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INFLUENCES OF COHORT DIFFERENCES AND POSITIVE EMOTION ON THE RELATIONSHIP BETWEEN COGNITION AND DISABILITY IN ACTIVITIES OF DAILY LIVING AMONG OLDER MEXICAN AMERICANS

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by

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Dedication

To my family, mi Rodolfo, and Niko. You believed in me when I didn't and kept my drive going. I dedicate my dissertation to you in recognition of all the time we spent apart so I could accomplish this goal. Thank you for your support.

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I would like to acknowledge my committee members for their tireless efforts in guiding me throughout this dissertation process. Thanks to their passion for teaching and collective expertise, I was able to learn and grow to great extents during this experience. I would also like to express my deepest appreciation to my committee chair and mentor, Dr. James Graham, who was patient, encouraging, and cultivated a fantastic learning atmosphere for me.

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ABSTRACT: Background: Mexican Americans are the fastest growing minority group in the U.S. and older Mexican Americans are more likely to be living with chronic health conditions, such as diabetes and hypertension, compared to non-Hispanic white Americans. The rising prevalence of chronic conditions has contributed to an increased number of older Mexican Americans with disability in activities of daily living. Furthermore, recent cohorts of Mexican Americans exhibit greater disability than prior age-matched cohorts. Cognitive impairment is a known risk factor for disability. Positive emotion is associated with improved health outcomes. Little is known regarding its ability to modify the relationship between cognition and disability. Lastly, the driving factor behind the increase in disability for newer cohorts of Mexican Americans is unknown. This dissertation aims to explore the roles of cohort and positive emotion in changing the relationship between cognition and ADL disability. **Methods:** A systematic review was conducted on studies looking on the relationship between cognition and disability. We then did two retrospective cohort studies using waves 1 – 8 of the Hispanic Established Population for the Epidemiologic Study of the Elderly (EPESE). General estimation equations were used in three different models (cross-sectional, longitudinal, and predictive) to examine the independent and modifying effects of cohort, positive emotion, and cognition on risk of ADL disability in Mexican Americans aged 75 years and older. **Results:** The systematic review included 41 studies, 40 of which demonstrated significant relationship between cognition and disability. In the retrospective studies, there was not a significant difference between cohorts on the relationship between cognition and disability. The second cohort had a higher prevalence of disability, cognitive impairment, and chronic illnesses. The main effects of positive emotion were

consistently protective against ADL disability and positive emotion was a significant modifier in the cross-sectional model. Cognitive impairment was consistently a strong risk factor for ADL disability. **Conclusion:** Further research is needed to identify why the newer cohorts have increased disability, as well as research to identify interventions that address cognitive and emotional needs; specifically interventions that are appropriate for Mexican Americans.

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List of Abbreviations

UTMB	University of Texas Medical Branch
GSBS	Graduate School of Biomedical Science
MMSE	Mini-Mental State Examination
ADL	Activities of daily living
IADL	Instrumental activities of living

CHAPTER 1. BACKGROUND

INTRODUCTION

Disability is a strong predictor of several poor health outcomes such as depression, institutionalization, and death, for older adults.[1,2] Older Mexican Americans are more likely than other ethnicities to be living with chronic health conditions such as diabetes, hypertension, and other risk factors for disability.[3,4] Disability prevalence is rising in the older Mexican American population, whereas rates have remained relatively stable in other ethnic populations.[56] Increasing evidence suggests a relationship between cognition and disability.[2,7–9] However, it is unclear whether the relationship between cognition and disability vary when comparing older cohorts of Mexican Americans to newer cohorts of Mexican Americans. Furthermore, due to the preventative and restorative function of positive emotion[10–14] further investigation is needed to understand the role of positive emotion in modifying the relationship between cognitive function and disability in older Mexican Americans.

OLDER MEXICAN AMERICANS

The prevalence of older adults has been increasing worldwide. In the United States it has been projected that by 2030, 74 million persons in the United States will be 65 years or older. This is approximately one fifth of the projected population[15] and a drastic increase from the 35 million older persons in 2000.[16] Of those 74 million older adults in 2030, approximately 8 million are projected to be Hispanic Americans, and that number is projected to nearly double to 15 million by 2050.[17] It is important to gain a better

understanding of the Hispanic population, especially in regards to health needs of older Hispanics.

The U.S. Office of Management and Budget defines Hispanic as "a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race."[18] Mexican Americans are the largest subgroup of Hispanics in the United States and make up approximately 64% of the Hispanic population according to the 2013 census.[19] It is important to note that Hispanic and Mexican are two separate terms and that this dissertation focuses primarily on Mexican Americans.

Mexican Americans are more likely to be living with chronic health conditions, to have impaired cognition, and have less education and access mental health services compared to older non-Hispanic White Americans,[2,20–22] all of which are risk factors for poor health outcomes.[7,20,23] In a study assessing older adults from 1999-2002, 24.9% of Mexican Americans had a diagnosis of diabetes compared to 14.3% of non-Hispanic Whites.[7] In a study investigating ethnic differences in cognitive function, Diaz-Venegaz et al. reported that Hispanics had significantly lower cognition than Non-Hispanic Whites, which they attributed primarily to differences in education between the two groups.[22] Others have reported cognitive differences between Hispanics and non-Hispanic Whites, even after controlling for education.[20]

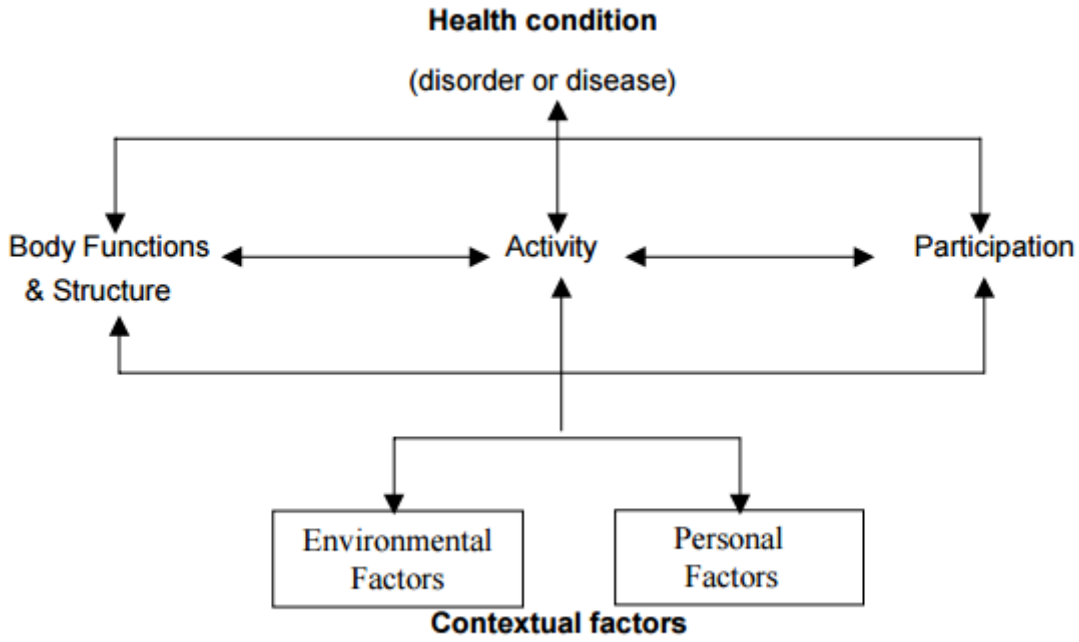
The high prevalence of chronic health conditions makes Mexican Americans susceptible to poor physical functioning and disability related to completing activities of daily living (ADL), such as walking independently, grooming, or the ability to move from the bed to a chair.[3,9] Previous research has demonstrated that Hispanics, compared to non-Hispanic whites, are more likely to be living with disability.[3,24,25] In a study by Latham,

Hispanics had 69% higher odds of progressive disability compared to non-Hispanic whites, even after controlling for age and education.[24]

DISABILITY

Disability has been described as "the difference, or gap, between an older individual's capability to complete a particular task and the demand imposed by the task."[26] Despite the difficulties of creating a simple, measurable definition of disability, due to its complex and dynamic nature, it is important to study as it plays a significant role in poor health outcomes.[1,2] In 2001, the World Health Organization published the International Classification of Functioning, Health and Disability (ICF), Figure 1.1, to facilitate understanding and standardize communication within the disability field. This framework promotes the concept that disability is not an inherent characteristic, but rather a dynamic condition resulting from multifaceted relationships between various elements such as an individual's personal characteristics, his or her physical abilities, demands of the activity, and the environment in which he or she is performing the activity.

Figure 1.1. International Classification of Functioning, Disability, and Health



Most studies measure disability by self-reported need of assistance with one or more activities of daily living such as walking across a small room.[2,15,26] Even with clearly-defined measures, most disability reports are cross-sectional snapshots that do not account for inevitable fluctuations in health and functional status of older adults, which ultimately influence a person's perceived or realized independence. Hardy and Gill (2004) have shown how dynamic disability status can be. Among older adults aged 70+ with new onset ADL disability, 81% recovered independence within 5 months; however, 73% of those who had recovered experienced recurrent disability within 9 months.[27] Conversely, in a study comparing trajectories of disability across three cohorts of older adults, Taylor and Lynch noted that there was not one single observed disability trajectory that experienced alternating periods of recovery following decline, suggesting this may not be common in

older adults.[28] Regardless, our project is designed to capture long-term patterns in disability status. We will include 4 disability assessments spread over 10 years in two cohorts of older Mexican Americans.

In addition to the negative impact that disability has on the lives of older adults, disability is a costly condition. Current estimated costs related to caring for adults with disabilities in the United States are $397.8 billion per year, with $119.0 billion being the estimated Medicare costs for disability. It was recently estimated that among older Mexican Americans, approximately one-third of direct healthcare expenditures are excess costs as a result of health inequities.[6] Better understandings of the natural history and unique correlates of disability among older Mexican Americans are needed to curb this growing public health problem and improve the lives of this growing population.

COGNITION

Cognition, like disability, is a broad and complex term that is difficult to define. Cognition refers to the process of our mental functions, including attention, memory, inhibition, problem solving, and other high-order functioning skills. Like physical functioning, cognition often declines with age. Interestingly, there is increasing evidence suggesting a relationship between cognition and disability[29–32] In a cross-sectional study using data from the Italian Longitudinal Study on Aging, older adults aged 65-84 years who had cognitive impairment without dementia, were 88% more likely to have disability than older adults with intact cognition.[33] Cognitive impairment without dementia was defined as having no diagnosis of dementia, a Cambridge Cognitive Examination total score of less than 80, and evaluation of neuropsychological tests. Conversely, cognition

was protective against disability in a study of older adults from Ireland. In a cross-sectional study of 3,499 adults aged 65 years and older, cognition, as measured by the Mini-Mental State Exam (MMSE), was protective against disability, as measured by activities of daily living and instrumental activities of daily living combined, with an odds ratio of 0.90 per unit increase on the MMSE.[34]

While many studies look at the co-occurrence between cognition and disability, some research suggests the potential impact of cognition on the development or progression of disability over time. Raji and colleagues showed that impaired cognitive function might be an indicator of future physical function. They reported a significant association between baseline cognitive impairment and physical performance two years later ($b = 0.06$, $SE = 0.02$, $p < 0.004$).[10] Additionally, using data from the New Haven Established Populations for Epidemiologic Study of the Elderly, Moritz et al. (1995) showed low cognitive functioning at baseline, as measured by trichotomized scores from the Short Portable Mental Status Questionnaire, to be predictive of incident ADL disability. Men with low cognitive function were 2.7 times more likely to develop incident ADL disability over a 3-year period than individuals with high cognitive functioning. Women with low cognitive function were 2.6 times more likely to develop incident ADL disability.[35] Amongst older Mexican Americans, Raji et al. (2004) reported that those with low cognitive functioning at baseline were 58% more likely to develop in incident ADL disability over a 7-year period, compared to those with high cognitive function at baseline.

Different theories have been formulated to explain the relationship between cognition and disability or physical function. It is possible that cognitive status may impede an individual's engagement in physical activities required to maintain the muscle strength

that is needed to perform ADLs.[2,8] It has also been suggested that cognition and physical function share pathogenic factors, such as interleukin-6, which is a pro-inflammatory cytokine. Therefore, cognitive decline may be an indicator of underlying inflammation or impending disease.[2,8,36] Lastly, it is conceivable that low cognition impedes awareness of symptoms from illnesses, which may affect health behaviors, such as delays in seeking medical care or may affect one's ability to comply with therapeutic intervention.[36]

COHORT DIFFERENCES

The term "cohort effect" is often used to describe observed differences in health outcomes between groups of people that are a result from the combination of their age along with distinct life exposures and/or experiences due to the period they live in.[37] Several cohort differences have been reported throughout the world, with newer cohorts typically experiencing negative health outcomes, such as increases in obesity, difficulty with sleep, and depression.[5,38–40] However, some newer cohorts demonstrate improvements in physical function. For example, in the United States, the prevalence of ADL disability among older adults has decreased steadily over the past 30 years.[14] Taylor and Lynch (2011) compared disability rates between three cohorts, each spaced five years apart. They used the National Long-Term Care Survey (NLTCS) and linked Medicare and Vital Statistics records and found that the odds of remaining non-disabled increase by 3% successively across the cohorts, with the newest cohort being 44% less likely to have a high trajectory of disability.[28] Similarly, in Europe, researchers used longitudinal data across 10 different countries and compared ADL disability across three birth cohorts, 1988 to 1991, 1993 to 1995, and 1998 to 2000. They discovered that the prevalence of ADL

disability decreased across cohorts, with the newest cohort having the least ADL disability.[41]

The Mexican American population does not seem to follow these trends. Data from the Hispanic Established Population for the Epidemiologic Study of the Elderly (HEPESE) indicates the prevalence of disability among Mexican Americans aged 75 and older has increased substantially from 29% in older cohorts (1993/94) to 41.5% in newer cohorts (2004/05).[5] Researchers studying disability have suggested that increased education among newer cohorts may results in more finances, easier access to care, and better understanding of health knowledge, which would result in diagnosing before a disease became disabling.[28] However, in the Hispanic population the decreased health in newer cohorts has been noted, despite there being no difference in insurance coverage and doctors visits, as well as the newer cohort having more education.[5]

There are several plausible explanations for the increased prevalence of ADL disability in newer cohorts of older Mexican American adults. First, newer cohorts of Mexican Americans aged 75 and older have an increased prevalence of diabetes, from 20.3% to 37.2%. They also have higher rates of obesity and hypertension, compared to prior cohorts.[5] It's possible that the increase in chronic health conditions among Mexican Americans can be attributed, in part, to acculturation. Acculturation describes the process of individuals from one culture adopting the attitudes, values, and behaviors of another culture.[42] Acculturation also has a stress component to it, due to language barriers and cultural isolation.[3] In a study examining the relationship between acculturation and hypertension in older Hispanics, the prevalence of hypertension was 33% higher in acculturated Hispanic men compared to Hispanic men with low acculturation.[43] It's also

possible that the prevalence in disability in the United States is misunderstood. While the prevalence of disability has been documented as declining over the past 30 years, when Gill (2014) studied the rates of disability among older adults only, he discovered little to no change in the chronic disability rates, which have remained around 7 million.[15]

Whatever the reason for the differences being observed among cohorts of Mexican American adults, it is important to discover which factors are playing important roles in the development of disability currently and whether any of the factors that previously impacted disability have changed in the strength of their relationship. This information will be needed to inform future research to better the care for the unique needs of older Mexican American adults.

Positive Emotion

Emotions affect physical health and recovery in both healthy and diseased adult populations.[10,44] Depression, for example, is significantly associated with declines in both cognitive and physical functioning over time,[2,21] weaker immune systems,[45] and increased risk for developing hypertension and ADL disability.[13,22] Barry et al. (2009) showed that non-disabled community-dwelling adults aged 70 years and older with depressive symptoms were twice as likely to develop severe disability burden, needing help with 3-4 ADLs, compared to those without depressive symptoms.[23]

Traditionally, a majority of studies identify emotional health as the presence or absence of negative emotions.[13] Recently, however, researchers have been studying the specific impact of positive emotions on health related outcomes. Positive emotions are described by feelings of joy, hopefulness, energy, and humor.[13,14] While negative emotions

certainly may influence positive emotions, the research suggests that the two are separate entities.[46] Such that the absence of one does not mean the presence of the other.[13,44,47] Positive emotion remains a significant predictor for better health outcomes, even when controlling for depression.[11] This is even demonstrated neurologically; recent studies have found that certain structures within our brain are related to processing positive emotion and different structures are specifically related to processing negative emotion.[48] This contrast in findings of positive versus negative emotion has led to a growing body of literature on the association between positive emotion and functional outcomes.

Positive emotion is significantly associated with better outcomes for individuals with cancer, kidney failure, coronary disease, and HIV.[13,14,44] Hope, a component of positive emotion, is negatively associated with incident hypertension in community-dwelling older adults. Each unit increase in hope decreased the odds of developing hypertension by 35% over a one year followup.[49] Positive emotion has also been associated with recovery after rehabilitation. Positive emotion, as measured by the positive items on the Center for Epidemiologic Studies – Depression (CES-D) scale, was assessed at discharge from rehabilitation for stroke survivors and was significantly associated with higher over-all function and higher motor and cognitive status at three months follow-up.[50] Similarly, while investigating the role of positive emotion over time on functional ability, as measured by the Duke Activity Status Inventory, Brummett, Morey, and Boyl found those with lower levels of positive emotion were likely to experience greater decline in their functional status over time, with a regression coefficient of 0.23 ($p < 0.05$).[48]

The benefits of emotion on functional health have been demonstrated in the Mexican American population as well. In a study by Ostir et al. (2000), positive emotion

was measured by the positive items of the CES-D scale at baseline among older Mexican Americans to study functional outcomes at a two-year follow-up. They found that having high positive emotion at baseline had many benefits, including a faster walking speed, less ADL disability, and a lower likelihood of dying at follow-up.[51] The odds of ADL disability for high positive emotion were 52% lower than those with low positive emotion. When investigating the relationship between positive emotion and ADL disability in older Mexican Americans with arthritis, positive emotion was found to significantly decrease the odds of developing ADL disability by 54% compared to those with low positive emotion. Lastly, overall emotion combined with cognition was studied as a factor for maintaining functional abilities among older Mexican Americans.[10] This study found that individuals with low cognition and higher overall CES-D score (indicating higher depressive symptoms) were on average 0.99 points lower on their performance measure of lower extremity physical functioning (e.g., timed walk, standing balance) two years later and those with high cognition and lower overall CES-D score were 0.42 points lower at their two year follow-up.

