Poverty and Sleep in Later Life

Jen-Hao Chen
Department of Health Sciences & Harry S Truman School of Public Affairs
University of Missouri
Email: chenje@health.missouri.edu

Abstract

Economic well-being plays a key role in older adults' life and well-being. However, relatively few studies have considered the role of poverty on sleep—a critical risk factor for physical health and mortality in later life. This study investigated the relationship between poverty and sleep using two waves of data (2009 and 2013) from Panel Study of Income Dynamics—Disability and Use of Time Supplement (DUST). Results from cross-sectional analysis showed that recent poverty was associated with longer sleep duration in 2009 and lower sleep quality rating in 2013. Further analysis on poverty history showed that both short-term and long-term poverty were associated with lower sleep quality rating. Results from longitudinal analysis also suggested that changes in poverty status were associated with decreases of sleep quality rating. Material hardship and psychological distress, however, did not explain the associations in cross-sectional and longitudinal analysis. Taken together, findings from this study suggest that poverty appears to be more consequential for older adults' sleep quality than sleep duration.

Introduction

Not having a good night's sleep is increasingly recognized as a critical behavioral risk factor for chronic diseases and poor health among older adults; poor sleep has been linked to declines in cognitive function (Cricco, Simonsick, & Foley, 2002); and increases in diabetes (Gangwisch et al., 2007), heart disease (Phillips & Mannino, 2007) and mortality (Cappuccio et al., 2010b). Poor sleep is an important risk factor because sleep problems are common among older adults (Ancoli-Israel, 2009); one large survey reports that nearly half of older adults report at least one insomnia symptom (Foley et al., 1995). However, despite its importance, our understanding of what determines good sleep in older adults is very limited. The vast majority of sleep research is clinic-based, includes a non-representative patient population, and focuses on the roles of the biological aging process and physical illness in older adults' sleep outcomes. This is a serious oversight since, over the past few decades, social scientists have demonstrated that socioeconomic context, particularly economic hardship, has a significant impact on health. As people age, their risk of living in poverty increases (Sandoval, Rank, & Hirschl, 2009). However, we know little about the impact of poverty on older adults' sleep.

This project takes advantage of new time-use data from the Disability and Use of Time (DUST) supplement of the Panel Study of Income Dynamics (PSID) to identify how poverty affects sleep among older adults. Specifically, this project draws theories from economics, sociology, and social epidemiology to understand the relationship between poverty and sleep. In addition, this study focuses on three aspects of sleep outcomes: sleep duration, insomnia symptoms, and quality of sleep. As the very first study of its kind, findings from this study provide new insight into the link between older adults' economic well-being and sleep, a critical behavioral risk factor for poor health. In doing so, the research also helps illuminate the

mechanisms through which poverty affects chronic diseases and mortality at older ages.

Economic Well-Being, Health, and Sleep

When asked what social condition determines health, social scientists often mention socioeconomic status. Decades of social science research have found strong and consistent socioeconomic disparities in almost every health outcome and in every stage of life (Bowling, 2004; Minkler, Fuller-Thomson, & Guralnik, 2006; Robbins et al., 2001; Ward et al., 2004). Because individuals from high socioeconomic status can deploy a wide range of resources that promote health and prevent illness, they always have better health outcomes than their socially and economically disadvantaged counterparts (Link, & Phelan, 1995). This mechanism produces persistent disparities in health irrespective of the advancement of medical technology. Thus, Bruce Link and Jo Phelan (1995) argue that socioeconomic status is the fundamental cause of diseases.

For adults, a key indicator of individuals' socioeconomic status is income. Comparing to high-income individuals, those fall under the poverty line have higher prevalence of chronic diseases, higher mortality, and worse mental health conditions (Bowling, 2004). As individuals age, the role of income for health is more consequential. Economic resources are essential for access to healthcare that offers preventive care which help early diagnosis and treatments of diseases. A number of studies have showed that inequalities in health outcomes across the income spectrum persisted at old age (Bowling, 2004; Schoeni, Martin, Andreski, & Freedman, 2005). Thus, it is well-established that, for older adults, economic well-being is an influential factor for health and well-being.

