
Some bachelor's degree or more	63	19.1	80.9	
Health system affiliation[c]				
None	83	30.1	69.9	.26

Abbreviations: HOMA, homeostasis model assessment; IMSS, the Mexican Social Security Institute (Spanish: Instituto Mexicano del Seguro Social); IQR, interquartile range; ISSSTE, the Institute for Social Security and Services for State Workers (Spanish: Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado).
[a] Diabetic retinopathy classification according to Revised English Diabetic Eye Screening Program Grading System (grade 1, grade 2, or grade 3) (25).
[b] χ^2 test (contingency tables for more than 2 categories or proportion comparison), Student *t* test, or Mann–Whitney *U* test.
[c] The percentage of participants with missing data was <5.0% or with complete information.
[d] Socioeconomic index developed by using first principal component methodology.
[e] Prevalence of diabetic retinopathy was 32.5% among those measured for triglycerides, total cholesterol, and high-density lipoprotein cholesterol (n = 418).
[f] Prevalence of diabetic retinopathy was 25.9% among those measured for insulin (n = 112).
[g] The percentage of participants with missing data ≥5.0%.
[h] Determined by answer to question "Do you have any other treatment for sugar control?" Exercise (no/yes) and diet (yes/no) were provided as possible responses.
[i] Prevalence of diabetic retinopathy was 30.7% among those measured for fasting capillary glucose (n = 423).
[j] Prevalence of diabetic retinopathy was 31.6% among those measured for random capillary glucose (n = 402).
[k] Prevalence of diabetic retinopathy was 32.5% among those measured for fasting venous glucose (n = 418).

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Table 1. Prevalence of Diabetic Retinopathy[a] by Sociodemographic and Clinical Characteristics, and Means/Medians for Other Clinical Characteristics by Diabetic Retinopathy[a] Status of Study Population in 3 Low-Income Municipalities, Mexico, 2014–2016

Characteristics	Total (N = 1,000)	Has Diabetic Retinopathy, % (n = 317)	Does Not Have Diabetic Retinopathy, % (n = 683)	*P* Value[b]
IMSS	150	27.3	72.7	
ISSSTE	72	23.6	76.4	
Seguro Popular	681	33.5	66.5	
Private	13	46.2	53.8	
Other	1	0.0	100.0	
Body mass index,[c] kg/m²				
<25.0	247	44.9	55.1	<.001
25.0–29.9	416	30.8	69.2	
≥30.0	321	23.1	76.9	
Abdominal obesity (waist circumference ≥80 cm for women and ≥90 cm for men)[c]				
Yes	869	30.4	69.6	.008
No	115	42.6	57.4	
Triglycerides ≥150 mg/dL[e]				
Yes	294	34.0	66.0	.32
No	124	29.0	70.1	
Cholesterol ≥200 mg/dL[e]				
Yes	168	37.5	62.5	.08
No	250	29.2	70.8	
High-density lipoprotein cholesterol <50 mg/dL for women and <40 mg/dL for men[e]				
Yes	329	31.3	68.7	.30
No	89	37.1	62.9	
Insulin resistance HOMA index ≥3.8[f]				
Yes	48	39.6	60.4	.004
No	64	15.6	84.4	
High blood glucose[c] (fasting glucose ≥126 mg/dL or random glucose ≥200 mg/dL)				
Yes	603	38.1	61.9	<.001

Abbreviations: HOMA, homeostasis model assessment; IMSS, the Mexican Social Security Institute (Spanish: Instituto Mexicano del Seguro Social); IQR, interquartile range; ISSSTE, the Institute for Social Security and Services for State Workers (Spanish: Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado).
[a] Diabetic retinopathy classification according to Revised English Diabetic Eye Screening Program Grading System (grade 1, grade 2, or grade 3) (25).
[b] χ^2 test (contingency tables for more than 2 categories or proportion comparison), Student *t* test, or Mann–Whitney *U* test.
[c] The percentage of participants with missing data was <5.0% or with complete information.
[d] Socioeconomic index developed by using first principal component methodology.
[e] Prevalence of diabetic retinopathy was 32.5% among those measured for triglycerides, total cholesterol, and high-density lipoprotein cholesterol (n = 418).
[f] Prevalence of diabetic retinopathy was 25.9% among those measured for insulin (n = 112).
[g] The percentage of participants with missing data ≥5.0%.
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[i] Prevalence of diabetic retinopathy was 30.7% among those measured for fasting capillary glucose (n = 423).
[j] Prevalence of diabetic retinopathy was 31.6% among those measured for random capillary glucose (n = 402).
[k] Prevalence of diabetic retinopathy was 32.5% among those measured for fasting venous glucose (n = 418).