Positive emotion may impact health through indirect and direct pathways.[44,49] An indirect pathway suggests that healthy behaviors may be directed by positive emotion. For example, positive emotion results in making healthier lifestyle choices and having better coping skills during injury or illness.[44] All of which may account for the improved health outcomes among those with positive emotion.[48,49] A direct pathway proposes a benefit from a physiological standpoint. Positive emotion is associated with lower cortisol, a lower heart rate when walking, enhanced immune systems, and enhance sympathetic and parasympathetic nervous systems.[47,44] This is extremely important in older adults, as aging

is associated with declining neuroendocrine systems, cardiovascular health, and immune markers.[47] Additionally, older adults are more likely to experience stress-induced dysregulation to their immune systems and cardiovascular systems, compared to younger adults.[44] Therefore, the adverse affects of aging can potentially be mediated through the central nervous system by positive emotion.[45]

CONCLUSION

Hispanic Americans experience more cognitive impairment, chronic health issues, and disability compared to non-Hispanic Whites and newer cohorts of older Mexican Americans exhibit higher rates of diabetes, hypertension, and disability than their prior cohorts[5,20,24,43] Thus, it is important to investigate variables that may change the relationship between cognition and disability among old Mexican Americans. Furthermore, while the preventative and restorative effects of positive emotion are well documented, to our knowledge there is no published information on the potential role of positive emotion in modifying the relationship between cognitive function and disability in older Mexican Americans. This research will examine these issues through the three following aims:

Aim 1. Conduct a systematic review of studies on the association between cognition and disability in adults, 65 years and older.

Aim 2. Determine if there is a cohort difference on the relationship between cognition and ADL disability among Mexican American Adults aged 75 years and older.

Aim 3. Determine if positive emotion modifies the relationship between cognition and ADL disability status over 10 years in Mexican American Adults aged 75 years and older.

This research project will address these important issues to inform the development of prospective studies on clinical interventions to better prevent the development and/or slow the progression of disabilities in older Mexican Americans.

CHAPTER 2. COGNITION AND DISABILITY IN OLDER ADULTS: A SYSTEMATIC REVIEW

INTRODUCTION

Disability has been defined as "the negative aspects of the interaction between an individual and that individual's contextual factors."[52] Disability prevalence is high among older adults. According to the U.S. Census Bureau, in 2010 approximately 50% of adults age 65 years or older are living with a disability.[53] This estimate is concerning given that disability is one of the primary reasons why older adults lose their ability to live an independent life.[54] Furthermore, disability is a strong predictor of negative health outcomes, such as depression, comorbidities, and death.[1,2]

When investigating the development of disability in older adults, there are several commonly-used predictors, such as age, diagnoses of chronic illnesses, and visual impairments. [55,56] Recently, cognition has also been identified as a factor strongly associated with disability. In a cross-sectional study of adults 65 years and older, individuals with cognitive impairment had 88% increased odds of disability in activities of daily living (ADL) than those with intact cognition.[33]

Cognition is a broad term for mental processes such as attention and memory. Like physical functioning, cognition also tends to decline with age.[57] Approximately 4% of adults age 65 years and older have a cognitive impairment and approximately 36% of adults 85 years and older have a cognitive impairment.[58] Cognitive impairment may impede the ability to perform simple tasks, making choices, reacting quickly, and utilizing working memory.[59] Thus, strong cross-sectional relationships between cognition and disability are not suprising.[60]

While the population average for cognition declines rapidly with age, there is substantial heterogeneity in individual cognitive status trajectories.[61] Many individuals maintain cognitive functioning as they age. Examining the relationships between different cognitive functioning trajectories and incident disability is an important public health and research topic. Many studies have already found cognitive impairment to be a statistically significant risk factor for future disability.[62]

While studies consistently show a significant relationship between cognition and disability,[8,54,63] estimates for the strength of the relationship vary greatly between studies. Similarly, the measures and cut-points for determining impairment are not consistent. Given the complexity of both disability and cognition, there are bound to be some variability by population and research question; however, it is important to understand how these alterations change the strength of the relationship being studied. Then it can be determined which approach may be the most logical measure(s) to create consistent and comparable research.

This study aims to systematically review published articles on the relationship between cognition and disability for two purposes: first, to provide a better understanding of the relationship between cognition and disability among older adults in a single resource and second, to explore the measures, cut-points, and combinations currently being used. The results of this review will be used to understand how variety in measures can change the significance and strength of the relationship between cognition and disability and to serve as a resource to inform measure selection in future studies.

METHODS

SEARCH STRATEGY

A trained reference librarian assisted with the development of this search strategy. All included journal articles came from indexed electronic databases. CINAHL, Medline Ovid, Cochrane CENTRAL, and PsycINFO were searched using keywords and descriptors of cognition, disability, and older adults. Specific search terms were cognition, cognitive, executive function, disability, functionally impaired, functional ability, and older adults. Included articles were not limited to a specific time frame and needed be accepted for publication at time of inclusion. Articles were searched for and gathered from August 1, 2016 to August 8, 2016. Articles were excluded if cognition was not an independent variable and if disability was not the outcome variable.

STUDY SELECTION

After pooling the results from the various databases, the articles were screened by four steps: 1) removing duplicate articles, 2) screening article titles, 3) screening abstracts, and 4) full-text reviews. The articles were systematically removed during each step based on the exclusion criterion in Table 1. Two reviewers independently screened articles identified by the database search. The first reviewer screened 100% of the results by title, abstract, and full text. The second reviewer screened 25% of the abstracts and coinciding full texts, selected at random.[30] Any disagreement between the two reviewers was settled by discussion.

Table 2.1. Exclusion Criteria

1.	Not about humans
2.	Not a journal article
3.	Included participants younger than 65 years
4.	Cognition is not an independent variable
5.	Disability is not the dependent variable
6.	Study not in English
7.	Not an observational study

Initial results from the search term are presented in figure 2**.** After completing primary exclusion criteria there were 86 full text articles to include in this review. This allowed for a second screening process to select articles that better fit the population of interest for this dissertation: older, community dwelling adults. Thus, articles focused on condition-specific populations or with outcomes measuring direct physical function, such as walking speed or grip strength, rather than disability were excluded.

QUALITY ASSESSMENT

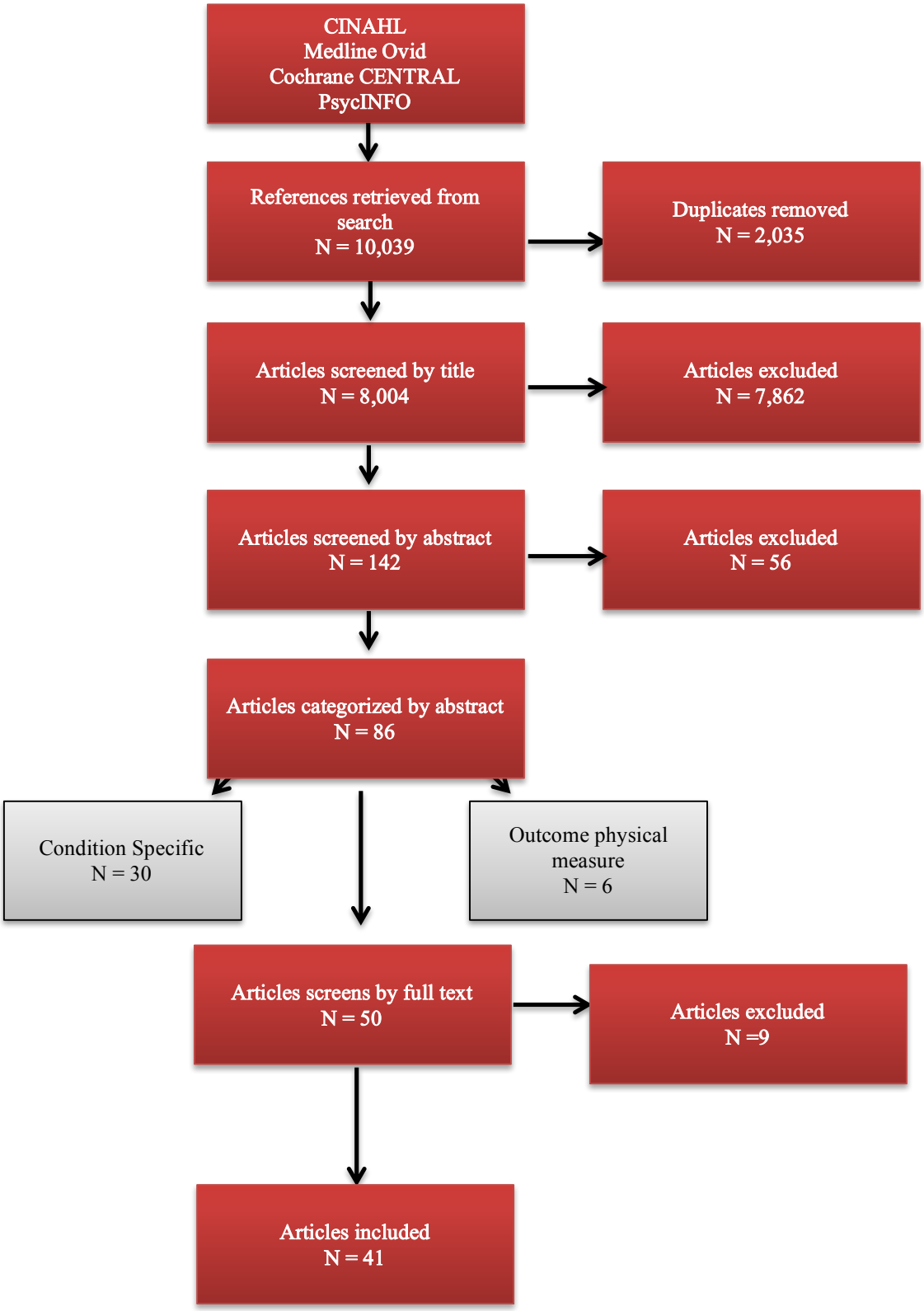
The quality of the studies was assessed using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies of NIH (National Institute of Health - USA). This assessment tool has a checklist of 14 questions that are answered "yes" or "no" regarding sample size, inclusion, and loss to follow up, as well as appropriate measures

used, statistical analysis, and if potential confounders were accounted for. The assessment tool specifies that it should not be used as a grading rubric. Rather, researchers should use their professional judgment on the quality of the study based on the information gathered form the checklist. To provide consistency during this review, however, a scoring system was created. Summative scores were calculated across the 14 items (yes = 1; no = 0). Every article was categorized as Poor (score 0–7), Fair (score 8-11), or Good (12-14). Articles of poor quality (N = 1) were not included in the review.

DATA SYNTHESIS

In order to manage data collected throughout the review and to facilitate synthesizing the heterogeneous features of the studies, a data abstraction form was created. The form included study design, population characteristics, how the independent variable was measured, how the dependent variable was measured, analyses used, significance of the association, and quality score. Both cognition and disability are complex terms that can be measured in a variety of ways. This study included all measures to gather information on commonly used measures, how results vary by measures, and the strengths and weaknesses of the measures used. However, the outcome variable needed to be a measure of disability and not a measure of physical strength. Data were extracted to summarize in tables if the articles were of either "fair" or "good" quality.

Figure 2.1. Search results



RESULTS

The initial search from all electronic databases resulted in 10,039 articles retrieved. Duplicates (N = 2,035) were removed, leaving 8,004 articles. Screening by title excluded 7,862 articles, resulting in 142 articles to screen by abstract. Screening by abstract excluded an additional 56 articles for the following reasons: 4 were not journal articles, 12 included participants who were younger 65 years old, 23 did not have cognition as an independent variable, 13 did not have disability as a dependent variable, and 4 were not observational studies. This original screening process resulted in 86 articles to be screened by full text. As this number of articles is outside the scope of this aim, it was decided to add additional exclusion criteria to select articles with populations that align with the population of interest for this dissertation; older, community dwelling adults. We therefore excluded articles if the population was specific to a condition (N = 30), such as heart failure, and articles that had an outcome measure of physical function (N = 9), rather than a specific disability measure; e.g., Activities of Daily Living. This resulted in 50 articles to screen by full text. Of those articles, 8 were excluded for including populations younger than 65 years and 1 for disability not being a dependent variable. A total of 41 one articles were included in the review.

Characteristics of the studies are described in table 2.2. A majority of the studies were longitudinal (N = 28), had more females than males (N = 36), and included participants aged 65 years and older (N = 23). The second most common age inclusion was 70 years and older (N=10). Among the longitudinal studies, length of observation ranges from 1 year – 12 years, with the most frequent length being 3 years (N = 9). The size of

each study varied greatly; the smallest study had 106 participants and the largest study had 13,129 participants.

Table 2.2. Basic study characteristics for all 41 articles.

First Author	Year	N	Design	Population	Age	Female	Inclusion/Exclusion Criteria	Length, observations	Quality
Avila-Funes	2011	475	Cross-sectional	Community dwelling, frail, elderly Mexicans residing in Mexico City	70+	53.9%	Excluded if incomplete data on frailty or cognition	N/A	Good
Bennett	2006	106	Cross-sectional	Community dwellers, Australia	75+	48.0%	Excluded if not capable of giving consent, unable to participate (sickness), met MRI exclusion criteria, had dementia, MMSE < 22	N/A	Good
Berlau	2010	216	Longitudinal	Retirement community in Southern California	90+	74.0%	Must have one follow-up after baseline assessment. Excluded if ADL disability at baseline	6 years, 3 observations	Good
Black	2002	365	Longitudinal	Community dwelling Hispanic Americans, African American, non-Hispanic White in Galveston, TX	75+	62.0%	Living outside of Galveston County, or living in nursing home	3 years, 2 observations	Good
Blaum	2002	6,436	Cross-sectional	Community dwelling adults, united states. 13.2% African American	70+	62.0%	Proxy	N/A	Fair
Conolly	2016	3,499	Cross-sectional	Community dwelling participants, Ireland	65+	52.0%	NR	N/A	Good
Cullen	1996	126	Cross-sectional	Community dwelling with cognitive impairment in Canberra and Queanbeyan, Australia	70+	48.0%	Excluded if scored 28 or higher on MSSE and lived in hostel or nursing home	N/A	Good
Di Carlo	2000	780	Cross-sectional	Community or institutionalized older adults in Italy	65+	45.5%	Excluded if MMSE score equal to or greater than 24.	N/A	Fair
Dodge	2006	953	Longitudinal	Community dwelling in Southwestern Pennsylvania	65+	60.8%	Excluded if institutionalized or missing data	10 years, 5 observations	Good
Dodge	2005	1,260	Longitudinal	Community dwellers in Azuchi, Japan	65+	60.4%	Excluded if missing HDS scores	3 years, 2 observations	Fair

Doi	2015	3,482	Longitudinal	Community dwellers in Obu, Japan	65+	53.5%	Excluded if ADL disability at baseline, in other studies, hospitalized or in residential care, certification higher than 3 in Japanese public long-term care insurance, or if history of dementia, Parkinson's, or cerebrovascular disease	3 years	Good
Dotchin	2015	296	Longitudinal	70+ Community dwellers in Tanzania, Africa	70+	68.2%	"Described elsewhere"	1 years, 2 observations	Fair
Fauth	2007	149	Longitudinal	Community dwellers and institutionalized older adults in Sweden	86+	69.8%	Proxy	4 years, 3 observations	Good
Galluci	2010	668	Cross-sectional	Older adults residing in Treviso, Italy	70+	54.4%	NR	N/A	Fair
Gill	1996	775	Longitudinal	Community dwellers in New Haven, Connecticut, white 84%	72+	74.0%	Ambulatory, speak English, Spanish, or Italian, able to follow simple commands. Excluded disability at baseline.	3 years, 3 observations	Good
Hebert	1999	504	Longitudinal	Community dwelling older adults in Quebec, Canada	75+	63.5%	"Described elsewhere"	2 years, 3 observations	Good
Jagger	2005	643	Longitudinal	Older adults in Melton Mowbray, Leicestershire in the community and institutions	75+	37.0%	Excluded disability at baseline.	11 years, 5 observations	Good
Johnson	2007	7,717	Longitudinal	Community dwelling older women in Baltimore, Pittsburgh, Minneapolis, and Portland	65+	100.0%	NR	6 years, 2 observations	Good
Kim	2013	12,478	Longitudinal	Community dwelling older adults in 4 U.S. cities	65+	62.0%	Excluded disability at baseline and missing data on >50% predictors	5 years, 6 observations	Good
Kim	2005	1,204	Cross-sectional	Community dwelling adults in Kwangju, South Korea	65+	58.0%	"Described elsewhere"	N/A	Good
Lau	2015	407	Longitudinal	Community dwelling older adults in California. 55.3% Caucasians, 22.7$ African American, 15.8% Hispanic, 5.2% Asian, 1.0% unknown	75+	59.2%	Spoke English, had a proxy, cognitively intact or mild cog impair at baseline, IADL independent at baseline. Excluded if major medical/psychiatric illness,	1-9 years, at least 2	Good

							neurologic disorders, and substance abuse		
Lee	2005	977	Longitudinal	Community based persons in Suwon, South Korea	65+	60.7%	NR	1 years, 2 observations	Fair
Leveille	1998	3,585	Cross-sectional	Older women in East Baltimore, Maryland. 75.1% white and 24.9% Black	65+	100.0%	Excluded if institutionalized, missing race data, race other than Black or White MMSE <18	N/A	Good
Li	2009	13,129	Longitudinal	Black (18.29%) or White (81.71%) Community dwelling older adults, receiving nursing care	65+	73,71%	Black or White and assessed at least three times. Excluded if Severe cognitive impairment (≥ 4 on the MDS cognitive performance scale)	2 years, 8.5 observations	Fair
Li	2005	3,161	Longitudinal	Low-income, Frail elderly participating in Michigan's Medicaid Waiver Waver Program and living in the community. Black (22.9%) or White (77.1%)	65+	73.1%	Income at or below 300% of Supplemental Security Income and assets not exceeding the limit set for Medicaid, and medically appropriate for nursing home placement	3 years, 15 observations	Good
Martin	2015	9,471	Longitudinal	Older adults	65+	57.2%	NR	12 years, 7 observations	Good
McGuire	2006	4,077	Longitudinal	Community dwelling older adults	70+	62.6%	Completed without proxy, known vital status at second observation. Excluded if missing outcome variable, missing covariates, severe cognitive impairment	2 years, 2 observations	Good
Millan-Calenti	2011	600	Cross-sectional	Community dwelling older adults in Naron Council, Spain	65+	NR	Excluded if unable to be assessed by MMSE, minimally conscious	N/A	Fair
Nikolova	2009	456	Longitudinal	Community dwelling frail older adults receiving home nursing in Montreal, Canada	65+	72.2%	Excluded if missing assessments for cognition or functional status	3 years, 3 observations	Good
Rajan	2012	5,317	Longitudinal	Community dwelling older adults in Chicago Black (65%) and White (35%).	65+	61.0%	Excluded disability at baseline	8 years, 8 observations	Good