However, despite the large volume of literature on economic well-being and health at old age, there are no studies that comprehensively examine the effects of economic resources on

sleep in later life. Sleep is one of the most important restorative behaviors for an individual's health and well-being. All humans require sleep because it provides new energy for the brain and for physical activities. However, as individuals age, the ability to maintain a continuous and consolidated sleep decline (Espiritu, 2008; Vitiello, 2006). This makes older adults' sleep more sensitive to the influential of external environment and conditions. However, we know more about the role of mental and physical illness in shaping an individual's sleep outcomes than about the effects of social processes. Most extant sleep research remains clinic based, includes patients or volunteers, and collects data in a clinical sleep laboratory. Relatively few sleep studies focus on the general population of older adults because many population-based surveys did not include measures of sleep.

This, however, appears to have changed recently; epidemiologists and social scientists have begun to link a wide array of social factors to sleep outcomes using population-based samples. In a series of papers, Chen and colleagues demonstrated the critical role of martial relationship and social involvement on older adults' sleep using data from the National Social Life Health and Aging Project (Chen, Lauderdale, & Waite, 2015; Chen, Waite, & Lauderdale, 2016). They found that married older adults showed better actigraphic sleep characteristics than single older adults. Among married older adults, positive aspects of the marital relationship were associated with better actigraphic sleep characteristics (Chen, Lauderdale, & Waite, 2015). In a recent article, Chen and colleagues (2016) found that social engagement, particularly religious participation, was associated with an improvement of sleep consolidation of older adults. These works suggest that older adults' sleep is susceptible to the influence of social conditions as the case for other health outcomes. Nevertheless, whereas these studies document the influence of marriage and social participation on older adults' sleep, older adults' economic well-being—the

fundamental factor that generates inequalities in almost all social and health outcomes— have received little attention. Prior studies have found that income were negatively associated with time to fall asleep (Lauderdale et al., 2006; Friedman et al., 2007), higher rates of sleep complaints (Grandner et al., 2010), and short sleep duration (Stamatakis, Kaplan, & Roberts, 2007). However, these studies focus on young and middle-aged adults and do not consider the elderly, the population that is more vulnerable to the influence of social conditions.

Furthermore, few prior studies on the social determinants of sleep consider the processes through which economic well-being can influence sleep. Most studies treat income as a control variable and do not explore the relationship between economic well-being and sleep in greater detail. Additionally, even fewer studies consider complex nature of human sleep. Defining what constitutes good sleep is not straightforward. Sleep duration, insomnia symptoms, and experience of restfulness are all key aspects for evaluating a person's sleep. As such, the social scientific literature of sleep would be strengthened by considering the influence of economic well-being on both sleep duration and sleep quality. Because of these limitations, there are substantial gaps in our understanding of the influence of economic well-being on sleep in the general population of older adults.

Theoretical Perspectives on Economic Well-Being and Sleep

Two theoretical perspectives provide valuable insights into the process through which economic well-being influence sleep. The first is economic perspective of time allocation. Like other behaviors, sleep has its opportunity cost (Biddle & Hamermesh, 1990). In a typical day, people allocate their 24 hours to different activities. The more time an individual spends on sleep, the less time available for alternative activities. As such, high-income people face higher

opportunity cost for sleep as compared to low-income people. Prior studies using time-use data are generally consistent with the economic model of time allocation. These studies find that individuals reallocate more time to sleep whenever their time in labor market activities or their resources decrease (Antillon, Lauderdale, & Mullahy, 2014; Ásgeirsdóttir, & Ólafsson, 2015; Biddle & Hamermesh, 1990; Hamermesh, 2002). Hence, the economic model of time allocation predicts that poverty at old age can lead to an increase of sleep time.

The second theoretical perspective emphasizes the stressful experience of living in poverty (Pearlin, Schieman, Fazio, & Meersman, 2005). Poverty can affect health through it impact an individuals' material life (Marmot, 2002). Material hardship may result in suboptimal living conditions which, in turn, may affect sleep. For example, low-income people may not be able to afford air conditioner and find it difficult to sleep during the summer season. Living in a small house and crowded neighborhood may also affect individuals' sleep. In addition, living in poverty may be stressful. Low-income people who are consistently worry about food security and finance are more likely to have psychological distress and mental health problems (Lorant, Deliège, Eaton, Robert, Philippot, & Ansseau, 2003). These can affect both sleep duration and sleep quality. Prior studies on sleep have demonstrated the role of stress on sleep quality in the general population (Ailshire & Burgard, 2012; Burgard & Ailshire, 2009; Moen, Kelly, Tranby, & Huang, 2011). These studies find that relationship strain and job stress are strong predictors of poor sleep quality and short sleep duration. According to this perspective, it is expected that poverty can affect both sleep duration and sleep quality. Specifically, poverty may shorten sleep duration and lead to poor sleep quality of individuals.