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Table 1. Prevalence of Diabetic Retinopathy[a] by Sociodemographic and Clinical Characteristics, and Means/Medians for Other Clinical Characteristics by Diabetic Retinopathy[a] Status of Study Population in 3 Low-Income Municipalities, Mexico, 2014–2016

Characteristics	Total (N = 1,000)	Has Diabetic Retinopathy, % (n = 317)	Does Not Have Diabetic Retinopathy, % (n = 683)	*P* Value[b]
No	345	20.0	80.0	
General hypertension[c] (previous diagnosis or measurement of blood pressure ≥140/≥90 mm Hg)				
Yes	524	35.5	64.5	.006
No	469	27.3	72.7	
Physical activity used to control diabetes[g, h]				
Yes	272	26.8	73.2	.01
No	554	35.6	64.4	
Diet used to control diabetes[g, h]				
Yes	345	30.4	69.6	.23
No	483	34.4	65.6	
Age, mean (SD), y[c]	57.2 (11.0)	57.9 (9.3)	56.9 (11.7)	.16
Time since diabetes diagnosis, median (IQR), y[c]	7.0 (3.0–14.0)	13.0 (8.0–18.0)	5.0 (2.0–10.0)	<.001
Fasting capillary glucose, median (IQR), mg/dL[i]	149.0 (118.0–221.0)	194.5 (140.0–243.0)	137.0 (113.0–195.0)	<.001
Random capillary glucose, median (IQR), mg/dL[j]	214.5 (155.0- 295.0)	240.0 (182.0–325.0)	196.0 (148.0–273.0)	<.001
Fasting venous glucose, median (IQR), mg/dL[k]	153.0 (117.0–219.0)	198.0 (146.0–252.0)	135.5 (110.0–197.0)	<.001
Insulin, median (IQR), μIU/mL[f]	9.75 (6.7–13.8)	10.4 (7.3–15.6)	9.5 (6.6–13.7)	.48
Systolic blood pressure, median (IQR), mm Hg[c]	127.5 (115.5–142.0)	131.5 (118.5–147.5)	126.5 (114.0–140.0)	<.001
Diastolic blood pressure, median (IQR), mm Hg[c]	72.0 (64.0–79.5)	72.5 (65.0–80.5)	71.5 (63.5–79.5)	.19

Abbreviations: HOMA, homeostasis model assessment; IMSS, the Mexican Social Security Institute (Spanish: Instituto Mexicano del Seguro Social); IQR, interquartile range; ISSSTE, the Institute for Social Security and Services for State Workers (Spanish: Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado).
[a] Diabetic retinopathy classification according to Revised English Diabetic Eye Screening Program Grading System (grade 1, grade 2, or grade 3) (25).
[b] χ^2 test (contingency tables for more than 2 categories or proportion comparison), Student *t* test, or Mann–Whitney *U* test.
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[g] The percentage of participants with missing data ≥5.0%.
[h] Determined by answer to question “Do you have any other treatment for sugar control?” Exercise (no/yes) and diet (yes/no) were provided as possible responses.
[i] Prevalence of diabetic retinopathy was 30.7% among those measured for fasting capillary glucose (n = 423).
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[k] Prevalence of diabetic retinopathy was 32.5% among those measured for fasting venous glucose (n = 418).