Raji	2004	2,431	Longitudinal	Community dwelling older Mexican Americans in Texas, Arizona, California, New Mexico and Colorado	65+	58.6%	Excluded disability at baseline	7 years, 4 observations	Good
Raji	2005	1,419	Longitudinal	Community dwelling older Mexican Americans in Texas, Arizona, California, New Mexico and Colorado	65+	57.0%	Excluded disability at baseline, missing cognitive or grip measures.	7 years, 4 observations	Good
Rist	2015	5,219	Longitudinal	Community dwelling older adults in the united states Black (9.6%)	65+	67.0%	Excluded IADL disability at baseline and heavy drinkers	12 years, 6 observations	Good
Royall	2004	547	Longitudinal	Septuagenarians (70-79 years old) living in continuing care retirement communities	70+	58.3%	Living in non-institutionalized levels of care	3 years, 3 observations	Good
Saito	2014	1,347	Longitudinal	Community dwelling older adults in Fukushima Prefecture, Japan	70+	60.1%	Excluded disability at baseline, hospitalized, not home for baseline interview and those who didn't fit in one of 4 living situations (three generations, with children, with spouse, alone)	7 years, NR	Fair
Scanlan	2007	2,192	Cross-sectional	11 Italian regions	65+	58.0%	Enrolled in local population registry. Excluded speech, hearing, or hand impairment	N/A	Fair
Shega	2010	5,143	Cross-sectional	Community dwelling older adults living in 36 cities throughout Canada, 97% White	65+	59.7%	Excluded cancer in the past year, missing data, or greater than moderate cognitive impairment	N/A	Good
Slavin	2015	620	Longitudinal	Community dwellers, Sydney Australia	70+	54.7%	Excluded those diagnosed with schizophrenia, bi-polar, or psychotic symptoms, non-English speaking, or MMSE score <24	4 years, 2 observations	Fair
St. John	2015	1,028	Longitudinal	Community dwelling older adults in Manitoba, Canada	65+	58.5%	Excluded those residing in institution or missing screening interview	5 years, 2 observations	Fair
Vermeersch	2015	143	Cross-sectional	Community dwelling adults with cognitive impairment, Alzheimer's, or no impairment aged 65+	65+	63.0%	Excluded those with acute pathology, communicative or sensory impairments, and any pathology of CNS	N/A	Good

Yaffe	2010	2,733	Longitudinal	Community dwelling, bi-racial (39.82% Black) adults from Tennessee, Pennsylvania	70+	52.0%	Excluded disability at baseline, difficulty walking 1/4 mile or using stairs, life-threatening cancer diagnoses, planning to move in the next 3 years	5 years, 3 observations	Good

Abbreviations:
ADL = Activities of Daily Living
HDS = Hasegawa Dementia Scale
IADL = Instrumental Activities of Daily Living
MMSE = Mini-Mental State Exam
N/A = Not Applicable

COMMONLY USED MEASURES

Detailed data on the measures used in each study are presented in table 3. The most commonly used cognitive measure was the Mini-Mental State Examination (MMSE) (N = 23). The next most frequently used measures were the Telephone Interview for Cognitive Status (TICS) (N = 4),[64–67] the Short Portable Mental Status Questionnaire (SPMQ) (N = 3),[31,57,58] and the Trail Making Test – Part B (N = 3).[60,68,69] Many other measures were used in only one or two studies. Disability was most frequently measured by Activities of Daily Living (ADL) (N = 15), Instrumental Activities of Daily Living (IADL) (N = 4) or a combination of the two measures (N = 18). Other disability measures used only once or twice were the World Health Organization Disability Assessment Scale,[52,70] Barthel Index,[52] Items from Disability Assessment Schedule,[71] and disability as determined by Long Term Care Insurance.[62,72]

COGNITIVE IMPAIRMENT CUT-POINTS

Studies varied in their use of cognition as a continuous score to study protective factors and having a cut-point for cognitive impairment. Cut-points for measuring cognitive impairment with the MMSE varied from scores of less than 21,[8] 23,[63] or 24.[73]. A few studies created MMSE categories. Among those, the lowest-functioning category ranged from a singular score of 23,[74] 18-20 (this study excluded a score of less than 18 to exclude dementia),[75] or 0-21.[76]

Studies also varied for their reasoning in cut-points. For example, Johnson et al. used a one standard deviation below the mean approach to select a cut-point of < 23.[69]

Similarly, Berlau et al's cut-point of <23 was determined by previous studies with the same cohort determining this to be the most sensitive for their cohort.[29] While Royall et al. and Gallucci et al. stated they used <24 as it is the cut off for impairment with MMSE.[42,73] Raji et al. claim that <21 is used for studying cognitive aging.[2] Lee et al. used a cut-point of <19, however, their study used the Korean version of MMSE, which presumably has slightly different scoring. Most studies did not specify whether the cognitive measure or the cut-points were culturally appropriate.

DISABILITY CUT-POINTS

The most commonly used cut-point for defining disability was an individual needing help or being unable to complete any single item in ADLs for ADL disability or in IADLs for IADL disability (N = 16). Some studies that used both ADL and IADL required that an individual be dependent on an item in both ADL and IADL[54,66]or created a combined category where dependence in either ADL or IADL qualified as disabled.[34]

Other studies used scales for scoring increased dependence.[61,68,71,73,77,78] For example, Bennet et al. had individuals rate their ADL difficulty from 1-3 and their IADL difficulty from 1-4 and created a composite score.[60] Cullen et al. used a cumulative score with ADL, IADL, and Items from the Disability Assessment Schedule. Li had participants score their ADLs 0-4 and summed together for a total disability score.[78] Scanlan et al. took a slightly different approach, and scored each item 0 – 2 (unable, some difficulty, no difficulty) and summed for a 0- 12 scale. Those with a score < 9 were qualified as disabled.[79]

To study disability trajectories, various studies examined different intensities of disability or changes in ability. Dodge et al. in 2006 followed disability trajectories and used categories to look at no decline, moderate decline, or sharp decline.[60] Johnson et al. denoted incident disability as difficulty with either an ADL item or an IADL item. Worsening difficulty was further defined as an increase of 2 points in ADL or IADL scale.[69]

Table 2.3. Cognition and disability measures, analysis, and reported associations from all 41 studies.

Author	Year	Cognitive Measure	Cut Points	Disability Measure	Cut Points	Statistical Analysis	Significant Relationship	Risk/Odds Ratio (95% CI)
Avila-Funes	2011	1) MMSE 2) Isaac Set test	Scores for both were broken into quartiles and combined, with the lowest quartile labeled cognitively impaired	8 IADL and 5 ADL.	Disability was dichotomized as "no help" vs. "need help/unable to complete." A disability in one item was considered incident disability in that domain.	Logistic regression	IADL Disability: Yes ADL Disability: No	2.06 (1.04, 4.06)
Bennett	2006	1) MMSE 2) Boston Naming Test 3) Semantic Verbal Fluency Test 4) Judgment of Line Orientation Test 5) Digits Forward and Backward 6) WMS-R Logical Memory and Visual Reproduction 7) TMT-B 8) WAIS-R 9) CDR	Continuous scores	3 ADLs and 3 IADLs	Rate 1-3(ADL) and 1-4 (IADL). Higher number = increased dependence.	Partial regression	Yes, in all but Digits Backward and CDR	
Berlau	2010	1) MMSE 2) CVLT	MMSE< 23 = Impaired CVLT < 4 = Impaired	6 ADLs	Needing help in any 1 ADL = disability	Cox proportional hazards analysis.	Yes	MMSE: 2.05 (1.11, 3.78) CVLT: 1.86 (1.07, 3.26)

Black	2002	SPMQ	3 ≤ errors = Impaired	7 ADLs	Inability to perform any ADL at follow-up that they were able to perform at baseline.	Multivariate logistic regression	Yes	1.09 (1.03, 1.15)
Blaum	2002	Modified Telephone Interview for Cognitive Status	Lowest 25% quartile = Impaired	5 IADLs and 5 ADLs	Needing help with any 1 task.	Logistic regression	IADL Disability: Yes ADL Disability: Yes	IADL range: 1.5 - 1.8 ADL range: 1.7 - 3.2
Conolly	2016	MMSE	Continuous score	5 ADLs, 6 IADLs, and ADL/IADL combined	Difficulty with 1 item (ADL alone, IADL alone, or either in the ADL/IADL combined)	ANOVA and Logistic regression	IADL Disability: Yes ADL Disability: No Combined: Yes	IADL: 0.90 (0.43, 0.96) ADL/IADL: 0.84 (0.78, 0.91)
Cullen	1996	DEM (Acquired chronic cognitive impairment)		1) 9 ADLs and 13 IADL s 2) Items from Disability Assessment Schedule.	Cumulative score, higher score equated higher dysfunction.	Multiple regression analysis	IADL Disability: Yes ADL Disability: Yes	
Di Carlo	2000	1) CAMDEX sections B and H 2) Examination by neurologist.	Participants grouped into Cognitive Impairment No Dementia, Age Related Cognitive Decline, or Dementia	6 ADLs	Needing help with any 1 ADL = disability	Multiple logistic regression	ADL: Yes	1.88 (1.41, 2.49)

Dodge	2006	1) MMSE 2) TMT-A and B 3) CERAD 10-word Word List Learning and Delayed Recall 4) Story Immediate Retell and Delayed Recall 5) Initial Letter and Category 6) Fluency 7) 15-item CERAD version of the Boston Naming Test 8) CERAD constructional Praxis 9) Clock Drawing.	Continuous	7 IADLs	Summed together and categorized as "no decline", "moderate decline" (2 IADLs) or "sharp decline" (3 or more IADLs)	Trajectory modeling latent class analysis	Yes, in all but MMSE.	Range: 1.46 - 1.95
Dodge	2005	Hasegawa Dementia Scale	Categorized into 4 groups." Intact cognition" (>25), "minimal impairment" (21-24), "mild impairment" (17-20), and "severe impairment" (0-16)	5 ADLs and 7 IADLs	Categorized into 3 groups: Completely independently, partly independent, completely dependent.	Logistic regression and population attributable risk	Yes	IADL range: 2.4 - 4.9 ADL range: 3.0 - 9.4
Doi	2015	National Center for Geriatrics and Gerontology Functional Assessment Tool.	Categorized as single domain impairment and multiple domain impairments.	Long Term Care Insurance	Used incident disability	Kaplan-Meier analysis using a log rank test and cox proportional hazards regression models.	Single domain: No Multiple domain: Yes	2.56 (1.31, 5.02)

Dotchin	2015	Community Screening Instrument for Dementia	Categorized as "poor performance", "moderate performance", "good performance"	1) WHODAS 2) Barthel Index	Ranked as "minimum disability" (0-24) and "maximum" (75-100) and Barthel index ranked "severe" (0-12), "moderate" (15-18), and "mild/none" (19-20).	Chi-square and Logistic regression	Yes	5.31 (1.91, 14.7)
Fauth	2007	1) MMSE 2) Memory in Reality test	Continuous	5 ADLs and 4 IADLs	Unable to complete or able with great difficulty both ADL and IADL = disability.	Multinomial logistic regression	MMSE: No Memory in Reality: Yes	Range: 0.61 - 0.65
Galluci	2010	MMSE	Dichotomized impaired (< 24.) not impaired (>25)	6 ADLs and 8 IADLs	Scored ADL 0-6, IADL 0-8	Contingency tables, proportional odds logistic regression	ADL: Yes IADL: Yes	
Gill	1996	MMSE	Categorized < 23, 23-25, 26-27, 28- 30	7 ADLs	Incident disability in any 1 ADL.	Mantel-Haenszel chi-square and multivariable binomial regression	Yes	Range: 1.3 - 2.4
Hebert	1999	Modified MMSE	Scored 0-100 with impairment at <80/100.	Functional Autonomy Measurement System (Includes 7 ADLs, 8 IADLs)	Scored 0 (independent) to 3 (dependent). Increase of 5 points = decline.	Logistic regression	At 1 year: Yes At 3 year: No	0.96 (0.93, 0.98)
Jagger	2005	1) MMSE (baseline only) 2) Information/Orientation subtest of the CAPE (baseline and follow-up)	Continuous, descending	7 ADLs	Needing help in any 1 ADL = disability	Cox proportional hazards	MMSE: No I/O: Yes MMSE and I/O combined: Yes	I/O: 1.10 (1.02, 1.19) MMSE and I/O: 2.36 (1.3, -4.28)

Johnson	2007	1) MMSE modified to a 26 point scale) 2) TMT-B	MMSE <23 and TMT-B >180 seconds = impaired	4 ADLs and 4 IADLs	Difficulty with any one item = incident difficulty. Increase of 2 points on ADL or IADL scale 0-12 (0-3 points per item) = worsening difficulty.	Logistic regression	Incident IADL: - MMSE: No - TMT-B: No -Combined: No Incident ADL - MMSE: No - TMT-B: Yes - Combined: No Worsening IADL - MMSE: No - TMT-B: No - Combined: No Worsening ADL - MMSE: No - TMT-B: Yes - Combined: No	Incident: 1.34 (1.07, 1.69) Worsening: 1.48 (1.16, 1.89)
Kim	2013	SPMQ	Normal (2 or less errors), Mild (3-4), Moderate to Severe (5+)	6 ADLs	Needing help with 3+ ADL for two consecutive observations = Severe, persistent ADL dependence	Cox proportional hazards	Yes	1.85 (1.64, 2.08)

Kim	2005	MMSE	Continuous	WHODAS, two versions for those working vs. non-working	Scored 0-100 higher numbers being greater disability	General linear models	Yes	
Lau	2015	Everyday Cognition (informant based assessment)	Higher score denotes severity of impairment	8 IADLs	Dichotomized as independent or needing help. Disability was defined as needing help in 2 or more IADLs	Cox proportional hazards	Yes	3.9 (2.8, 5.4)
Lee	2005	MMSE-K	MMSE <19 = impaired	5 ADLs and 5 IADLs	Converted into 0-100 scale, higher score indicates better function	Generalized Estimating Equations	Yes	
Leveille	1998	MMSE	Categorized into 5 groups: 18-20, 21-23, 24-26, 27-28, and 29-30. Scores < 18 were excluded from the study to exclude dementia.	5 ADLs and 5 IADLs	Not reported	Logistic regression	Black participants - MMSE: No White participants: - MMSE: Yes	Range: 1.45 - 2.70

Li	2009	Change in Minimum Data Set (MDS) for Home Care Cognitive Performance Scale (CPS, score 0-6).	Categorized Cognitively intact (0) bordering (1) and impaired (>2) Assessed at each observation	8 ADLs and 7 IADLs	Each ADL item was scored 0-4 and ADL 0 -2, then summed together for total disability. ADL was dichotomized as 0 "No help/supervision only in all ADL" or 1 "needs help/unable in 1 or more ADL". IADL dichotomized as 0 "independent in one or more IADL" or "difficulty with all IADLS."	Hierarchical linear models and Bernoulli Hierarchical generalized linear models	ADL Disability: Yes IADL Disability: Yes	ADL: 1.28 (1.04, 1.57) IADL: 2.15 (1.74, 2.65)
Li	2005	Change in Minimum Data Set (MDS) for Home Care Cognitive Performance Scale (CPS, score 0-6).	Dichotomized as some dependence vs. none.	8 ADLs	Each item was score 0-4 and summed together for total disability	Hierarchical linear model using likelihood estimation	Yes	
Martin	2015	Telephone Interview Cognitive Screen	Continuous	6 ADLs	Dichotomized as "no difficulty in any" 0 or "difficulty with 1 to all" 1.	Finite Mixture Modeling using likelihood estimation	Yes	
McGuire	2006	Telephone Interview for Cognitive Status,	Scored 0-20 with lower score equating lower cognition. Baseline cognitive function broken into quartiles: 9-12, 13-14, 15, 16-20	6 ADLs and 6 IADLs	Categorized into IADL & ADL impaired, ADL impaired, IADL impaired, Disability free. Additional outcome of dead	Multivariate Logistic regression	Compared highest to lowest cognitive function IADL Disability: No ADL Disability: Yes Combined: Yes	ADL: 1.83 (1.27, 2.61) Combined 1.58 (1.15, 2.16)

Millan-Calenti	2011	MMSE	Continuous and MMSE $\leq$ 23 = impaired	6 ADLs and 8 IADLs	Cannot complete any one IADL or ADL = dependent in that category	Logistic regression and spearman's rho	Impaired MMSE - IADL Disability: Yes - ADL Disability: Yes Continuous MMSE -IADL protective: Yes - ADL protective: Yes	Impaired MMSE - IADL: 5.7 (3.5, 9.3) - ADL: 4.1 (2.7, 6.1) Continuous MMS - IADL: 0.9 (0.8, 0.9) -ADL: 0.9 (0.8, 0.9)

Nikolova	2009	SPMQ	Scored 0-10 points, >5 points = "severe impairment" Change in cognition categorized as "Catastrophic decline", "Mild decline", and "Slight decline"	6 ADLs and 8 IADLs	IADL: scored as 1-3 (independent, need help, dependent) for each item for a total of 8-24 points. Disabled = > 11 ADL: scored 0 (without problems) or 1 (with help/unable) for a range 0-6. Disabled = > 4	Repeated measures ANOVA and Tukey pairwise multiple comparisons	IADL Disability: Yes ADL Disability: Yes	
Rajan	2012	1) Immediate and delayed recall 2) East Boston Memory Story 3) Symbol Digits Modalities Test 4) MMSE.	Composite score created with all 4 measure	6 ADLs	Each item score 0 (no help) or 1 (with help). Summary score 0-6. Incident disability was a score of 1 in one or more ADLs for two consecutive years.	Regression time event model	Age of onset: Yes Progression of Disability: Yes	Age of onset: 1.03 (1.02, 1.04) Progression of disability: 0.89 (0.82, 0.96)

Raji	2004	MMSE	Categorized as "impaired" (0-21), "low/normal" (22-24), "normal" (25-28), or "high" (29-30)	7 ADLs	Needing help/unable to perform one or more item = disabled	Cox proportional hazards	Yes	Impaired: 1.58 (1.18, 2.12) Low/normal: 1.38 (1.04, 1.82) Normal: 1.30 (1.02, 1.66)
Raji	2005	MMSE	Scored < 21 impaired	7 ADLs	Needing help/unable to perform one or more item = disabled	Generalized Estimating Equations	Yes	1.62 (1.26, 2.10)
Rist	2015	1) Immediate and delayed recall 2) Telephone Interview for Cognitive Status	Combined to create a 0-1 "dementia probability" and broken into quartiles.	5 IADLs	Ranked as "can do yes or no" and summed for a range of 0-5.	Poison regression, inverse probability weights.	Yes	Lowes probability: 0.44 (0.28, 0.70) Mild probability: 0.35 (0.27, 0.45) Moderate probability: 0.53 (0.44, 0.65)
Royall	2004	1) EXIT 2) MMSE	EXIT scored 0-50, higher indicates impairment MMSE score <24 = impaired. Measured at baseline and each follow-up.	OARS IADL scale.	Scored to be inversely proportionate to disability level.	Latent Growth Curve Analysis	Baseline scores - EXIT: Yes - MMSE: Yes Cognition Deterioration - EXIT: Yes - MMSE: No	
Saito	2014	Self-report	1) No inconvenience of cognitive dysfunction 2) slight inconvenience 3) Serious inconvenience	Long Term Care Insurance	Approval of care in 1-7 need levels was labeled as incident disability.	Cox proportional hazards	No	

Scanlan	2007	Mini-Cog: Three-item word recall and executive clock drawing.	Summed range 0-5. Score < 2 = impaired	6 ADLs	Each item scored 0 = unable, 1 = some difficulty 2 = no difficulty. Summed for 0-12 scale, score < 9 = disabled.	Hierarchical Logistic Regression	Yes	
Shega	2010	Modified MMSE.	Scored 0 - 100, score < 77 = impaired.	5 IADLs and 7 ADLs	Each item scored 0 = complete without help, 1 = some help, 2 = unable. A score of 1+ in any item categorized as disabled in that domain.	Multivariate Linear Regression	IADL Disability: Yes ADL Disability: Yes	
Slavin	2015	1) Cognitive Complaints Questionnaire 2) Memory Complaints Questionnaire	Four indices were created (participant vs. informant and memory vs. no memory) and ranked 0-1: endorsed, not endorsed.	Bayer-ADL, reported by informants	Frequency of difficulty scoring 1 (never) to 10 (always).	Ordinary Least Squares Regression	Informant answers - Cognitive: Yes - Memory: Yes Participant answers - Cognitive: No - Memory: No	
St. John	2015	1) Modified MMSE	Scored 0 - 100	6 ADLs and 7 IADLs	Dichotomized as "able to complete" vs. "needing help/unable." Disability in any one item qualified as disabled.	Cross-sectional analysis and Prospective Analysis	Cross-sectional: Yes Prospectively: Yes	Cross-sectional: 0.96 (0.95, 0.98) Prospectively: 0.97 (0.95, 0.99)
Vermeersch	2015	1) MMSE 2) CAMCOG		49 Advanced ADLs	Scored 0 (no difficulty) - 4 (complete difficulty)	ANOVA and Pearson's Product Moment Coefficients	MMSE: Yes CAMCOG: Yes	