The literature above provides the theoretical framework for my hypotheses that link poverty and sleep in later life. First, according to the economic model, time allocated to sleep

depends on the cost of sleep, the cost of spending time in alternative activities, and wages. As individuals' economic well-being declines, the cost of sleep also decreases (Antillon, Lauderdale, & Mullahy, 2014; Biddle & Hamermesh, 1990). Furthermore, better economic resources afford older adults a better sleep environment, such as a quiet neighborhood, a comfortable bed and air conditioning. All these features may promote sleep. Accordingly, one would expect that poor older adults have longer sleep duration but poorer sleep quality. Second, socio-psychological stress theory suggests that economic hardship generates stress (Kahn, & Pearlin, 2006). The stress increases neurological arousal, which leads to poor sleep quality and short sleep duration (Ailshire & Burgard, 2012; Burgard & Ailshire, 2009; Moen, Kelly, Tranby, & Huang, 2011). Thus, the stress model predicts that older adults who are relatively poor will have shorter sleep duration and poorer sleep quality. Overall, with respect to sleep *duration*, the two perspectives offer competing predictions. The sign of the coefficient will depend on which effect dominates. With respect to sleep *quality*, following theory and prior studies, I expect that poverty will lead to poorer sleep quality.

Methods

Data. This study used 2009 and 2013 waves of data from the Panel Study of Income Dynamics—Disability and Use of Time Supplement (DUST). In 2009, DUST sampled older couples in the PSID who met the following criteria: (1) both were 50 or older as December, 31 2008 (2) at least one spouse was 60 or older, (3) non-marred, cohabitating couples were excluded. The process identified 832 eligible couples, sampled 543 couples, and had 394 couples (788 individuals) with at least one complete time diary. In 2013, a second wave of DUST was conducted. Yet, the eligibility rules changed. All households were eligible for DUST 2013 if

either household head or spouse was 60 or older as of December 31, 2012. If the household head was married or cohabitating, his/her partner was also eligible. In total of 1698 households (including single) were eligible and 1217 households competed at least one diary. For statistical analysis, I further eliminated older adults who had only one time diary. This dropped 749 individuals in the 2009 wave and 1711 individuals in 2013 wave.

The differences of eligibility rules made two waves of DUST not total comparable. However, a subsample of approximately 500 older adults were in both waves of the survey, allowing for longitudinal analysis. After excluding individuals with only time diary, the longitudinal sample for two waves of DUST was 477 (and 407 for sleep quality). Because of the small sample size, the longitudinal analysis presented in this study is for exploratory purpose.

Measures of Sleep. Key outcome variables are sleep duration, reported insomnia symptoms, and average sleep quality. First, I calculated older adults' sleep duration, defining as the total time of the length of the longest sleep episode (Antillon, Lauderdale, & Mullahy, 2014). This excluded nap and short term sleep. Because each older adult completed two time diaries, I averaged the two days by weighting the weekday diary by 5/7 and the weekend diary by 2/7. In addition, the DUST questionnaires included three questions of respondents sleep quality if the respondent reported sleep as either the first activity or last activity of the day. These questions were "Did it take you more than half an hour to fall asleep?", "Did you wake up during the night, that is, between the time you fell asleep and end time of sleeping episode?", and "If yes, did you have trouble falling back to sleep?". Answers of these questions were "yes" or "no". I created a count of insomnia symptom by adding up the number of "yes" reported in both weekend and weekday diaries. Finally, all respondents were also asked to rate the quality of sleep the night before: "Would you say it was Excellent, Very good, Good, Fair, or Poor?" I created a global

sleep rating by averaging the weekend and weekday rating. High score indicated better sleep quality.