Table 2. Predictive Multivariate Model in the Development of a Screening Tool for Diabetic Retinopathy for Use in Low-Income Communities, Mexico, 2014–2016

Risk Factors for Diabetic Retinopathy	Predictive Probit Model (n = 939)[a]			
	Coefficient (SE)	*P* Value[b]	Estimated Probability[c], % (95% CI)	*P* Value[b]
Time since diabetes diagnosis, y				
<5	—[d]	—[d]	11.4 (7.9–14.9)	—[d]
5 to <10	0.55 (0.13)	<.001	24.9 (19.2–30.6)	<.001
10 to <15	1.16 (0.14)	<.001	46.6 (39.4–53.9)	<.001
≥15	1.41 (0.13)	<.001	56.0 (49.5–62.6)	<.001
High blood glucose (fasting venous or capillary glucose ≥126 mg/dL or random capillary glucose ≥200 mg/dL)				
No	—[d]	—[d]	23.9 (19.5–28.3)	—[d]
Yes	0.41 (0.10)	<.001	35.6 (32.2–39.0)	<.001
High systolic blood pressure (≥140 mm Hg)				
No	—[d]	—[d]	29.3 (26.2–32.4)	—[d]
Yes	0.27 (0.10)	.007	37.4 (32.3–42.5)	.007
Physical activity used to control diabetes[e]				
No	—[d]	—[d]	34.8 (31.4–38.2)	—[d]
Yes	−0.33 (0.11)	.002	25.4 (20.9–30.0)	.002
Constant	−1.48 (0.12)	<.001	—[d]	—[d]

Abbreviations: CI, confidence interval; SE, standard error.
[a] Multivariate probit model with any grade of diabetic retinopathy (grade 1, grade 2, or grade 3) as dependent variable according to Revised English Diabetic Eye Screening Program Grading System (25).
[b] *P* value for probit coefficients or for comparison of estimated probabilities among categories and lowest category of different variables.
[c] Obtained by predictive margins.
[d] Lowest category or estimated probability of constant.
[e] Determined by answer to question "Do you have any other treatment for sugar control?" Exercise (no/yes) was provided as a possible response.

Table 3. Cross-Validation Analysis (*k* = 10) of Predictive Probit Model (n = 939) in the Development of a Screening Tool for Diabetic Retinopathy for Use in Low-Income Communities, Mexico, 2014–2016

Iteration	Training Data Set (n ~ 90%), AUC ROC (95% CI)	Validation Data Set (n ~ 10%), AUC ROC (95% CI)
1	0.775 (0.742–0.809)	0.806 (0.720–0.891)
2	0.780 (0.747–0.813)	0.784 (0.690–0.877)
3	0.783 (0.751–0.815)	0.756 (0.642–0.870)
4	0.782 (0.750–0.814)	0.764 (0.659–0.869)
5	0.777 (0.744–0.810)	0.806 (0.712–0.899)
6	0.779 (0.747–0.811)	0.780 (0.664–0.896)
7	0.786 (0.754–0.818)	0.723 (0.603–0.842)
8	0.783 (0.750–0.815)	0.754 (0.653–0.855)
9	0.774 (0.740–0.807)	0.830 (0.746–0.914)
10	0.778 (0.746–0.811)	0.776 (0.672–0.881)
Average	0.780	0.778

Abbreviations: AUC ROC, area under the receiver operating characteristic curve; CI, confidence interval.

Table 4. Diagnostic Tests for Cut Points of a Screening Tool for Diabetic Retinopathy for Use in Low-Income Communities, by Misclassification-Cost Ratio and Various Scenarios of Diabetic Retinopathy Prevalence, Mexico, 2014–2016