Yaffe	2010	Mini-MMSE (baseline and follow-ups)	Rates of change were assessed and participants were categorized as "maintainers", "mild decline", or "major decline"	4 ADLs	Difficulty with any 1 item = disabled	Kaplan-Meier Curves and Cox Proportional Hazards Regression Models	Maintainers: Yes Major Decline: Yes	Maintainers: 0.74 (0.62, 0.89) Major decliners: 1.49 (1.19, 1.86)

Abbreviations:
ADL = Activities of Daily Living
CAMCOG = Cambridge Examination for Mental Disorders of the elderly, cognitive portion
CAMDEX = Cambridge Mental Disorders of the Elderly Examination
CAPE = Clifton Assessment Procedures for the Elderly
CDR = Clinical Dementia Rating
CERAD = Consortium to Establish a Registry for Alzheimer's Disease
CVLT = California Verbal Learning Test-II Short form
EXIT = The Executive Interview
MCI = Mild Cognitive Impairment
MMSE = Mini-Mental State Examination
MMSE-K = Mini-Mental State Examination, Korean version
OARS = Older Americans Resource Services
SPMQ = Short portable Mental Status Questionnaire
TMT - A, B = Trail Making Test parts A, B
WAIS-R = Wechsler Adult Intelligence Scale
WHODAS = World Health Organization Disability Assessment Scale
WMS-R = Wechsler Memory Scale - Revised

RELATIONSHIP STRENGTH

Table 2.3 outlines whether relationships were significant and what the odds ratio or risk ratio was, if reported. Studies that reported other measures (such as r or beta) were included in the table, but the strengths of their relationships were not reported in the table. Only one study did not report a significant relationship. This study, by Saito et al, used self-reported inconvenience from cognitive dysfunction and used disability as found on Long Term Care Insurance.[72] Every other study reported a significant relationship between cognition and disability, in at least one of their measures. Only 12 studies reported at least one of their relationships studied to be insignificant. Strengths of the relationships ranged from cognitive impairment/low cognition having 1.09 to 9.4 times higher odds/risk of disability[58,77] and cognition being protective of disability from 0.44 to 0.90 odds/risk.[34,67]

Of the studies that looked at the relationship between cognition and ADL disability only, the strength (as measured by risk ratios and odds ratios) ranged from 1.09 to 4.1.[58,63] The strength for IADL only ranged 1.46 to 5.7.[63,68] When using the MMSE to measure cognitive impairment, the strength of the relationship ranged from 1.30 to 5.7.[63,74] When using the TIC, the strength of the relationship ranged from 1.5 to 3.2. Lastly, using the SPMQ resulted in a range from 1.09 to 1.85.[31,58]

Among the studies that did not find a significant relationship, 5 did not find a relationship between MMSE and ADLs,[7,34,54,69,80] 3 did not find a relationship between MMSE and IADLs[54,68,69], 1 did not find a relationship between a change in MMSE score and IADLs,[42] and 1 did not find a relationship between TICS and IADLs.[66] Leveille et al. did not find a relationship between MMSE and ADL/IADLs among Black participants and Hebert et al. did not find a relationship between MMSE and ADL/IADL at 3 years, though

they did at 1 year. As mentioned earlier, Saito et al. did not find a relationship between their measure of cognition and disability and Doi et al, who also used Long Term Care Insurance as a disability measure, did not find a relationship with a single domain from the National Center for Geriatrics and Gerontology Functional Assessment Tool. However, they did find a significant relationship when using multiple domains of cognition.

No trends in the strength of the relationship were observed by study design or by quality of study. Results remained consistently heterogeneous. For cross-sectional studies the strength of the relationship between impaired cognition and disability in ADLs ranged from 1.7 – 4.1, IADLs ranged from 1.5 – 5.7, and combined ADLs with IADLs ranged from 1.5 – 2.7. The longitudinal designs were similar in the strengths of relationship, with the exception the study by Dodge et al., which reported an OR as high as 9.4.[77]

Of note, the results incorporated studies from all over the world and cognition appears to be strongly associated with disability regardless of race or ethnicity. There were ten different countries included and five studies that specifically looked at a Hispanic population. All five of these studies looked at ADLs, one studied did not find a significant association and the other four found impaired cognition to have 1.09, 1.58, 1.62, and 4.1 higher odds of disability. Two studies looked at IADLs and found impaired cognitive to have 2.06 and 5.70 higher odds of disability.

SUMMARY OF RESULTS

This review found that cognitive impairment among older adults is broadly associated with increased likelihood of having disability. Cognitive impairment ranged from 9% to more than 9-fold higher odds/risk of having disability than those with intact

cognition. The MMSE was the most commonly used measure and was found to have a significant relationship with disability 18 of the 23 times it was used. The TICS was the second most used cognitive measure and was found to have a significant relationship 3 of the 4 times it was used. ADLs and IADLS were the most commonly used measures for disability. However, the type and number of items, as well as the cut-points for disability varied greatly.

DISCUSSION

The aim of this study was to systematically review all available research on the relationship between cognition and disability, in order to provide a resource on the relationship between cognition and disability among older adults and to explore the measures, cut-points, and combinations currently being used. The goal was to provide a clearer understanding on how the measures used can change the significant and strength of a relationship, in hopes of informing future research methodology. Forty-one observational studies were included. Results of this systematic review suggest that there is a strong association between cognition and disability. Only one article did not find a statistically significant relationship, the other reported significant relationships in one or more of their measures. It is possible, however, that publication bias could be playing a part in the lack of non-significant findings being published.

Cognition and disability are broad terms, with many available measures and a variety of cut-points and scoring systems possible. The combinations between the two provide almost an endless possibility of study design and analysis options. These possibilities are important, as no two populations are exactly the same and different

approaches may be needed to study specific populations. For example, there is no single cut-point for indicating impaired cognition that is appropriate across all age and education attainment groups.[8,63,69] Regardless of how it is measured, there seems to be a consistently strong relationship between cognition and disability.

It is our view that in order to create research that is consistent and comparable, there must be a consensus on the appropriate measure methodology. Our review found that sample size, measures, cut-points, length of study, and analyses used all varied greatly among the articles found. The strength of the relationship varied from cognitive impairment having 9% higher odds of disability to having over 9 times higher odds. It is possible there would be less variability in the strength of this relationship if there were more consistency in the measures used and culturally appropriate cut-points selected. Based on the results from this review, we strongly encourage that in future studies all investigators provide clear justification for their measure choices and why their selected cut-point is appropriate for their population. This would provide a solid foundation for creating a decision aid on measure methodology.

LIMITATIONS

One should be careful when generalizing the results of this study due to a few limitations. The first is the culturally appropriateness of the measures. This systematic review included studies from over 10 different countries and it is unclear whether the cognitive measures were adapted to be culturally appropriate, or simply translated into the needed language. This would affect the validity of the cognitive measure. Second, all studies come with a certain amount of bias and error, when pooling together 41 studies it is difficult to ascertain or account for the various biases in the studies, which in turn could

bias the results of the systematic review. Lastly, only one study reported a non-significant relationship between cognition and disability, but this may be due to publication bias such that other studies with similar results were not published.

CONCLUSION

Cognition is strongly associated with disability. Overall, older adults with cognitive impairment are much more likely to develop disability than those with intact cognition. We live in a rapidly aging world and as the oldest-old population continues to grow it is imperative that we find ways to prevent or delay the onset of disability. Through careful monitoring of cognition it may be possible to forecast future functional needs, allowing for early intervention before impairment progresses. Future research is needed to determine the best approaches for clinical intervention to optimize the health, independence, and satisfaction of older adults.

CHAPTER 3. EXAMINATION OF THE RELATIONSHIP BETWEEN COGNITION AND ADL DISABILITY ACROSS COHORTS OF OLDER MEXICAN AMERICANS

INTRODUCTION

A cohort difference, sometimes referred to as cohort effects or generation effects, is the term for variations in health outcomes experienced by a group of persons that are attributable to a combination of factors: age, the year or period in which the group was born, and the risk factors a population of that period was exposed to.[37] Prior studies show cohort differences in rates of obesity, difficulty with sleep, depression, and disability.[5,38–40] Differences in disability rates between cohorts is particularly strong among older Mexican American Adults.[5] It is important, from both a public health standpoint and for the individuals themselves, to identify current factors playing a part in the dynamic disabling process.

Among older Mexican Americans, there have been recent cohort differences found in several health outcomes. Newer cohorts have a higher prevalence of chronic conditions, such as obesity, hypertension, and diabetes.[81] The prevalence of diabetes has increased drastically over 10 years, from 20.3% in 1993/94 to 37.2% in 2004/05.[5] This high prevalence of chronic health conditions results in Mexican Americans being susceptible to poor physical functioning and disability. In recent research by Beard et al, newer cohorts of older Mexican Americans had 12.5% higher prevalence of ADL disability compared to older cohorts.[5] This change in disability among older Mexican Americans is surprising when juxtaposed with the overall disability prevalence in the United States. Over the past 30 years in the U.S. there has been a decrease in the prevalence of disability.[15,28] This

positive cohort difference is in stark contrast to the negative cohort differences among Mexican Americans.

Research has repeatedly found disability to be associated with poor outcomes among older adults, such as institutionalization, depression, higher utilization of home services, and death.[1,2,15] Caring for adults with disability can also be a burden on caregivers and health care resources.[15] In the United States, disability costs an estimated $119.0 billion in Medicare alone.[82]

The systematic review presented in Chapter 2 identified a strong and consistent relationship between cognition and disability in older adults (Chapter 2). Individuals with a cognitive impairment have up to 9 times higher odds of developing disability than those with intact cognition.[77] According to a report published using the Hispanic EPESE data, rates of cognitive impairment have remained consistent across cohorts, but rates of disability have increased drastically for the newer cohort.[5] This study aims to investigate if the resulting increase in disability can be attributable, at least in part, to a cohort difference in the relationships between cognitive impairment and disability. We hypothesize that cohort will have a modifying effect on the relationship between cognitive impairment and incident ADL disability. It is hoped that the results of this study can be used to provide clarity on the current needs for preventing disability, in order curb this rising health concern among older Mexican Americans.

METHODS

POPULATION

Participants were selected from the Hispanic Established Populations for the Epidemiologic Studies of the Elderly (Hispanic EPESE), which was collected during eight observation periods from 1993/94 to 2012/13. The Hispanic EPESE is a multistage, stratified representative sample of community-dwelling Mexican-American elderly, aged 65 years and older, residing in the five southwestern states: Arizona, California, Colorado, New Mexico, and Texas. The design of the Hispanic EPESE was modeled after other Established Populations for Epidemiologic Studies of the Elderly. Information on the sampling process has been previously described.[1,83]

Data collection for the baseline observation began in September 1993 and lasted to June 1994. The baseline data included several demographic characteristics, such as age, sex, type of Hispanic race, income, education, marital status, number of children, and employment. Additionally, participants were asked the following personal characteristics: height, weight, social and physical functioning, self-reported physician diagnosed health conditions, related health problems, health habits, self-reported use of dental, hospital, and nursing home services, and depression. The data were collected via personal interviews, questionnaires, and physical assessments. Information on sampling and data collection was gathered from the National Archive of Computerized Data on Aging (NACDA), Inter-university Consortium for Political and Social Research, as well as other published studies.[84]

The Hispanic EPESE data included 3050 Mexican Americans aged 65 years and older living in the Southwest. Of those, 1,132 were aged 75 years and older. A total of eight waves of data have been collected: 1993/94, 1995/96, 1998/99, 2000/01, 2004/05, 2006/07,

2010/11, and 2012/13. A new cohort (N = 902) of participants aged 75 years and older was added to the sample in wave 5 (2004/05). We downloaded the public-use files for waves 1-8 from the NACDA website.

Inclusion/Exclusion Criteria

We included individuals aged 75 years and older with interviews completed by themselves or via proxy assistance. Initial exclusion criteria were missing data on cognition or disability in four consecutive waves. After completing the first analysis those with disability at baseline were excluded in order to study incident disability.

MEASURES

Disability

Disability was assessed via self-reported need of assistance with activities of daily living (ADL). The Hispanic EPESE data includes self-reported responses to seven items from a modified version of the Katz ADL scale, used frequently with older Hispanic adults.[1,5,8] Activities include walking across a small room, bathing, personal grooming such as brushing teeth, dressing, eating, transferring from a bed to a chair, and using the toilet. Participants are asked to respond if they can complete each task independently without help, if they need help, or if they cannot complete the ADL. Participants were classified as having an ADL disability if they reported needing help or being unable to complete one or more of the seven ADLs. Disability was assessed at baseline and was continually monitored for incident disability across the successive waves. We chose to study ADL only and did not include instrumental activities of daily living (IADL), such

as balancing a checkbook. First, we were interested in studying incident disability. Older adults are more likely to become disabled in IADLs before ADLs and excluding participants with IADL disability at baseline would significantly reduce our sample size. Second, IADLs are more cognitive by nature; comparing the effects of cognitive impairment on IADL disability may overinflate the relationship between cognition and disability.[34]

Cognition

Cognition was assessed using the Mini Mental State Exam (MMSE), which is the most frequently used measurement tool in cognitive aging.[85–87] The MMSE is a 19-item scale that assesses various functions of cognition: orientation, working memory, attention, delayed memory, and language. Versions are available in English and Spanish.[88] The MMSE score is a continuous variable with possible scores ranging from 0 to 30, and dichotomized as poor/low cognitive function (≤ 21) and normal/high cognitive function (> 21).[89,90] This cut-point is standard for aging populations with low levels of education[8] and validated for identifying cognitive impairment among older Mexican Americans.[86] Cognition was assessed at baseline and each follow-up wave for both cohorts and was included as a time variant variable.

Cohorts

We created an indicator variable to differentiate the original cohort (cohort 1) from the newer cohort (cohort 2). Participants were selected for the original cohort if they were 75 years or older during the wave 1 (1993/94) baseline assessment. Participants were

selected for the newer cohort if they were 75 years or older at wave 5 (2004/05) and were not included in the original cohort; i.e., they were new additions at wave 5 or they aged into the age criterion since wave 1. Allowing participants to age into the newer cohort provides a larger sample to power this study.

Covariates

Several sociodemographic and medical characteristics were included in this analysis. We controlled for age, sex, marital status, years of education, arthritis, diabetes mellitus, heart attack, hypertension, stroke, body mass index (BMI), depression (measured using the CES-D scale),[89,91] and smoking status. Age, BMI, education, and depression score were included as continuous variables. Marital status, sex, and medical characteristics were included as dichotomous variables. Marital status was dichotomized as married or not married (included not married, divorced, and widowed), sex was dichotomized as male or female, and medical characteristics were dichotomized as yes or no in regards to a doctor ever diagnosing the illness.

STATISTICAL ANALYSIS

We first stratified our sample by cohort and compared group means and frequency distributions of participant characteristics via t-tests and chi-square contingency tables, respectively. Additionally, we compared those included versus those excluded from the study.

For the multivariable analyses assessing the modifying effect of cohort on the relationship between cognition and incident disability, we used a series of General

Estimating Equations (GEE). GEE provides reliable estimators of the regression coefficients and of variances under weak assumptions in regards to the correlation between repeated subject observations.[87] Because GEE modeling is useful for unbalanced data, as it uses means, variance, and covariance to make assumptions, participants with missing information were included in the study until their last interview date.[92] In the paragraphs below, we describe the key differences in each of the three models we used, but it is important to note that we controlled for all of the sociodemographic and medical covariates described above in all models.

Model 1 included cognition and ADL disability scores from each of the four waves; i.e., cognition was treated as a time-varying variable. Essentially, this data structure equates to a series of cross-sectional analyses and yields an overall association between the co-occurrence of cognitive impairment and ADL disability. The interaction term for cohort-by-cognition was included to determine if the overall relationship between cognitive functioning and disability status demonstrated a cohort effect.

For Model 2 we excluded those with ADL disability at baseline and included only baseline cognition measures along with full set of interaction terms to assess the moderating effect of cohort on the relationship between baseline cognition and incident disability over time. Step 1 included a 3-way interaction for cognition-by-cohort-by-time along with each of the 3 paired combinations: cognition-by-cohort, cognition-by-time, and cohort-by-time. In subsequent steps we simply removed non-significant interaction terms; however, we kept the cognition-by-time and cohort-by-time interaction terms in the model, regardless of significance level as our focus was on incident disability over time.

Lastly, we restructured the data to perform a longitudinal analysis of the moderating

effect of cohort on the relationship between cognition and future disability over time. We excluded disability at baseline and aligned cognition scores from each wave with ADL disability status from the successive wave; i.e., baseline cognition predicted observation 2 disability, observation 2 cognition predicted observation 3 disability, and observation 3 cognition predicted observation 4 disability. Again, we included a cognition-by-cohort interaction term.

Together, the three models enabled us to get a comprehensive view of the relationship between cognition and disability in older Mexican Americans, and to determine whether there is a cohort effect on this relationship. All analyses were two-tailed with $p < 0.05$ and performed using IBM SPSS 23.

RESULTS

The Hispanic EPESE contained 3,050 individuals. After excluding those under 75 years old (N = 1,918) and missing all 4 observations of cognition or disability (N = 64) there were 1,068 participants in the sample used for model 1. For models 2 and 3, to study incident disability, we excluded those with disability at baseline (N = 225) and those missing information on disability at baseline (N = 3). The final sample for cohort 1 was 840 non-disabled Mexican Americans aged 75 years or older.

Cohort 2 started with 902 new participants aged 75 years and older. Adults who aged into cohort 2 (N = 882) were added to this sample. After excluding those missing all four observations of cognition or disability (N = 56), 1,728 participants remained and were used for model 1. Again, we excluded those with disability at baseline (N = 561) and missing baseline disability information (N = 1) for models 2 and 3. The final sample for

cohort 2 was 1,166; totaling 2,006 for the entire study. Figures 3.1 and 3.2 illustrate the sample selection process.