Poverty. I created indicators of each family's poverty status for each survey year based on federal poverty line, using the total pretax family income and adjusting for family size. Total family income[1,2] includes a family's (1) head and wife taxable income (2) head and wife transfer income (3) taxable income from other family members, (4) transfer income from other family members, (5) heath social security income, (6) wife social security income, (7) other family members' social security income. This did not include benefits from mean-tested programs including SNAP. This also did not consider the assets of a family. It is worth noting that the PSID collected income information for the prior tax year, not the survey year. As such, I labelled the poverty status as a year prior to the survey year as "recent poverty". For the purpose of this study, I traced a family's poverty status 5 years prior to the DUST survey year. For example, I traced a family's poverty status back to 2004 for respondents in 2009 DUST and back to 2009 for respondents in 2013 DUST. Using the 5-year poverty information, I further constructed two variables that represented the poverty history for respondents in each wave of DUST survey. I distinguished not-in-poverty (i.e., not being in poverty within the 5 years period), short-term

[1] The definition of family unit and household unit in PSID needs some clarification. According to the PSID website (2016), family unit is "a group of people living together as a family. They are almost always related by blood, marriage, or adoption. And they must all be living in the same household unit". Occasionally, unrelated persons can be part of an FU. They need to be permanently living with the family and share both income and expenses. Any person in a study family is a family unit member. The term "other family unit member" (OFUM) is used of members who are not the Head or Wife/"Wife". The household unit (HU) is the physical dwelling where the members of the FU reside. It can be a house, townhouse, apartment, a room in a rooming house, even a tent or a car. Not everyone living in an HU is automatically part of the FU. There may be other people living in the HU temporarily who do not meet the criteria of relatedness and economic integration. The PSID data is about FU Members only.

[2] This variable is generated by the PSID survey team by summing all sources of income for family members. The survey team imputed missing data such that there is not missing value in the total family income. When doing imputation, each income source was imputed separately by the PSID team (Duffy, 2011).

poverty (i.e, being in poverty in some years within the 5 years period), and long-term poverty (i.e., being in poverty for all 5 years).

Covariates. The rich information in PSID and DUST allows for inclusion of additional variables that may explain the associations between poverty and sleep. First, since 2005, PSID has included a wealth of consumption variables which measured respondents' material hardship more accurately. Because one of the key mechanisms that poverty affects sleep is through the material hardship and sub-optimal living standards, I created a series of indicators of material hardship. I calculated yearly consumption of each household for the following six category: food, apparel, housing, transportation, healthcare, leisure. Answers of all questions were recoded into yearly consumption. For housing consumption, if the respondents own the house, I adopt the market approach to calculate the value of housing consumption.[3, 4] After obtaining the total amount of consumption for each household, I used the federal poverty line as the cut-off points for material hardship. These processes generated a series of dummy indicators of material hardship.

Another key confounder or mediator is psychological distress. Starting from 2005, PSID added K-6 psychological stress scale in the main survey. I followed the convention to construct the K-6 scale by averaging the answers of the six items.

[3] One problem of the PSID consumption questions is that the PSID expenditure data collected in a single interview do not represent a single reference period. Questions about food, housing, and transportation ask about current level or the preceding month. On the other hand, questions about healthcare, apparel, and vacations refer to the preceding calendar year. I follow the convention and refer the PSID expenditure data by the survey year (Bavier 2014)

[4] There are two approaches to calculate the housing consumption flow (Smeeding et al., 1993). The first is the market value approach which assigns market value of housing based on its own conditions and characteristics. The second approach is the opportunity cost approach which assigns the value of capital market return as the imputed rent (Pendakur 2001). I adopted the later approach because of no data on local housing cost as Smeeding and colleagues. The implicit rental value for owned homes can be measured as a fixed interest return on the net worth of the home. The implicit rent will equal a safe private market rate of return (or the rate of relatively riskless long-tern government bonds) on an equal value of investment.

Finally, I controlled for a wide range of social and demographic variables. These variables were: age, gender, race and ethnicity (white, African-American, Hispanic, others), education (less than high school, high school, some college, college or above), retirement status, self-rated health, weekly hours of work, interview month, and marital status.

Statistical Strategy. I stared with cross-sectional analysis. Because most of respondents' spouses were also in the DUST surveys, to account for the nested nature of the data, I used multilevel model to link poverty status to sleep. The first level unit was individual and the second level unit was family. Model 1 included only social and demographic variables. Model 2 included variables of material hardship, psychological distress, and self-rated health. After analyzing each wave separately, I also explored the relationship between poverty and sleep with longitudinal analysis. Here, I used a 3-level model with time points nested in individuals and individuals nested in family. While the Users' Guide suggests the use of diary-level weights when analyzing time-use data, the combination of two diaries make it difficult to weight the analysis properly. Given this, I did not weight my statistical analysis.