Misclassification Cost Ratio[b]	Predictive Probit Model (n = 939)[a]				
	Sensitivity, %	Specificity, %	Positive Predictive Value, %	Negative Predictive Value, %	*z* Cut Point
Diabetic retinopathy prevalence of 31.7% (observed)					
1	56.4	83.0	60.7	80.4	−0.046
4	82.9	61.9	50.3	88.6	−0.640
10	96.6	28.7	38.7	94.9	−1.209
Diabetic retinopathy prevalence of 35.0%					
1	60.1	81.1	63.2	79.1	−0.121
4	90.9	45.9	47.5	90.4	−1.017
10	96.6	28.7	42.2	94.1	−1.209
Diabetic retinopathy prevalence of 40.0%					
1	67.8	76.4	65.7	78.1	−0.305
4	90.9	45.9	52.8	88.4	−1.017
10	96.6	28.7	47.5	92.8	−1.209
Diabetic retinopathy prevalence of 45.0%					
1	71.5	74.0	69.2	76.0	−0.374
4	96.0	31.7	53.5	90.6	−1.190
10	96.6	28.7	52.6	91.3	−1.209

[a] Multivariate probit model with any grade of diabetic retinopathy (grade 1, grade 2, or grade 3) as dependent variable according to Revised English Diabetic Eye Screening Program Grading System (25). Estimated coefficients from the multivariate probit model are shown in Table 2.
[b] Misclassification-cost ratio = cost of classification of false negatives divided by cost of classification of false positives. Ratios of 1, 4, and 10 were used, assuming that false-negative classification of a person receiving diabetic retinopathy screening would generate greater health costs than would a false-positive classification.

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ESSAY

Achieving Excellence in the Practice of Chronic Disease Epidemiology

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Heart disease, diabetes, cancer, arthritis, and other chronic diseases are the leading causes of death and disability and the leading drivers of health care costs in the United States (1). Health disparities and inequalities exist across chronic diseases, behavioral risk factors, environmental exposures, social determinants, and health care access by sex, race and ethnicity, income, education, disability status, and other social characteristics (2). A white paper developed by the Council of State and Territorial Epidemiologists' (CSTE's) Chronic Disease Epidemiology Capacity Building Workgroup stated that for 3 of the Essential Public Health Services — surveillance, communication, and consultation — chronic disease epidemiologists (CDEs) perform functions that are critical to health departments (3). Collecting, analyzing, interpreting, and disseminating data on chronic diseases and related risk factors is vital to understanding and raising awareness about morbidity, mortality, associated costs, and disparities. These data are also vital inputs throughout the process of implementing evidence-based public health approaches to reduce the burden of chronic diseases in the United States.

Chronic disease surveillance is changing, with new priorities that are more upstream, more clinical, more cross-cutting, and more granular than previous priorities; new data sources, such as electronic health records, to supplement traditional sources; and new technologies. Today's state, territorial, local, and tribal CDEs increasingly need to be strategic, innovative, collaborative, and efficient while wearing many hats and taking on leadership roles: statistician, informaticist, demographer, cartographer, evaluator, communications specialist, privacy officer, strategist, convener, and others. CDEs need to expand partnerships across multiple sectors to leverage data and resources to address social, environmental, and economic conditions that affect health and advance health equity. Timely and locally relevant data, metrics, and analytics are of utmost importance in this work to guide, focus, and assess the effect of prevention initiatives, including those targeting the social determinants of health and enhancing equity (4). Concurrently, chronic disease surveillance is challenged by data gaps, limitations in data access and timeliness, increases in data collection costs, decreases in funding, and inadequate staffing. The CSTE's *2017 Epidemiology Capacity Assessment Report* enumerated 304 CDEs in all 50 states and the District of Columbia (5). Survey respondents from the 51 jurisdictions indicated a need for 137 additional CDEs (a 45% increase) to reach full capacity, and most (88%) jurisdictions indicated a need to improve capacity in the Essential Public Health Services in chronic disease epidemiology (5).

The public health structure varies across states, and many state public health agencies provide epidemiological technical assistance and resources to local public health agencies. The size, resources, and other demands of local public health agencies might prohibit the hiring of dedicated CDEs or even the ability to have general epidemiologists perform chronic disease epidemiology and surveillance services. In 2016, the National Association of County and City Health Officials conducted a study on the funding, workforce, programs, and partnerships at local public health agencies; 1,930 local public agencies responded to the study survey (6). The survey showed that 49% of local public health agencies directly provided chronic disease epidemiology and surveillance services in the past year; this percentage ranged from 44% to 65% according to the size of the population served: 44% for small populations (<50,000), 56% for medium populations (50,000–499,999), and 65% for large populations (≥500,000) (6). Increasing the number of CDEs to build capacity and enhance expertise in surveillance, communication, and consultation is critically important. The Centers for Disease Control and Prevention's (CDC's) State Chronic Disease Epidemiology Assignee Program aims to address the workforce shortage of CDEs in states.