Figure 3.1 Sample selection for cohort 1

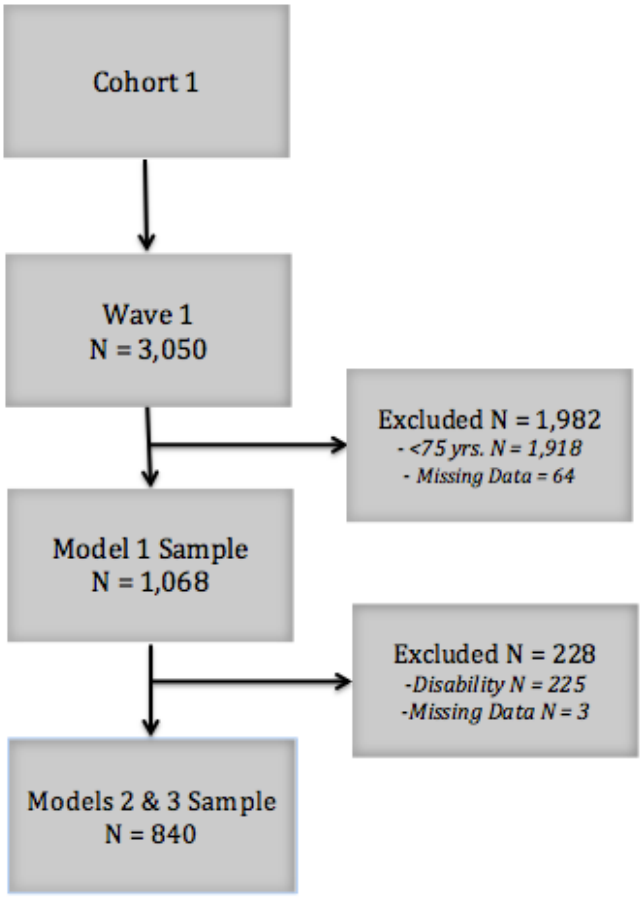
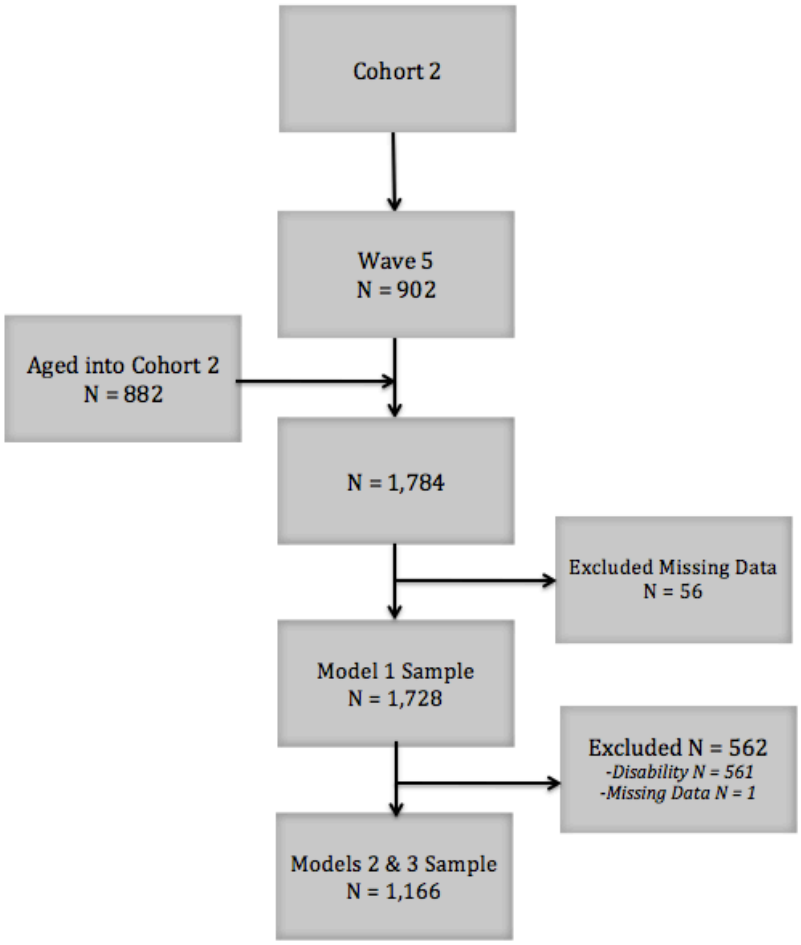


Figure 3.2 Sample selection for cohort 2



Compared to those included, the excluded participants were more likely to be older, female, married, have less education, higher rates of depressive symptoms, higher BMI, were non-smokers, required a proxy or proxy assistance, and were more likely to have a cognitive impairment, heart attack, high blood pressure, hip fracture, stroke, diabetes, and arthritis. As those with disability were excluded, the excluded group was also more likely to have an existing disability. There was no statistically significant difference in nativity between those included and excluded.

The sociodemographic and medical variables are compared between cohorts in table 3.1. There was not a statistically significant difference between cohorts in regards to age, gender, marital status, and history of heart attack or hip fracture. Participants in the newer cohort were more likely to be cognitively impaired; smoke; have histories of high blood pressure, stroke, diabetes, and arthritis; been born in the U.S.; and complete their interviews independently. The newer cohort, on average, also had more years of education, and higher BMI.

Table 3.1. Descriptive Characteristics for Entire Sample and by Cohort

	Cohort			
	1	2	Total	
N	840	1166	2006	*P*
Male	42.98%	42.20%	42.52%	0.749
Married	55.71%	0.17%	53.64%	0.148
Ever Disabled	33.20%	47.90%	41.70%	*< 0.001*
Cognitively Impaired	26.55%	33.70%	30.71%	*< 0.01*
Smoker/Former Smoker	40.95%	48.63%	45.41%	*< 0.05*
History of:				
Heart Attack	10.95%	13.72%	12.56%	0.980
High Blood Pressure	40.83%	61.49%	52.84%	*< 0.001*
Hip Fracture	3.21%	5.32%	4.44%	0.054
Stroke	5.48%	9.35%	7.73%	*< 0.01*
Diabetes	21.43%	31.56%	27.32%	*< 0.001*
Arthritis	37.26%	52.57%	46.16%	*< 0.001*
Completed by respondent only	92.74%	95.80%	94.52%	*< 0.01*
Nativity				*< 0.01*
Mexico	49.80%	42.40%	45.50%	
United States	50.10%	57.60%	54.50%	
Re-Interviewed				*< 0.001*
Observation2	83.21%	77.53%	79.91%	
Observation 3	63.81%	60.81%	62.10%	
Observation 4	51.55%	42.80%	46.46%	
Mean (SD)				
Age	80.12(4.42)	80.03 (3.51)	80.07 (3.92)	0.620
Grade	4.38 (3.81)	5.34 (4.13)	4.94 (4.03)	*< 0.001*
BMI	26.64 (4.72)	27.34 (4.68)	27.05 (4.71)	*< 0.001*

CES-D	9.70 (8.75)	7.9 (8.11)	8.66 (8.4)	*< 0.001*

The first multivariable model tested whether there was an overall cohort difference in the relationship between cognition and disability. We conducted a series of cross-sectional analyses with an interaction term for cohort by cognition. This tested whether cohort modified that relationship by looking at the cross-sectional relationship throughout the 4 observations. The results from the cross-sectional analyses are shown in table 3.2. The interaction term of cohort by cognition was not statistically significant (OR 1.03 [95% CI: 0.78, 1.35]). Thus, cohort did not modify the overall relationship between cognition and disability over our 10-year study period. However, the main effects for cohort, cognition, and time all demonstrated substantial and statistically significant independent associations with ADL disability. The newer cohort had 2.21 higher odds of having disability compared to the original cohort. Those with impaired cognition had two times higher odds of disability compared to those with intact/normal cognition. Regarding time, our results indicate that each wave was associated with 65% higher odds of ADL disability.

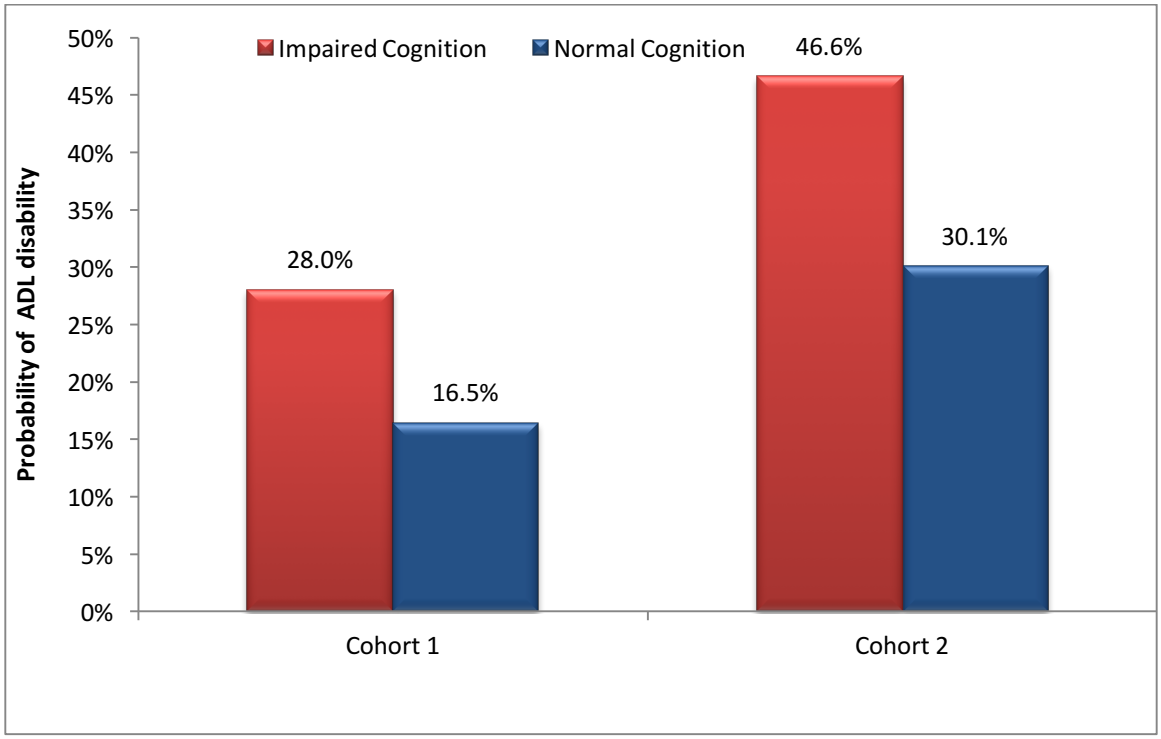
Table 3.2 Model 1: Cross-sectional series of cognition and cohort on ADL disability.

	Step 1	Step 2
Variables	OR (95% CI)	OR (95% CI)
Cohort 2 (Cohort 1)	**2.18 (1.76, 2.72)**	**2.21 (1.87, 2.62)**
Impaired Cognition (Normal)	**1.98 (1.58, 2.47)**	**2.01 (1.75, 2.32)**
Time	**1.65 (1.55, 1.75)**	**1.65 (1.55, 1.75)**
Cohort 2 * Impaired Cognition	1.03 (0.78, 1.35)	

Socio-demographic and medical variables controlled for: age, sex, education, marital status, body mass index, smoking status, diabetes, heart attack, stroke, high blood pressure, hip fracture, arthritis, and negative emotion
(Reference group shown in parentheses)

Figure 3.3 is an illustration of the probability estimates for developing ADL disability comparing impaired and normal cognition between cohorts. While the interaction term is not significant ($p = 0.58$), this figure demonstrates the difference in ADL prevalence by cohort and cognitive function. Those in the newer cohort have a much higher prevalence of disability than those in the original cohort. Similarly, those with impaired cognition have much higher disability than those with normal/intact cognition.

Figure 3.3 Probability estimates from the cross-sectional relationship between cognition, cohort, and disability.



The next two models used GEE modeling to look at the modifying effect of cohort on the relationship between cognition and disability in two different ways. Model 2, shown in table 3.3, excluded individuals with disability at baseline and used baseline cognition as an interaction term with cohort to predict incident ADL disability over time. The three-way

interaction term, cohort-by-cognition-by-time, was not statistically significant (OR 0.92 [95% CI 0.70, 1.21]). Thus, cohort did not modify the effect of baseline cognition on incident disability over time.

The next step removed the three-way interaction and examined the three separate interaction terms of cohort-by-cognition, cohort-by-time, and cognition-by-time. Cohort-by-cognition was not statistically significant (OR 0.86 [95% CI 0.56, 1.33]). Thus, cohort did not modify the relationship between baseline cognition and incident disability. We then removed that interaction term, i.e., cohort-by-cognition, and ran the last step of the main effects plus two interaction terms, i.e., cohort-by-time and cognition-by-time. In this model, cohort, time, and cognition-by-time were statistically significant.

Table 3.3. Model 2: Baseline cognition and cohort examining incident disability over time

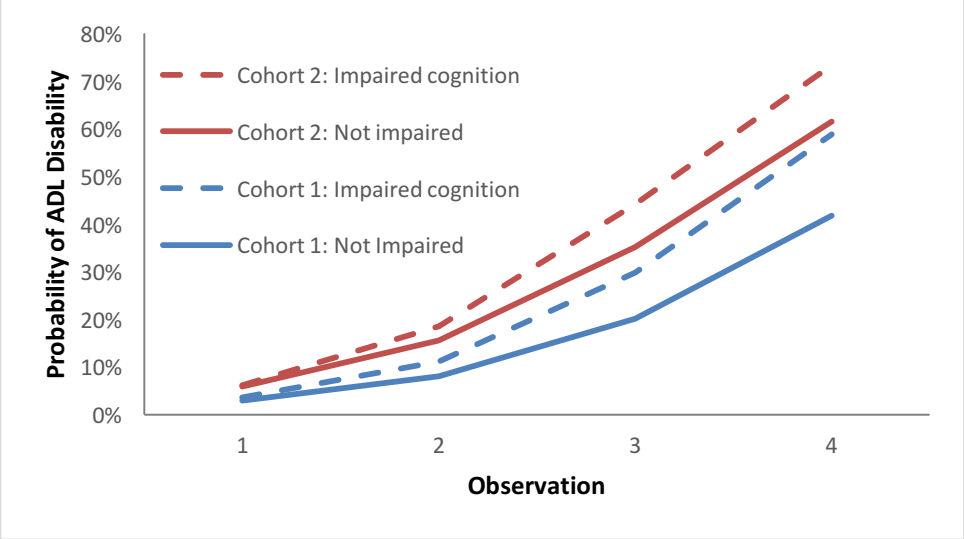
	Step 1	Step 2	Step 3
Variables	OR (95% CI)	OR (95% CI)	OR (95% CI)
Cohort 2 (Cohort 1)	**1.85 (1.22, 2.80)**	**1.97 (1.35, 2.89)**	**1.86 (1.32, 2.61)**
Impaired Cognition (Normal)	0.88 (0.48, 1.60)	1.02 (0.64, 1.62)	0.91 (0.64, 1.28)
Time	**2.81 (2.52, 3.12)**	**2.85 (2.58, 3.15)**	**2.83 (2.57, 3.12)**
Impaired Cognition * Time	**1.25 (1.00, 1.55)**	**1.18 (1.04, 1.35)**	**1.19 (1.05, 1.36)**
Cohort 2 * Time	1.05 (0.92, 1.21)	1.03 (0.92, 1.16)	1.04 (0.92, 1.17)
Cohort 2 * Impaired Cognition	1.08 (0.52, 2.21)	0.86 (0.56, 1.33)	
Cohort 2 *Impaired Cognition*Time	0.92 (0.70, 1.21)		

Socio-demographic and medical variables controlled for: age, sex, education, marital status, body mass index, smoking status, diabetes, heart attack, stroke, high blood pressure, hip fracture, arthritis, and negative emotion
(Reference group in parentheses)

Figure 3.4 provides a visual representation of the results from the final step in model 2. While the interaction of cohort-by-cognition-by-time was not significant ($p = 0.50$), meaning that cohort did not modify this relationship over time, the figure demonstrates the independent effects of both cohort and cognition on ADL disability over time. The figure

clearly demonstrates that despite the increased risk of disability from cognitive impairment, being in the newer cohort was a stronger risk for ADL disability. Participants in the older cohort with impaired cognition had lower odds of disability than participants in the newer cohort with intact cognition.

Figure 3.4 Probability estimates of ADL disability from longitudinal model



The final model used time varying variables to look at a series of predictive relationships. Cognition from observation 1 was included with disability from observation 2, cognition from observation 2 was included with disability from observation 3, and cognition from observation 3 was included with disability from observation 4. Step one included an interaction term for cohort-by-cognition. This interaction term was not significant (OR 1.23 [95% CI 0.89, 1.69]). Thus, cohort did not modify the relationship between cognition and ADL disability at subsequent waves.

This interaction term of cohort by cognition was then removed and the final step included the main variables while controlling for sociodemographic and medical

covariates. In this model cohort, cognition, and time were all significant predictors of disability (see Table 3.4). Individuals in the newer cohort had 2.32 times higher odds of developing incident ADL disability than those in the original cohort. Those with impaired cognition had 75% higher odds of developing incident ADL disability than those with intact cognition. Lastly, with each observation individuals had 53% higher odds of developing ADL disability.

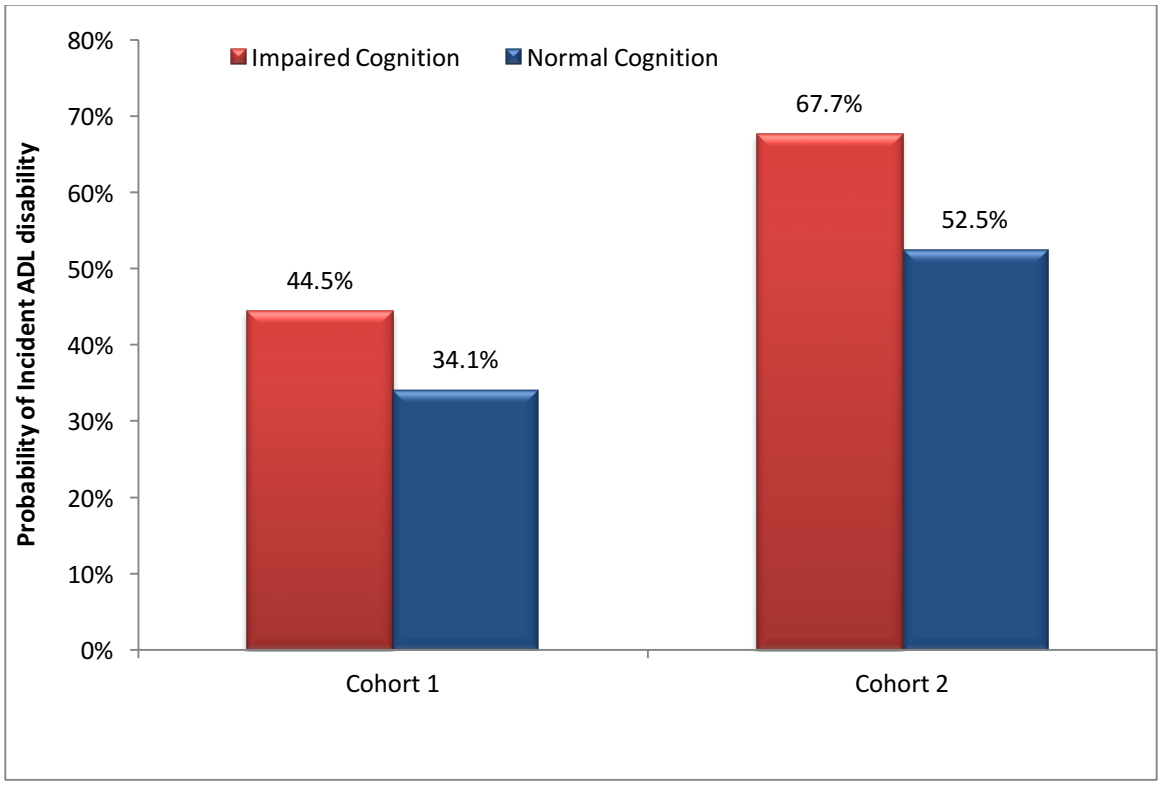
Table 3.4 Model 3: Predictive Series of time varying cognition and cohort on incident disability

	Step 1	Step 2
Variables	OR (95% CI)	OR (95% CI)
Cohort 2 (Cohort 1)	**2.13 (1.71, 2.67)**	**2.32 (1.93, 2.79)**
Impaired Cognition (Normal)	**1.55 (1.21, 1.97)**	**1.75 (1.48, 2.06)**
Time	**1.54 (1.42, 1.68)**	**1.53 (1.41, 1.66)**
Cohort 2* Impaired Cognition	1.23 (0.89, 1.69)	

Socio-demographic and medical variables controlled for: age, sex, education, marital status, body mass index, smoking status, diabetes, heart attack, stroke, high blood pressure, hip fracture, arthritis, and negative emotion
(Reference group is in parentheses)

Figure 3.5 plots out the probability estimates of developing incident disability as predicted by the cognitive status from the prior observation. Our data consistently showed that while cohort does not significantly modify the relationship between cognition and disability – whether cross-sectionally, from baseline over time, or with time dependent variables predicting subsequent disability ($p = 0.21$) – cohort and cognition both demonstrate strong independent associations with probability of developing incident disability.