Results

Summary Statistics

Table 1 shows summary statistics of sleep measures in 2009 and 2013 waves of the survey. For the first wave of DUST, older adults spent approximately 461 minutes sleep. About 27% of older adults had sleep duration less than 7 hours and 18% of older adults reported sleep duration more than 9 hours. On average, they reported one insomnia symptom. The average rating of sleep was 2.47 (out of 5). Moving to the second wave of DUST, older adults' sleep

patterns were similar. Older adults spent 453 minutes slept, with 31% less than 7 hours and 15% more than 9 hours. On average, they also reported one insomnia symptom and rated their sleep 2.54.

Table 2 provides an overview of key variables in both waves of DUST. The 2013 sample had higher proportion of older adults living in poverty and material hardship. This may be due to the fact that as 2013 DUST included single households. The 2013 sample also had more minorities and more women. However, the 2013 sample and 2009 sample were similar in terms of education, weekly hours of work, and retirement status.

Regression Results

Table 3 and Table 4 show the association between poverty and sleep by each sleep outcome from cross-sectional analysis. As Table 3 shows, recent poverty was associated with an increase of sleep duration by 0.6 hours. The association did not change after adding consumption and health variables. Moving to two measures of sleep quality, recent poverty was not associated with insomnia symptoms scale or global sleep rating. Evidence from the 2009 DUST suggests that recent poverty was associated with longer sleep duration but not sleep quality. Table 4 shows results for the 2013 DUST. Patterns were different. Recent poverty was not associated with sleep duration or insomnia symptoms scale. However, Table 4 shows that recent poverty was associated with decreases of global sleep quality rating. The association changed very little after the inclusion of consumption and health variables. While many of the social and demographic variables remained significant predictors of sleep outcomes in both waves of the DUST surveys, I found differential associations between poverty and sleep in two waves of survey.

Table 5 further investigated the association between poverty history and sleep by each wave of the survey. Panel A shows results from the 2009 DUST and Panel B shows results from the 2013 DUST. All regressions included the full set of control variables. Results from the Panel A indicate that short-term poverty was associated with longer sleep duration by approximately 0.7 hours. While long-term poverty was also associated with longer sleep duration, the association was not statistically significant. Poverty history did not predict other sleep outcomes in 2009 DUST. The patterns, again, were different for 2013 DUST. I observed no association between poverty history and sleep duration. However, both short-term and long-term poverty were associated with lower rating of sleep quality. Specifically, short-term poverty was associated with a reduction of sleep rating by 0.13 and long-term poverty was associated with a reduction of sleep rating by 0.39.

Table 6 explored the association between poverty and sleep using longitudinal data of DUST data. As the results show, changes in poverty status were not associated with sleep duration and insomnia symptoms scale. Nevertheless, changes in poverty status were associated with decreases of global sleep rating. Because only a subset of respondents in 2009 DUST were in 2013 DUST, the sample for longitudinal analysis decreased substantially. The small sample size might make it less likely to detect an effect between poverty and other sleep outcomes in the longitudinal analysis. Thus, interpretations of results from the longitudinal analysis should be cautious.

Additional Analysis

In addition to the main analysis, I performed several sensitivity analyses. First, some prior epidemiologic studies (Cappuccio, D'Elia, Strazzullo, & Miller, 2010b; Ferrie et al., 2007; Kripke, Garfinkel, Wingard, Klauber, & Marler, 2002) suggest that long sleep duration or short

duration comprise risk factors for poor health and mortality. As such, the relationship between poverty and sleep duration may be U-shaped rather than linear. In other words, poverty may be associated with increased chance of long sleep duration or short sleep duration. To address this issue, I transformed sleep duration into an ordinal variable with three categories: short sleep duration (< 7 hours), normal sleep duration (7-9 hours), and long sleep duration (>9 hours). I then used multinomial logistic regression to examine if poverty was associated with long or short sleep duration. None of the coefficients was significant. Second, I also examined each insomnia symptom indicator separately using logistic model. Results showed that poverty was not associated with any insomnia symptom. Third, I fitted the longitudinal data using fixed-effects model. While the association between poverty and sleep was in the expected direction, all coefficients became statistically insignificant. However, given the small number of older adults who changed poverty status between the two waves (N=24), interpretation of the results from the fixed-effects model should be made with cautions. Finally, I used alternative cut-off point for poverty indicators. I used 138% federal poverty line and 150% federal poverty line. Results were similar. This suggests that not only people fall under the poverty line are at risks of poor sleep outcomes. Low-income people that near the poverty line may also at risks of poor sleep outcomes.