CDC's State Chronic Disease Epidemiology Assignee Program

Since 1991, the CDC's State Chronic Disease Epidemiology Assignee Program has helped states build chronic disease epidemiology capacity by placing a CDC employee (hereinafter referred to as field assignee) in a state or local public health agency. Field assignees assist states by providing epidemiologic consultation and leadership for surveillance systems; offering expertise in designing epidemiological studies, analyzing data, evaluating chronic disease prevention and health promotion programs, and disseminating findings; providing data and identifying priority populations for public health program planning; and mentoring and training entry-level and mid-level CDEs and other staff members in epidemiologic methods and data interpretation.

To date, CDC's State Chronic Disease Epidemiology Assignee Program has benefited 36 states and New York City during its 28-year history (Figure). Field assignees have served in their state position for up to 12 years. Currently, the program has 4 field assignees; they are in Arizona, Colorado, Illinois, and Indiana. The field assignees' work has directly enhanced chronic disease epidemiology capacity, and CDC has provided forums and training (eg, introduction to CDC surveillance systems, Evaluation 101, geospatial data methods, Behavior Risk Factor Surveillance System weighting methodology, public health law, legal epidemiology) for the field assignees and state CDEs. Field assignees serve as a liaison between the state or local public health agency and CDC. As a CDC employee, field assignees have access to CDC subject matter experts, training, data sets, analytic software, and an electronic library for broad access to the scientific literature, which can help supplement state resources and further contribute to statewide capacity in the practice of chronic disease epidemiology.

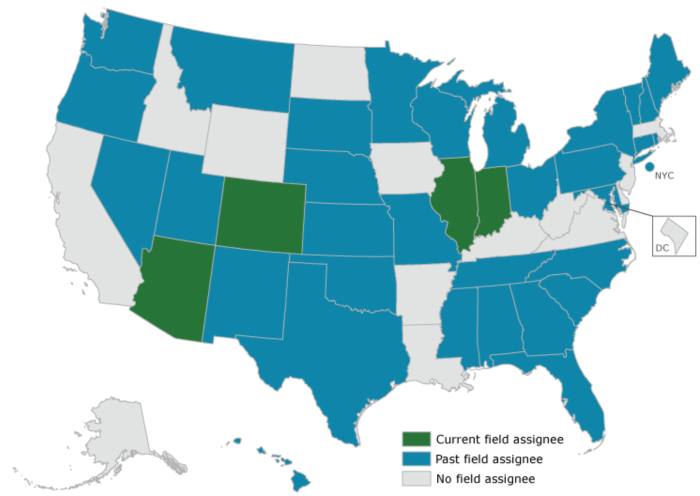

Figure. States that have hosted an assignee through the Centers for Disease Control and Prevention's State Chronic Disease Epidemiology Assignee Program, 1991–2018. The program has benefited 36 states and New York City.