Figure 3.5 Probability estimates of incident ADL disability in predictive series



DISCUSSION

We hypothesized that we would find a significant difference between cohorts in the relationship between cognition and disability. A recent report demonstrated that newer cohorts of Mexican Americans have a higher prevalence of disability, yet no difference in cognitive status compared to older cohort. Research suggests that cognition may lead to disability through behavioral mechanisms; e.g., those with cognitive impairment are less likely to be active and maintain physical function.[44] Cohort effects arise as the interaction of age and period[37]; we theorized that the cohort effect of increased disability may be resulting from cognitive impairment having a stronger effect due to the period in which the second cohort lived. While we did not find a modifying cohort effect on the relationship between cognition and disability, we did find significant differences between cohorts. The

second cohort of Mexican American older adults have significantly higher odds of developing incident ability, compared to the first cohort. Every way we analyzed the data; as a series of cross-sectional analyses, from baseline predicting incident disability over time, and in a series of predictive models predicting incident disability at the subsequent observation, those in the newer cohort were approximately 2 times as likely to have a disability or develop incident disability.

Similarly, cognitive impairment was a strong predictor of disability as well. The first and third model showed that time varying cognitive impairment increases the odds of disability by roughly two times. However, in the second model, using baseline cognitive impairment, cognitive impairment alone was not significant. However, the interaction of baseline cognitive impairment by time was a statistically significant predictor. Meaning for those with a cognitive impairment, with each successive observation they had higher odds of developing disability than those without a cognitive impairment.

Descriptive analyses of sociodemographic variables and comorbidities found the newer cohort to be more likely to have high blood pressure; high BMI; history of stroke, diabetes, and arthritis; been born in the U.S.; be smokers; and complete their interviews independently. The newer cohort also had more years of education. We therefore controlled for all of these variables in every model. These findings are consistent with previously published research by Beard et al.[81]

Our cohort findings fall in line with previous research, which has found adults in newer cohorts have a higher prevalence of poor health conditions such as depression, obesity, and diabetes.[5,38,40] Beard et al. found that in older Mexican Americans with diabetes, the newer cohort had a 12.5% higher prevalence of disability compared to the

older cohort.[5] Our sample was not diagnosis specific, and still found similar results. Approximately 48% of the newer cohort developing disability over 10 years, compared to only 33% in the original cohort ($p < 0.001$). These findings are not universal, however. In a study of European adults 70 years and older, ADL difficulty has steadily declined across newer cohorts.[41]

Regarding cognitive impairment differences between cohorts, our results differ from one recent report. Beard and colleagues' research found no difference between cohorts in prevalence of cognitive impairment.[81] We found cognitive impairment to be significantly higher in the newer cohort, 34% compared to 27% ($p < 0.001$). It is possible this discrepancy is due to sample differences. Both studies used Hispanic EPESE data; however, our study had more participants in the newer cohort as we allowed participants to age into this group. In regards to cognitive impairment predicting incident ADL disability, however, our study matches the results of those by Gill et al, Berlau et al, and many others.[29,74] Both studies used MMSE to measure cognitive impairment among older adults and found those with cognitive impairment to have approximately 2 times higher odds of incident ADL disability than those without cognitive impairment.

While the definitive mechanism behind the relationship between cognitive impairment and ADL disability is still unclear,[75] a few suggestions have been made. Raji et al. suggested that impaired cognition may make an individual less likely to engage in physical activities and therefore lose muscle strength, impeding the ability to independently complete activities of daily living.[8] Doi et al. suggested that age related changes in the brain, such as brain atrophy and ventricular enlargement, may be presenting as cognitive impairment before progressing into deterioration of physical abilities.[62] Another possible

mechanism is that cognitive impairment and physical decline share pathogenic factors, such as interleukin-6, which is a pro-inflammatory cytokine, and low steroids. Making cognitive impairment an indicator of underlying or impending disease.[2,8,36] Lastly, low cognition may impede the ability to recognize symptoms from illnesses, which may delay seeking medical care or may affect one's compliance.[36]

We found that the newer cohort had more disease, cognitive impairment, and disability than the original cohort. Indicating that while the prevalence of cognitive and physical impairment may differ by cohort, the strength of that relationship is not minimized in the newer cohort. Despite all of the increases in diabetes, hypertension, and related risk factors for ADL disability among newer cohorts of Hispanics, cognitive impairment is still a significant risk factor for ADL disability and the strength of that significance does not change across cohorts.

LIMITATIONS

This study has several limitations. First, the assessment of the main outcome, disability, as well as several covariates are by self-report. Self-report may potentially lead to recall or response bias. While clinical assessment might result in more precise diagnosis, the use of self-report for medical variables has been found to be reliable in several studies.[93,94] Second, by assessing disability as the need for assistance with any one ADL it is possible to show an inflated prevalence of disability. However, by repeatedly assessing disability over a 10-year period, our approach allows for opportunities to evaluate if recovery from disability is a relevant factor and then will include this information in the analyses. Third, the use of MMSE to assess cognitive function in minority groups has been

shown to misdiagnose cognitive decline in older Hispanics.[90] To account for this, our study used an alternative cut point for MMSE that has been found to be more suitable for older Mexican Americans.[86] Attrition, due to death or loss to follow-up, is another serious limitation of all longitudinal studies. To account for this, we used GEE modeling and all participants remained in the study until their last interview date. Lastly, recent publications have argued that there are more sophisticated, and perhaps more sensitive, ways of studying cohort effects.[37,95] As our research question was to assess if cohort had a modifying effect on the relationship between cognition and disability, we chose a clean approach using GEE with clear interaction terms for our analyses. More sophisticated methods may allow for including aspects of the period to get a fuller view of the cohort differences.

CONCLUSION

Recent trends in healthcare demonstrate cohort differences in several negative health outcomes, such as disability. Our research tested if this increase in disability could be due to changes in how newer cohorts react to risk factors, such as cognition. We did not find this to be statistically significant in our study, possibly due to the analyses chosen; future research should investigate this difference with more sophisticated measures. We did find that newer cohorts are more likely to become disabled compared to older cohorts. As the proportion of older adults in our population is increasing, it is imperative that we understand factors influencing the trend of disability prevalence. Identifying factors that are creating this discrepancy in health outcomes for our current and future generations of older adults will increase their independence and quality of life, while decreasing the burden of costs associated with disability.

Our study also showed that cognitive impairment plays a substantial role in predicting incident ADL disability. These results should be a call to action to researchers

and clinicians alike. Future research is needed on the best approach to maintain cognitive health among older adults and on interventions for regaining cognitive function once signs of impairment arise. Close monitoring of cognitive status by clinicians should also be implemented, as cognitive impairment may be a warning sign of impending disability. Clinicians may then be able to prescribe appropriate care to slow down the onset or progression of disability.

CHAPTER 4. THE EFFECT OF POSITIVE EMOTION ON THE RELATIONSHIP BETWEEN COGNITION AND DISABILITY IN OLDER MEXICAN AMERICANS

INTRODUCTION

Positive emotion plays a role in both prevention and recovery across a variety of illnesses, injuries, and age groups.[44] Positive emotion may even ameliorate the negative impact of cognitive impairment,[96] which is positively associated disability among older adults.[58,77] As Mexican Americans are more susceptible to disability and cognitive impairment than non-Hispanic Whites,[21,97] it is important to understand if it's possible for positive emotion to modify the relationship between cognition and incident disability among older Mexican Americans.

Over the past few decades there has been a proliferation of research examining the role of emotions on physical health and recovery. Positive emotions, described by characteristics such as joy, hopefulness, energy, and humor, are associated with increased longevity for both healthy and diseased populations.[13,14] Positive emotion is significantly associated with better health outcomes for individuals with cancer, kidney failure, coronary disease, and HIV.[14,44,98] Further benefits of positive emotion include enhanced pain management and decreased anxiety, cortisol output, hypertension, and risk of disability.[1,11,44] Thus, positive emotion may also be considered a protective factor.

Many of the benefits listed above, such as decreased hypertension and risk of disability, were found among older adults.[1,11] Furthermore, in a study by Ostir et al, positive emotion in older adults significantly reduced the risk of frailty[97] and in a study by Xu and Roberts, positive emotion (described as subjective well-being and positive feelings)

predicted a lower risk of mortality when following adults aged 55 years and older for 28 years.[99] These findings are important given the current aging shift in the United States.

Due to improvements in healthcare, we are seeing an increase in the number of adults aged 65 years and older, henceforth referred to as older adults, throughout the world.[6] The United States has experienced growth from 35 million older adults in 2000[16] to projections of 74 million by 2030.[15] For Hispanic Americans, there were approximately 300 thousand older adults in 2012 and growth is projected to be 800 thousand in 2030 and 1.5 million in 2050.[17] It is important to gain a better understanding of the Hispanic population, especially in regards to health needs of older Hispanics.

Mexican Americans have a higher prevalence of impaired cognition, diabetes, cardiometabolic conditions, infectious diseases, and obesity compared to non-Hispanic White Americans.[7,20,21,97] Furthermore, Mexican Americans are more likely to be living in poverty and less likely to have access to healthcare than non-Hispanic Whites.[97,100,101] These contributing factors lead to Mexican Americans being susceptible to poor physical functioning and disability.[9,54]

It is important, therefore, to identify factors that may increase or decrease the progression of disability among older Mexican Americans. Recent studies have demonstrated the role of positive emotion in ameliorating the risk of incident disability among older Mexican Americans with arthritis, despite arthritis being a significant risk factor for disability.[1] Conversely, studies have found cognitive impairment to increase the odds of developing disability in older Hispanic and Mexican Americans.[2,8,58] Raji et al. found older Mexican Americans with impaired cognition had a 58% higher chance for disability compared to those with normal cognition.

Previous research has examined the relationship between positive emotion and cognition. However, there are no studies investigating how positive emotion may interact with cognition to modify the relationship with disability in the general population nor among older Mexican Americans. We examined the interaction between positive emotion and cognition on risk of incident disability in a large sample of community-dwelling older Mexican Americans. We hypothesized that positive emotion would modify the relationship between cognition and incident disability in activities of daily living. The findings of this study will provide important evidence to guide future research and clinical decisions to ameliorate one of the substantial risk factors for disability.

METHODS

POPULATION

This study used data from the Hispanic Established Populations for the Epidemiologic Studies of the Elderly (Hispanic EPESE). The Hispanic EPESE is a multistage, stratified sample representative of community-dwelling Mexican-American elderly, at least 65 years of age, and living in five southwestern states: Arizona, California, Colorado, New Mexico, and Texas. The Hispanic EPESE data was collected over 8 waves from 1993/94 to 2012/13. In the 5th wave, 902 participants aged 75 years and older were added to the sample in wave 5 (2004/05). Information on sampling and data collection was gathered from the National Archive of Computerized Data on Aging (NACDA), Inter-university Consortium for Political and Social Research, as well as from other articles published already.[84] Information on the sampling process has been published elsewhere.[1,83] This research used the publicly available waves 1-8, downloaded from the NACDA

website.

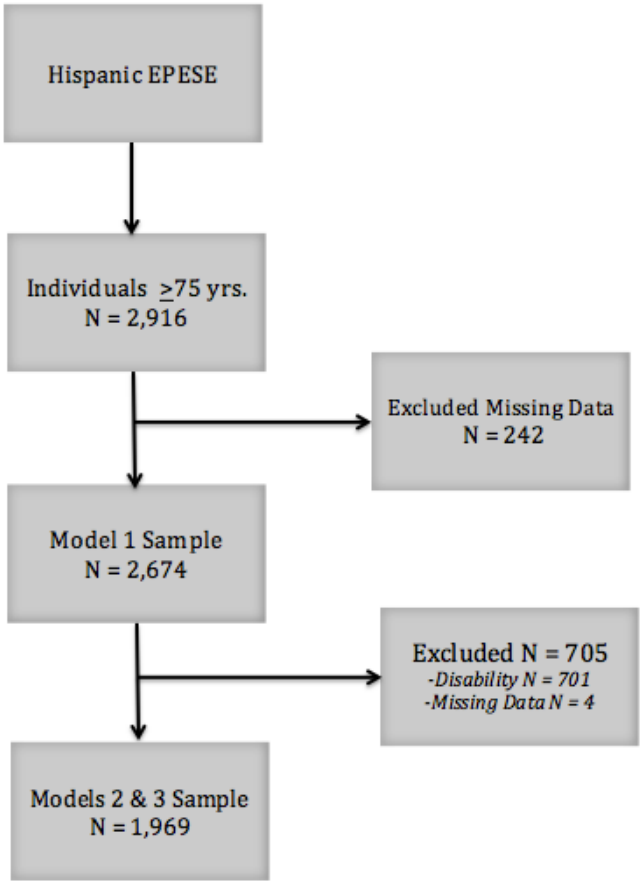
Inclusion/Exclusion Criteria

Adults 75 years and older were included in our study. Individuals missing data on cognition, positive emotion, or disability in all observations were excluded. This sample was used for the first analysis model. Then, in order to study incident disability, individuals with ADL disability at baseline were also excluded.

Initially, there were 2,916 adults aged 75 years and older. This included 1,132 participants aged 75 and older at Wave 1 and 1,784 participants aged 75 and older at Wave 5.After excluding those missing all four observations of disability, cognition, or positive emotion (N 242) there were 2,674 participants included in the sample for model 1. Next, in order to study incident disability, those with disability at baseline (N = 701) and missing all baseline observation of any key variables (N = 4) there was a total of 1,969 participants in the final sample used for models 2 and 3. Figure 4.1 illustrates the sample selection process.

Compared to those included, those excluded from the study had more participants who were: older; females; cognitively impaired; married; non-smokers; had history of a heart attack, high blood pressure, hip fracture, stroke, diabetes, and arthritis; required a proxy or proxy assistance to complete the interview; had higher BMI and negative emotion; and had less positive emotion and education. All differences were statistically significant $p < 0.001$.

Figure 4.1 Sample selection from Hispanic EPESE Data



MEASURES

Disability

Disability was assessed using self-reported answers to questions regarding Activities of Daily Living (ADL). The Hispanic EPESE data uses a modified 7-item version of the Katz ADL scale, which has been used frequently with older Hispanic adults.[1,8,81] Participations were asked about their ability to walk across a small room, bath, brush their teeth, dress, eat, transfer from a bed to a chair, and use the toilet. Participants

are asked if they are able to complete each task independently without help, if they need help to complete the activity, or if they cannot complete activity at all. Disability was dichotomized as "yes" or "no." A "no" meant they were able to perform all ADLs without help versus a yes meant they needed help with or were unable to complete any one or more of the seven ADLs. Disability was assessed at baseline and was continually monitored across the successive waves.

Cognition

The Mini Mental State Exam (MMSE) was used to assess cognition. The MMSE is the most common measurement tool used for studies on cognitive aging.[85–87] The MMSE assesses several functions of cognition over 19 items, such as: attention, memory, orientation, and language. Versions were available in both English and Spanish to suit the individual's needs.[88] The MMSE score is a continuous variable with possible scores ranging from 0 to 30, and we dichotomized it as poor/low cognitive function ($\leq$ 21) and normal/high cognitive function (>21).[89,90] This dichotomy score is standard when using the MMSE among aging populations with low levels of education[8] and it has been validated for classifying impaired cognition in older Mexican Americans.[86] Cognition was assessed at baseline and each follow-up wave and was included as both a baseline measure and a time variant variable.

Positive Emotion

Positive emotion summary score was created from the four items relating to positivity in the Center for Epidemiologic Studies Depression Scale (CES-D).[102] The four statements are: "I felt that I was just as good as other people", "I felt hopeful about the future", "I was happy", and "I enjoyed life." Participants rated their response to statements from 0 ("rarely or none of the time") to 3 ("most or all of the time"). The score for this scale was created by adding the scores from the responses of the four items: range = 0-12. Higher scores indicate higher positive affect. This is the measure used in many studies investigating positive emotion within this population and has high internal consistency (alpha = 0.80) and is weakly correlated (r = - 0.25) with the remaining 16 items on negative emotions.[1,97] Positive emotion was included as a continuous variable in the analyses.

Covariates

Socio-demographic and medical characteristics were included and controlled for in this study. These variables included age, sex marital status, and years of education, arthritis, diabetes mellitus, heart attack, hypertension, stroke, body mass index (BMI), negative emotion,[89,91] and smoking status. Our study included age, BMI, education, and depression score as continuous variables. Marital status was dichotomized as married or not married. Not married incorporated those not married, divorced, or widowed. Participants were asked if a doctor ever told them they had arthritis, diabetes, heart attach, hypertension, or stroke; the answers were all dichotomous yes or no. Sex was also dichotomized as male or female. Negative emotion was calculated by totaling the remaining items of the CES-D after removing the 4 items pertaining to positive emotion.[51]

STATISTICAL ANALYSIS

Descriptive characteristics and comorbidities were examined at baseline for the final sample used for Models 2 and 3 (see figure 4.1). Those who never became disabled were compared to those who eventually became disabled. Additionally, those included and those excluded from the study were also compared to each other. We used t-tests for continuous variables and chi-square contingency tables for categorical variables.

To test the modifying effect of positive emotion on the relationship between cognition and disability, we used a series of General Estimating Equations (GEE) models. GEE is appropriate for longitudinal data as it provides dependable estimators of the regression coefficients and of variances under weak assumptions in respect to the correlation between repeated observations of subjects.[87] Because GEE modeling is useful for unbalanced data, as it uses means, variance, and covariance to make assumptions, participants with missing information were included in the study until their last interview date.[92] The paragraphs below explain the differences in each of the three models we used. All of the demographic and medical covariates described above were controlled for in all models.

In model 1 cognition and ADL disability scores were included as time-varying variables. The data were structured to conduct a series of cross-sectional analyses and provides an overall association between cognitive impairment and ADL disability. The interaction term for positive emotion-by-cognition was included to determine if positive emotion had a modifying effect on the overall relationship between cognitive functioning and disability prevalence.

Next, for models 2 and 3, individuals with disability at baseline were excluded from

the sample. Model 2 assessed if baseline positive emotion had a moderating effect on the relationship between baseline cognition and incident disability over time. Step 1 included a 3-way interaction for positive emotion-by-cohort-by-time, as well as each of the 3 paired combinations: cognition-by-positive emotion, cognition-by-time, and positive emotion-by-time. Non-significant interaction terms were removed; however, cognition-by-time and positive emotion-by-time interaction terms were kept in the model, regardless of significance level as our focus was on incident disability over time.

For model 3 the data were restructured to conduct a longitudinal analysis of the moderating effect of positive emotion on the relationship between cognition and incident disability by the next observation. We excluded disability at baseline and aligned cognition scores from each wave with ADL disability status from the subsequent wave; i.e., baseline cognition predicted disability at the 2nd observation, 2nd observation of cognition predicted disability at the 3rd observation, and so on. This model also included an interaction term for positive emotion-by-cognition.

The culmination of these three models provided us with a comprehensive view of how positive emotion interacts with cognition and disability in older Mexican Americans. All analyses were two-tailed with $p < 0.05$ and performed using IBM SPSS 23.

RESULTS

Table 4.1 compares population characteristics between individuals who never became ADL disabled to those who did experience incident ADL disability. Those who experience incident ADL disability, compared to those who remained disability free, were more likely to be older, female, and cognitively impaired; have a history of hip fracture, diabetes, and arthritis; and have higher BMI and less education. There were no statistically

significant differences in marital status or smoking status; history of heart attack, high blood pressure, or stroke; who completed the survey; or positive or negative emotion.

Table 4.1 Descriptive characteristics of the final sample

	Included			
	No Disability	Disability	Total	P
N	1141	828	1969	
Cognitively Impaired	27.78%	33.82%	30.32%	<0.01
Male	47.24%	35.75%	42.41%	<0.001
Married	53.02%	54.71%	53.73%	0.379
Smoker/Former Smoker	46.45%	44.20%	45.51%	0.611
Heart attack	12.18%	12.92%	12.49%	0.880
Blood pressure	51.71%	54.47%	52.87%	0.429
Hip fracture	3.42%	5.80%	4.42%	<0.05
Stroke	6.92%	8.45%	7.57%	0.220
Diabetes	25.24%	29.95%	27.22%	<0.05
Arthritis				<0.001
Yes	40.75%	53.38%	46.06%	
No	58.11%	44.81%	52.51%	
Completed by participant	95.09%	95.05%	95.07%	0.978
Re-interviewed				*<0.001*
Observation 2	70.55%	95.29%	81.06%	
Observation 3	49.87%	81.04%	62.98%	
Observation 3	38.39%	71.56%	47.13%	
Mean (SD)				
Age	79.82 (4.07)	80.38 (3.68)	80.05 (3.92)	<0.01
Education	5.2 (4.08)	4.61 (3.9)	4.95 (4.02)	<0.001
BMI	26.84 (4.56)	27.33 (4.86)	27.04 (4.69)	<0.05
Cognition	23.96 (4.66)	23.03 (4.68)	23.57 (4.69)	<0.001
Positive Emotion	9.46 (2.95)	9.52 (2.83)	9.48 (2.90)	0.642
Negative Emotion	5.91 (6.87)	6.44 (7.19)	6.13 (7.01)	0.103

First we tested if positive emotion modified the relationship between impaired cognition and disability prevalence. Model 1, shown in table 4.2, included a series of cross-sectional analyses using the interaction term of cognition by positive emotion. This tested the overall association between the cognition-by-positive emotion interaction term and concurrent disability across the 4 observations. In this model, impaired cognition, positive

emotion, time, and the interaction between cognition and positive emotion were all statistically significant.

The largest predictive factor for disability was impaired cognition, demonstrating 2.73 higher odds of having disability than those without impaired cognition. Time was the next largest predictor of disability, with each subsequent wave increasing the odds by 49%. Positive emotion was protective against disability, with each unit increase in positive emotion decreasing the odds of disability by 11%. Lastly, we found that positive emotion did modify the overall relationship between impaired cognition and disability (OR 0.95, 95% CI: 0.90, 0.99).

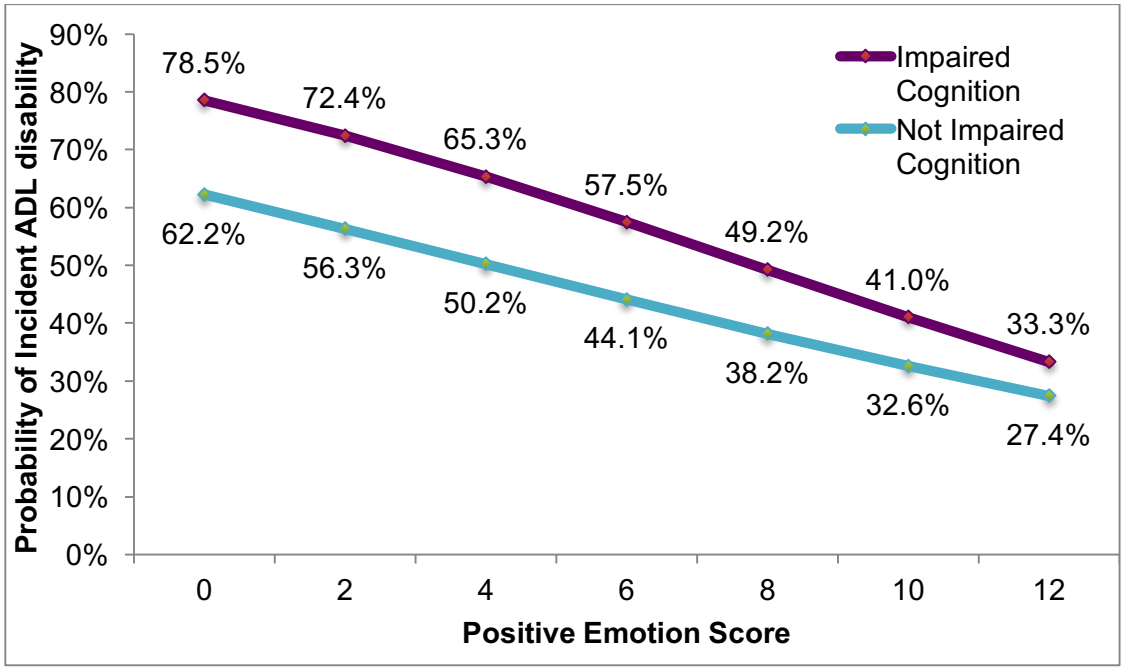
Table 4.2 Model 1: Cross-sectional series of cognition and positive emotion on ADL disability.

Variables	OR (95% CI)
Impaired Cognition (Not impaired cognition)	**2.72 (1.74, 4.27)**
Positive Emotion	**0.89 (0.86, 0.92)**
Time	**1.49 (1.40, 1.59)**
Impaired Cognition * Positive Emotion	**0.95 (0.90, 0.99)**

Socio-demographic and medical variables controlled for: age, sex, education, marital status, body mass index, smoking status, diabetes, heart attack, stroke, high blood pressure, hip fracture, arthritis, and negative emotion.
(Reference group in parentheses)

The modifying effect of positive emotion is graphed in figure 4.3. This illustration clearly shows that individuals with impaired cognition always have higher probabilities of ADL disability. However, as positive emotion increases, the overall disability risk as well as the difference in risk between impaired cognition and not impaired cognition decreases considerably.

Figure 4.2. Probability estimates from the cross-sectional relationship between cognition, positive emotion, and disability.



We next examined the effect of positive emotion as a modifier between cognition and incident disability over time. To do this, we excluded individuals with disability at baseline for models 2 and 3. These two models used GEE modeling to assess the modifying effect of positive emotion in two distinct ways. Model 2 used an interaction term of baseline cognition with baseline positive emotion scores to predict incident ADL disability over time. Table 4.3 shows the steps taken for model 2. Step 1 included a three-way interaction term for cohort-by-cognition-by-time, but it was not statistically significant (OR 1.02 [95% CI 0.97, 1.06]). Baseline positive emotion did not modify the effect of baseline cognition on incident disability over time.

In step 2, we removed the three-way interaction and examined the three separate interaction terms: cognition-by-positive emotion, positive emotion-by-time, and cognition-

by-time. Cognition-by-positive emotion was not statistically significant (OR 1.05 [95% CI 0.97, 1.13]). Baseline positive emotion did not modify the relationship of baseline cognition on incident disability. This interaction term was removed in step 3, which included the main effects plus the two remaining interaction terms, as outlined in table 4.3. In this model only time and cognition-by- time were statistically significant.

Neither baseline cognition nor positive emotion was a statistically significant predictor of incident disability and when interacted with time, only cognition remained a significant predictor. With each successive observation, participants had 2.68 times higher odds of developing incident ADL disability and individuals with impaired cognition had an additional 17% higher odds of developing incident disability with each successive observation, compared to those without impaired cognition.

Table 4.3 Model 2: Baseline cognition and positive emotion predicting incident disability over time

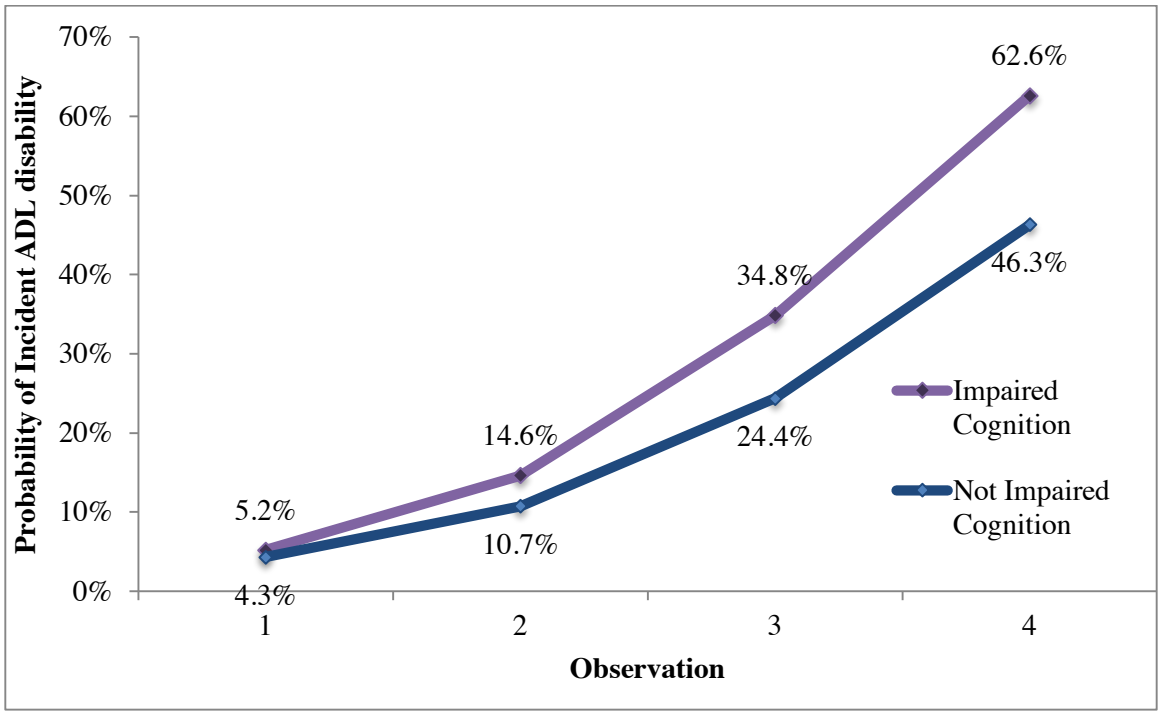
Variables	**Step 1** OR (95% CI)	**Step 2** OR (95% CI)	**Step 3** OR (95% CI)
Impaired Cognition	1.00 (0.31, 3.22)	0.69 (0.31, 1.51)	1.04 (0.74, 1.47)
Positive Emotion	0.99 (0.93, 1.06)	0.98 (0.92, 1.04)	1.00 (0.95, 1.06)
Time	**2.72 (2.17, 3.42)**	**2.62 (2.14, 3.21)**	**2.68 (2.18, 3.29)**
Positive Emotion * Time	1.00 (0.98, 1.03)	1.01 (0.99, 1.03)	1.01 (0.99, 1.03)
Cognition * Time	1.01 (0.64, 1.61)	**1.17 (1.02, 1.33)**	**1.17 (1.02, 1.33)**
Cognition * Positive Emotion	1.00 (0.89, 1.13)	1.05 (0.97, 1.13)	
Cognition*Positive Emotion*Time	1.02 (0.97, 1.06)		

Socio-demographic and medical variables controlled for: age, sex, education, marital status, body mass index, smoking status, diabetes, heart attack, stroke, high blood pressure, hip fracture, arthritis, and negative emotion

Figure 4.3 illustrates how cognition and positive emotion impact the probability of developing incident ADL disability. Individuals with impaired cognition have a higher

probability of incident ADL disability across all four observations and the difference increases over time.

Figure 4.3. Probability estimates of incident ADL disability over time



Our third and final model looked at a series of predictive relationship by incorporating time varying variables (See table 4.4). To do this, the data were restructured such that cognition and positive emotion from observation 1 were used with the disability measure from observation 2, and cognition and positive emotion from observation 2 were included with the disability measure from observation 3, and so on for each observation. An interaction term of cognition-by-positive emotion was included in the first step. This interaction term was not significant (OR 1.01 [95% CI: 0.95, 1.07]). Positive emotion did

not modify the relationship between cognition and incident ADL disability at the subsequent wave.

The interaction term of cognition-by-position emotion was removed and the final step included the main variables while controlling for socio-demographic and medical covariates. Cognition, positive emotion, and time were all significant predictors of incident ADL disability. Individuals with impaired cognition had 57% higher odds of developing incident ADL disability than those with intact cognition. Positive emotion had a strong protective relationship against incident ADL disability, with each unit increase in positive emotion decreasing the odds of developing ADL disability by 5%. Lastly, with each observation participants' odds of developing incident disability increased by 66%.

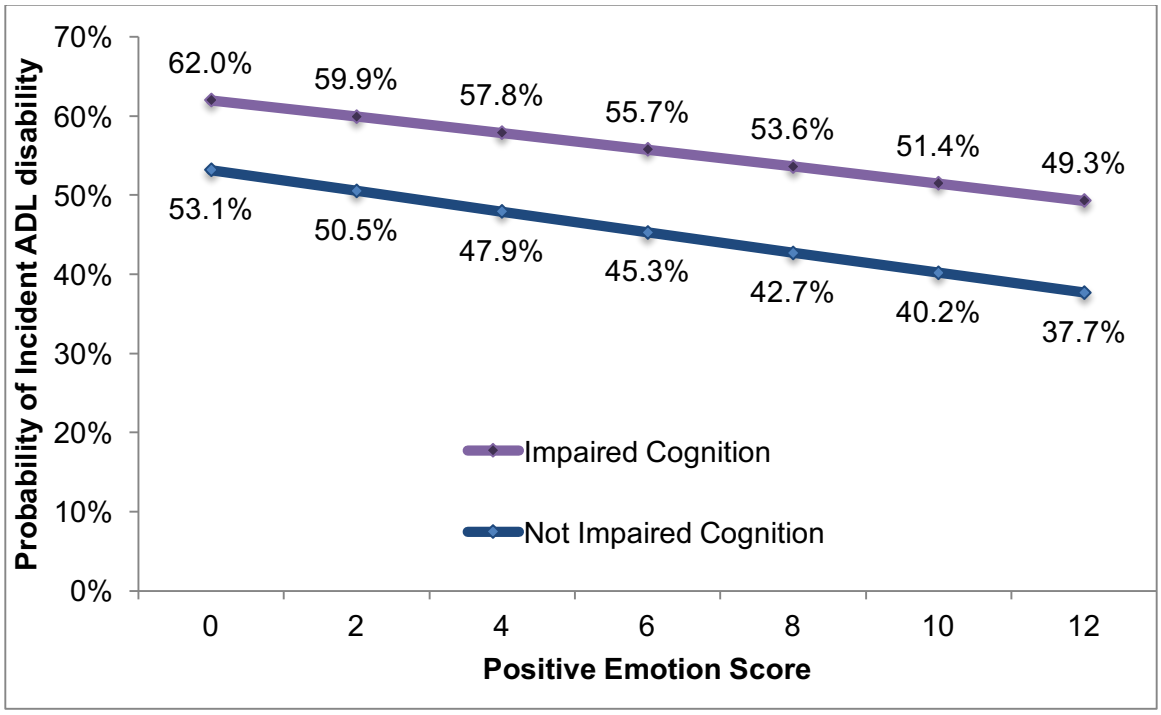
Table 4.4 Model 3: Predictive Series of time varying cognition and positive emotion on incident disability

	Step 1	**Step 2**
Variables	OR (95% CI)	OR (95% CI)
Impaired Cognition	1.44 (0.79, 2.61)	**1.57 (1.30, 1.90)**
Positive Emotion	**0.95 (0.91, 0.99)**	**0.95 (0.92, 0.98)**
Time	**1.66 (1.51, 1.82)**	**1.66 (1.51, 1.82)**
Impaired Cognition * Positive Emotion	1.01 (0.95, 1.07)	

Socio-demographic and medical variables controlled for: age, sex, education, marital status, body mass index, smoking status, diabetes, heart attack, stroke, high blood pressure, hip fracture, arthritis, and negative emotion.

The main effects of model 3 step 2 are plotted in figure 4.4. Consistent with earlier models, we see that participants with impaired cognition have a higher probability of developing ADL disability compared to those without cognition impairment. For both groups, the higher the positive emotion score, the lower the probability of developing ADL disability is.

Figure 4.4 Probability estimates of incident ADL disability in predictive series



DISCUSSION

Our study examined the modifying effect of positive emotion on the relationship between cognition and disability. We hypothesized that positive emotion would be a statistically significant modifier, based on the similar mechanisms by which cognition and positive emotion alter disability. For both variables, research suggests there is a behavioral component[8,48,96] and a neurological/neurochemical component.[36,62,103–105] From a behavioral standpoint, impaired cognition may decrease an individual's desire to engage in physical activities to maintain strength needed for independence[8] and positive emotion may increase an individual's likelihood to be maintain an active lifestyle, despite impairments or disease.[48,106]

From a neurological standpoint, age related cognitive impairment is often related to, and proceeded by, structural changes in the brain.[107] Cognitive impairment then, may be an early indicator of neurologic deficits that may begin to affect physical function later on.[62] Common areas for atrophy include the hippocampus, prefrontal cortices, and ventricular enlargement.[62,107] A study Matsunaga et al. found that when participants were in a state of positive emotion, their brains were significantly more activated in many different regions, including the medial prefrontal cortex, the thalamus, the posterior cingulate cortex, the superior temporal gyrus, and the cerebellum.[103] Simultaneously, there was an increase in the concentration of dopamine, a neuotransmitter which plays an important role in neuroplasticity and functional and cogntive recovery.[103–105]

Positive emotion was a statistically significant modifier in our cross-sectional analysis of the relationship between cognition and disability. Specifically, the difference in probability for disability between those with and without cognitive impairment decreases as positive emotion scores increase. A lot has been written regarding positive emotion's ability to maintain health and facilitate recovery in young and old alike.[14,44,48,99] However, less information is available on positive emotion's relationship with cognitive status and nothing to our knowledge on the interaction of these two important variables on physical function. Ostir et al. investigated positive emotion's role in recovery from stroke post discharge from rehabilitation and found individuals with high positive emotion had higher cognitive status at follow-up compared to those with low positive emotion.[50] Santos et al. studied the impact of mood on cognitive performance among community dwelling individuals in Portugal. Their study found that positive emotion stimulated cognitive ability and was protective of cognitive decline over time.[96]

In the cross-sectional model we were simply looking at the co-occurrence of the three variables of interest. Positive emotion was not a significant modifier in the longitudinal analysis or the predictive series. It is possible this is due to the statistical approach selected. We chose GEE modeling due to is strengths in longitudinal analysis as it handles unbalanced data well and allows for time-dependent variables.[92] It would be interesting to see if other longitudinal analysis approaches, such as latent growth curve modeling,[108] led to similar conclusions. Latent growth curve modeling allows for multiple variables to be included as varying over time, which may result in better ability to capture the interaction of our dynamic variables on an individual's trajectory.[109]

The main effects of positive emotion were not significant in the longitudinal analysis, but were significant in the predictive series. Emotional state can be highly dynamic. Thus, when examining the association between baseline positive emotion and incident disability over 10 years, we undoubtedly missed fluctuations in participants' emotional state an any potential influence those changes may have had on disability onset. In our predictive series, positive emotion was significantly associated with disability onset at the next wave. As other studies that have demonstrated positive emotion as a protective factor for disability have had shorter follow up, such as 3 months[51] or 2 years[1], it stands to reason that positive emotion must be included as a time-varying variable or only used in shorter longitudinal studies.