Accomplishments of Chronic Disease Epidemiology Field Assignees

Field assignees have contributed to capacity building in their states in numerous ways (Box). In recent years, field assignees have focused on analyzing and disseminating state and local data on health disparities and improving data-informed decision-making processes to target public health interventions for chronic disease prevention and management. Colorado's field assignee has worked to enhance data usage for chronic disease program planning. This field assignee collaborated with a state chronic disease grant program to develop a new data-driven approach to scoring grant applications. This new approach was designed to increase the effect of grantee programs on health disparities by elevating scores of applications proposing to serve areas of greater need. To develop the new approach, a county ranking was created by using a principal components analysis of county data on the burden of disease and the social determinants of health, and a new methodology was developed to apply the results of the county rankings to the scores of grant applicants. Arizona's field assignee contributed to several state reports to inform program priorities, including the *Arizona American Indian Health Status Summary Report for Data Year 2015* (7), which was shared statewide with tribal leaders and partners working with tribal communities. The report informed targeted interventions and focused on health disparities. Indiana's field assignee contributed to several quality improvement initiatives for chronic disease programming and surveillance, such as the development and implementation of out-of-hospital and telemedicine programs for heart disease and heart failure patients in rural areas that lacked both primary care providers and specialists. Illinois's field assignee applied a novel approach for the state to better understand implementation of evidence-based interventions for high blood pressure and glycemic control among Federally Qualified Health Centers, organizations that serve approximately 1.2 million of Illinois's most vulnerable citizens. The field assignee is also leading efforts to assess feasibility of a statewide quality improvement collaborative.

Box. Examples of Responsibilities and Expectations of Assignees in the Centers for Disease Control and Prevention's State Chronic Disease Epidemiology Assignee Program

- Provide general epidemiological consultation and assistance to the state public health agency, local public health agencies, and partners as appropriate.
- Ensure collaboration across chronic disease programs and with internal and external stakeholders for epidemiology, surveillance, and evaluation activities.
- Consult with chronic disease program managers about how data can be used to support and target chronic disease prevention efforts and develop strategies for strengthening those efforts.
- Enhance data collection, analysis, interpretation, and dissemination.
- Mentor, develop resources for, and conduct trainings for state and local chronic disease program staff members and epidemiologists to strengthen epidemiology capacity and enhance data usage.
- Serve as preceptor and mentor for student interns, fellows, and preventive medicine residents.
- Build partnerships with other agencies and stakeholders across multiple sectors to increase data sharing and usage.
- Develop and implement chronic disease surveillance plans.
- Develop and implement chronic disease program evaluation plans.
- Contribute to the development of chronic disease and related state plans.
- Provide technical assistance in writing chronic disease-related grant applications, cooperative agreements, and requests for proposals.
- Make presentations at national and local conferences and meetings on behalf of the state public health agency.
- Publish state reports and articles in peer-reviewed scientific journals.
- Participate in Council of State and Territorial Epidemiologists subcommittees and workgroups.

Past, Present, and Future Capacity-Building Efforts

Many other chronic disease epidemiology capacity-building efforts have occurred or are ongoing. Formal state and local capacity-building programs have included, but are not limited to, CDC/CSTE's Applied Epidemiology Fellowship and CDC/National Association of Chronic Disease Directors' Applied Chronic Disease Epidemiology Mentoring Program (8,9). These have been successful programs, but expanded efforts are needed. Governmental agencies, foundations, universities, and others committed to chronic disease–related public health capacity building should collaborate with those working in other subject areas to build capacity on cross-cutting competencies. Examples of topics include those identified by CSTE's chronic disease epidemiology capacity assessment: using informatics tools in support of epidemiologic practice; understanding institutional review board processes; using systems thinking in epidemiologic planning and policy development; leading community public health planning processes; practicing culturally sensitive epidemiologic activities; conducting program evaluations; and others (10).

Future efforts should build on past and current efforts, be informed by national assessment results, and target jurisdictions with subpar levels of chronic disease epidemiology capacity. Training efforts should be tailored to address changes occurring in public health and chronic disease surveillance. To achieve excellence in chronic disease epidemiology and to build capacity, the following are needed: 1) identify champions for enhancing capacity, 2) continually review and update the essential roles of CDEs, 3) expand the skills and competencies of the current and future workforce, 4) develop and enhance partnerships to improve data sharing, 5) leverage and link existing data sources, 6) improve the availability of local data, 7) fill data gaps to better measure determinants of health and health disparities, and 8) make data more actionable. Strong commitment is vital to building and maintaining capacity-building efforts in chronic disease epidemiology and surveillance in state, territorial, local, and tribal public health agencies. Throughout these capacity-building efforts and across all chronic disease epidemiology and surveillance efforts, the default view must be through a health equity lens.

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