Cognition was a significant predictor of disability in both the cross-sectional analysis and the predictive series. Cross-sectionally, impaired cognition was strongly associated with disability prevalence and increased the odds of ADL disability by nearly 3 times. In a prior cross-sectional analysis using older Mexican American's, Avila-Funes

and colleagues found a significant relationship with IADLs, but not with ADL disability.[7] It is possible that the size of our study (N = 1,969) compared to the prior research (N = 425) provided more statistical power for our findings. Furthermore, instead of being a single snapshot in time, our results showed the overall association of cross-sectional analyses over 4 observations, allowing for a more in-depth assessment. Consistent with prior research reviewed in chapter 2, the predictive series demonstrated that cognitive impairment was a significant predictor of incident ADL disability at the next observation.

In the longitudinal analysis, cognition-by-time was a significant predictor of disability, but the main effect of cognition was not. While a majority of the existing research has found a statistically significant relationship between baseline cognition and disability,[2,8,58,64] there have been some studies that mirror our results. Jagger, Spiers, and Arthur studied older adults over 11 years and found that MMSE at baseline was not significantly associated with incident ADL disability and found that using time-varying measures of the Information/Orientation (I/O) sub-test of the CAPE was. These inconsistencies emphasize the need for further research to delineate the appropriate way to study the relationship between cognitive impairment and incident disability.

To summarize, when cognition and positive emotion were allowed to be time varying they demonstrated a significant association with ADL prevalence and with predicting disability at the subsequent wave. However, main effects of baseline measures were not significant in predicting ADL disability over time. Impaired cognition increases risk of ADL disability and positive emotion decreases the risk of ADL disability. Lastly, in cross-sectional analyses, the relationship between impaired cognition and prevalence of ADL disability among older Mexican Americans.

LIMITATIONS

Our study has a few limitations. First, due to the design of our study we cannot show any causal relationships. Second, we used an over-simplified version of disability that was defined by activity only, without incorporating the environmental factors or the individual's ability to participate in life situations. By assessing disability as the need for assistance with any one ADL it is possible to show an inflated prevalence of disability. We repeatedly assessed disability at every observation, including in the models if participants recovered from ADL disability. Conversely, another limitation is that due to attrition from death or loss to follow-up, many participants became missing before a diagnosis of disability and were therefor included as never disabled. It is possible that during the 2-3 years between observations participants became disabled and declined rapidly resulting in institutionalization or even death.

CONCLUSION

Positive emotion and cognition largely influence the maintenance of health, the risk of developing disability, and the ability to recover. Whether this relationship is explained by their influence on behaviors, such as exercising regularly/remaining active, following medical advice, refraining from smoking and drinking, due to the neurological and biophysiologic responses, or a combination of the two - the two variables must be properly monitored and maintained. Future research must work on developing a better understanding of the influence of positive emotion on cognition and the outcomes improved by the interaction of the two. A better understanding will pave the way for generating interventions to increase positive emotion and delay cognitive impairment. This

work has the potential to sustain health, prevent disability, and enhance quality of life, which is necessary for populations such as older Mexican Americans who are pre-disposed to depression, chronic illness, and disability.

CHAPTER 5. DISCUSSION

Disability is associated with many adverse outcomes, such as depression, decreased quality of life, institutionalization, and death.[1,2,25] Rates of disability tend to increase as individuals age and the population of the United States is aging progressively. In the United States, Mexican Americans are the fastest growing population and the prevalence of older Hispanics is projected to more than double from 3 million in 2012 to 8 million in 2030.[17] Prior research has demonstrated that older Hispanic Americans have a higher prevalence of disability compared to non-Hispanic Whites[24] and that newer cohorts of Mexican Americans have a higher prevalence of disability compared to older cohorts.[5]

Understanding factors that play a role in the progression of disability in this population could potentially improve health outcomes for millions of older Mexican Americans in the coming years. To move forward with this research, we wanted to identify how disability and established risk factors (specifically cognition) are currently being measured in research, if cohort differences in disability rates could be due to changes in the relationship between cognition and disability, and if positive emotion modifies the relationship between cognition and disability. Specifically, our three aims to address these questions were as follows:

Aim 1. Conduct a systematic review of studies of the association between cognition and disability in adults, 65 years and older.

Aim 2. Determine if there is a cohort difference on the relationship between cognition and ADL disability among Mexican American Adults aged 75 years and older.

Aim 3. Determine if positive emotion modifies the relationship between cognition and ADL disability status over 10 years in Mexican American Adults aged 75 years and older.

We conducted the systematic review using PRISMA guidelines and included all articles that fit our inclusion/if they were electronically published by August 2016. We also conducted a series of GEE models using the Hispanic EPESE data to analyze cross-sectional relationships, longitudinal relationships from baseline over 10 years, and a series of predictive models that used prior observations to predict subsequent observations of incident disability.

Overall, we found cognition was a strong predictor of disability. While one study reported no significant findings,[72] the remaining manuscripts found one or more of their relationships significant. These findings remained significant across a variety of races and ethnicities. While there were certainly measures that were used frequently, such as the MMSE and ADL/IADL, there was not a consensus on appropriate cut-points or ways to include these measures (i.e., frequency of measure, dichotomized or quartiled). While some studies had justification for their cut-point, this was not found consistently and they're justifications varied as well. For example, Raji et al. stated a score of $\leq$21 was selected as that was appropriate for an aging population with low education, but Johnson et al. tested their population and created a cut-point based on the standard deviation of their population. The variations for disability cut-points were even more diverse and did not have justification. For example, some studies determined that inability to independently complete a single ADL item constituted disability and others converted the items into a scored scale and determined unique cut-points on that scale. This variability makes it

difficult to compare studies or to generalize their outcomes. Furthermore, lack of measure justification impedes the opportunity to conduct future research that is consistent and comparable.

For our second aim, we hypothesized that we would find a difference between the original cohort and newer cohort regarding the relationship between cognition and disability. Prior research has demonstrated that the prevalence if disability has changed between cohorts and that cognitive impairment has not. Therefore, it stands to reason that cognitive impairment may impact disability differently in the newer cohort. However, cohort was not a statistically significant modifier in any model; i.e., there was no difference between cohorts on the relationship of cognition and disability. This is possibly because in our sample the newer cohort did in fact have a significantly higher prevalence of cognitive impairment, compared to the original cohort, which was contrary to the report that influenced our hypothesis.[5]

The main effect of cohort was consistently a statistically significant predictor of ADL disability. In all three models the newer cohort was approximately 2 times as likely to have an ADL disability compared to the original cohort. Descriptive analyses also demonstrated that the newer cohort had higher levels of chronic illnesses, such as diabetes and arthritis. This is consistent with the findings by Beard et al. in which newer cohorts of Mexican Americans have been demonstrating increased prevalence of disability.[5] Our results differ in that we found cohort predicts both the prevalence and the incidence of ADL disability. Despite the increased prevalence of chronic illnesses and disability, the newer cohort had less depressive symptoms compared to the older cohort. This contradicts findings by Lewisohn et al. that found for community-dwelling adults, depression rates

increased across cohorts. Perhaps because Hispanic adults already have higher rates of depression compared to non-Hispanic Whites, there is more opportunity for the non-Hispanic whites to significantly increase their depressive symptoms.

Prior work has suggested that the cohort differences of chronic illnesses and disability may be due to acculturation. Acculturation can be a stressful experience, as individuals learn to adapt to the attitudes and beliefs of a new culture.[3,42] Acculturation can have negative health consequences for Hispanic Americans, such as increased hypertension, depression, and waist circumference.[43,110,111] In our study, the newer cohort had a higher prevalence of US born participants. Other studies have demonstrated adverse outcomes due to acculturation are higher in US born Mexican Americans compared to Mexican born Mexican Americans.[4,111] It is possible then that differences in disability and chronic illness between cohorts could be due to differences in acculturation-related stress

Another plausible explanation is that the differences could be attributed to the "healthy migrant hypothesis." This theory has been used to explain the Hispanic Paradox. Simply put, the Hispanic Paradox is the term for the observed mortality differences between Hispanics and non-Hispanic Whites. Despite the Hispanic population having higher levels of chronic illnesses, cognitive impairment, and poverty with less education and access to healthcare, Hispanics have a lower mortality rate compared to non-Hispanic Whites.[100,101,112] The healthy migrant theory suggest that participants who migrate tend to be those who are healthier in order to relocated for job opportunities, that are often physically demanding.[112] As the older cohort is comprised of more Mexican-born Mexican Americans than the newer cohort, it is possible this hypothesis could be the reason behind disability variance.

Aim 3 tested if positive emotion modified the relationship between cognition and disability. We hypothesized that positive emotion would be a statistically significant modifier. As cognitive impairment and positive emotion have similar mechanisms by which they affect the onset of disability, we theorized that positive emotion would counteract the negative effects of cognitive impairment and would increase the protective abilities of intact cognition. We found positive emotion to be a significant modifier in the cross-sectional analysis, demonstrating that positive emotion modified the relationship between impaired cognition and disability consistently across all 4 observations. However, these results were not found in the other models. The lack of published literature on this topic makes it difficult to speculate why this relationship was not found in the other models. Perhaps to see the modifying effect of positive emotion we should have focused on individuals who maintain positive emotion across waves. It is possible the interaction was not significant in the longitudinal model based on the dynamic nature of positive emotion.

The main effects of positive emotion were found to be protective against ADL disability cross-sectionally and in the predictive series. Cross-sectionally, each unit increase of positive emotion was associated with 11% lower odds of disability. When positive emotion was used to predict disability at the subsequent wave, each unit increase of positive emotion was associated with 5% decreased odds of incident disability. These results are consistent with prior research demonstrating the protective effects of positive emotion.

The results of our study build on the existing research for the effects of positive emotion. Prior research has demonstrated that positive emotion leads to better health outcomes, such as decreased hypertension and disability.[1,11] Fisher et al. studied the role of

positive emotion among older Mexican Americans with arthritis. They found that the odds of developing incident ADL disability were 54% lower for those with high positive emotion at baseline compared to those with low levels of positive emotion. One study demonstrated that positive emotion was associated with higher levels of cognitive recovery post stroke,[51] and another demonstrated that high levels of positive emotion were protective against cognitive decline.[96] Our finding of positive emotion modifying the cross-sectional relationship between cognition and disability has not been demonstrated before.

When cognition was included as a time-varying variable, those with cognitive impairment were more likely to have ADL disability. In both aims, the odds of disability for individuals with cognitive impairment ranged from 57% higher odds to 2.7 times higher odds. In both aims, baseline cognition did not predict disability in either longitudinal analysis, but the interaction term of baseline cognition-by-time demonstrated that those with cognitive impairment had 20% higher odds of developing incident ADL disability with each successive observation. These results are consistent with the systematic review conducted in chapter 2 and highlight the fact that conflicting results can be based on the statistical approach taken.

Overall, our findings confirm the strong relationship between cognition and ADL disability. The newer cohort of older Mexican Americans had increased prevalence of disability, cognitive impairment, and chronic health conditions compared to older cohort. We also showed that positive emotion is protective against incident disability and moderates the cross-sectional relationship between cognitive impairment and disability.

These findings emphasize the need to take care of our entire wellbeing, not simply our physical health. This research demonstrates that our cognition, our emotions,

and our physical capabilities are closely interrelated. Maintaining emotional and cognitive health may be critical for preventing or at least delaying disability. Effective monitoring may result in early detection of cognitive decline; thereby allowing for intervention to prevent or delay the onset of disability.

Further research is needed on interventions that enhance cognitive and emotional health of older adults and on the applicability of those interventions for older Hispanic Adults. A good starting point would be to establish consensus population-specific measures and cut-points. Additional research is also needed to better understand the mechanism(s) underlying cohort differences in disability and cognitive impairment.

Appendix A.

Descriptive Characteristics for Samples Including Disabled at Baseline.

Table 1. Descriptive Characteristics of Aim 2, Model 1 Sample and by Cohort

	Included Cohort			
	1	2	Total	*P*
N	1,068	1,728	2,796	
Disabled at Baseline				*<0.001*
Yes	21.10%	32.50%	28.10%	
No	78.70%	67.50%	71.70%	
Missing	0.30%	0.10%	0.10%	
Ever Disabled				*<0.001*
Yes	47.40%	64.80%	57.30%	
No	52.60%	35.20%	42.70%	
Missing	0.00%	0.00%	0.00%	
Cognition				<0.001
Cognitive Impaired	30.99%	38.95%	35.91%	
Not Cognitively Impaired	64.70%	54.75%	58.55%	
Missing	4.31%	6.31%	5.54%	
Gender				0.249
Male	41.01%	38.77%	39.63%	
Female	58.99%	61.23%	60.37%	
Marital Status				0.098
Married	42.70%	44.97%	44.10%	
Single	57.30%	54.75%	55.72%	
Missing	0.00%	0.29%	0.18%	
Smoking Status				<0.01
Smoker	40.26%	46.30%	43.99%	
Former/Non-Smoker	58.90%	53.07%	55.29%	
Missing	0.84%	0.64%	0.72%	
Heart Attack				0.341
Yes	13.11%	14.70%	14.09%	
No	86.24%	84.90%	85.41%	
Missing	0.66%	0.41%	0.50%	
High Blood Pressure				<0.001
Yes	42.42%	62.67%	54.94%	
No	56.65%	36.28%	44.06%	
Missing	0.94%	1.04%	1.00%	
Hip Fracture				

Yes	5.24%	6.48%	6.01%	
No	94.66%	93.46%	93.92%	
Missing	0.09%	0.06%	0.07%	
Stroke				0.019
Yes	8.90%	12.15%	10.91%	
No	90.92%	87.50%	88.81%	
Missing	0.19%	0.35%	0.29%	
Diabetes				<0.001
Yes	23.78%	35.07%	30.76%	
No	76.03%	64.64%	68.99%	
Missing	0.19%	0.29%	0.25%	
Arthritis				<0.001
Yes	40.73%	59.03%	52.04%	
No	58.15%	39.35%	46.53%	
Missing	1.12%	1.62%	1.43%	
Proxy				
Respondent Only	87.83%	89.87%	89.09%	0.214
Proxy Only	3.93%	3.01%	3.36%	
Both Respondent and Proxy	8.24%	7.12%	7.55%	
Final Status				0.664
Re-interview	14.89%	14.76%	14.81%	
Died	73.03%	74.25%	73.78%	
Refused/Loss to Follow-up	12.08%	11.00%	11.41%	
Mean (SD)				
Age	80.67 (4.78)	80.6 (4.07)	80.63 (4.36)	0.697
Education	4.25 (3.75)	5.08 (4.1)	4.76 (3.99)	<0.001
BMI	26.65 (4.94)	27.68 (4.94)	27.27 (4.96)	<0.001
CES-D	10.72 (9.24)	9.36 (9.04)	9.88 (9.14)	<0.001
Cognition	23.11 (5.46)	22.27 (5.36)	22.59 (5.41)	<0.001

Table 2. Descriptive Characteristics of Aim 3, Model 1 Sample and by Final Disability Status

	Never Disabled	Ever Disabled	Total	P
N	1142	1532	2674	

Cognition					<0.001
	Cognitive Impaired	27.8%	41.6%	35.8%	
	Not Cognitively Impaired	70.0%	54.0%	60.8%	
	Missing	2.2%	4.4%	3.4%	
Gender					<0.001
	Male	47.3%	34.1%	39.7%	
	Female	52.7%	65.9%	60.3%	
Marital Status					0.05
	Married	46.8%	42.0%	44.1%	
	Single	53.1%	57.8%	55.8%	
	Missing	0.2%	0.1%	0.1%	
Smoking Status					0.17
	Smoker	46.5%	43.0%	44.5%	
	Former/Non-Smoker	53.1%	56.3%	54.9%	
	Missing	0.4%	0.7%	0.6%	
Heart Attack					0.07
	Yes	12.2%	15.3%	13.9%	
	No	87.3%	84.2%	85.5%	
	Missing	0.5%	0.5%	0.5%	
High Blood Pressure					<0.01
	Yes	51.7%	57.6%	55.1%	
	No	47.6%	41.3%	44.0%	
	Missing	0.7%	1.0%	.9%	
Hip Fracture					<0.001
	Yes	3.4%	7.7%	5.9%	
	No	96.5%	92.3%	94.1%	
	Missing	0.1%	0.0%	0.01%	
Stroke					<0.001
	Yes	6.9%	13.0%	10.4%	
	No	92.9%	86.7%	89.4%	
	Missing	0.2%	0.3%	0.2%	
Diabetes					<0.001
	Yes	25.2%	34.7%	30.6%	
	No	74.4%	65.2%	69.1%	
	Missing	0.4%	0.1%	0.2%	
Arthritis					<0.001
	Yes	40.7%	60.1%	51.8%	
	No	58.1%	38.6%	46.9%	
	Missing	1.1%	1.4%	1.3%	
Proxy					<0.001
	Respondent Only	95.1%	89.3%	91.8%	
	Proxy Only	1.6%	2.5%	2.1%	
	Respondent & Proxy	3.3%	8.2%	6.1%	
Final Status					0.82
	Re-interview	14.5%	15.3%	15.0%	

	Died	73.9%	73.5%	73.7%	
	Refuse/Loss to Follow-up	11.6%	11.2%	11.3%	
Mean (SD)					
	Age	79.82 (4.07)	81.01 (4.29)	80.50 (4.24)	<0.001
	Education	5.20 (4.08)	4.49 (3.88)	4.80 (3.98)	<0.001
	BMI	26.83 (4.56)	27.70 (5.22)	27.30 (4.95)	<0.001
	Positive Emotion	9.46 (2.95)	9.00 (3.02)	9.20 (3)	<0.001
	Negative Emotion	5.91 (6.87)	7.85 (8.04)	7.01 (7.62)	<0.001
	Cognition	23.96 (4.66)	21.88 (5.38)	22.78 (5.19)	<0.001

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Vita

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