Discussion and Conclusion

Using two waves of data from the PSID-DUST, this study examined the relationship between poverty and sleep in the general population of older adults. The study asked two key questions. First, does poverty affect sleep duration and sleep quality of older adults? Second, if there is an association between poverty and sleep, do material hardship and psychological

distress explain the association? Results show that poverty was associated with lower sleep quality rating in both cross-sectional analysis and longitudinal analysis. I also found some suggestive evidence that poverty was associated with longer sleep duration in cross-sectional analysis. Findings suggest that poverty is more consequential for sleep quality than sleep duration.

While the coefficients were in the expected directions, the differential patterns of 2009 DUST and 2013 DUST deserve further discussion. Several factors may explain these patterns. First, the sampling strategy is not totally compatible in two waves of the survey. As such, the 2009 wave DUST and the 2013 wave DUST surveyed two different populations of older adults. To further investigate the impact of different sampling strategies on my results, I performed a sensitivity analysis by limiting my sample to older adults who were in both waves of the survey. Then, I did the cross-sectional analysis again using this subsample of older adults. Results for both waves were similar. This additional analysis suggests that different populations of older adults may be the primary reason that I found differential patterns in the 2009 and the 2013 waves. Results from such analysis also imply that characteristics of older adults may moderate the relationship between poverty and sleep outcomes. Future research is needed to investigate the characteristics that make older adults' sleep more vulnerable to poverty. Second, it is possible that period effects may explain the differences. For example, Antillon, Lauderdale, & Mullahy (2014) find that individuals sleep more during the periods of high unemployment rate. This may explain why I found larger coefficient between poverty and sleep duration in 2009 (when the impact of recession was at its highest) but not in 2013. However, with only two waves of data, I was unable to further investigate the interplay between poverty and macro social and economic conditions on older adults' sleep over time.

Furthermore, findings of this study make several contributions to the fields of health disparities and social epidemiology of sleep. First, the study provides a new insight into an understudied behavioral risk factor that is linked to chronic diseases and mortality. Biological evidence has linked shorter sleep duration to higher risks of diabetes and heart disease (Gangwisch et al., 2007; Phillips & Mannino, 2007). Many epidemiological studies have observed associations between shorter sleep duration and higher rates of diabetes, coronary heart disease and mortality (Cappuccio et al., 2010a; King et al., 2008). In this vein, it is possible that the influence of economic well-being on sleep operates through its influence on sleep outcomes. Results from this study provide the very first evidence on this hypothesis. Since I found some suggestive evidence of a negative impact of poverty on older adults' sleep quality, the findings imply that the relationships between poverty and physical health at old age may operate through the decline of good sleep. Nevertheless, since I did not test this mechanism directly, future studies with longitudinal data on economic well-being, sleep, and morbidity/mortality may provide additional empirical evidence on this issue.

Despite the innovation, this study has several limitations. First, results presented here were associational instead of causal. It is possible that unobserved characteristics produce the associations between poverty and sleep outcomes. Second, measures of income (and consumption) were not in the same year as sleep outcomes. As such, I was not able to examine the association between "'current poverty" and "current sleep outcomes". According to the theoretical perspectives, it is expected that current poverty has stronger effects on sleep as compared to poverty status a year before. Thus, many of the non-associations in this study could be due to the use of lagged poverty measures. However, given that the poverty was measured before sleep, this might ease some concerns of reverse causality. In fact, I performed a sensitivity

analysis by using sleep to predict poverty status and found no association. The results provided additional support on the plausible links between poverty and sleep at old age. Nevertheless, future data collection that includes concurrent measures of poverty, consumption, psychological well-being, and sleep can help further illuminate the issue. Third, the sleep measures in DUST might not capture all important aspects of sleep outcomes that may be affected by poverty. Measures of sleep quality were limited in two waves of DUST and the DUST surveys did not capture sleep consolidation—the aspect of older adults' sleep that has been demonstrated that is most likely to be affected by social conditions by previous studies (Chen, Lauderdale, Waite, 2015; Chen, Waite, Lauderdale, 2016). Better sleep measures may reveal stronger associations between poverty and sleep. Finally, the small longitudinal sample size may makes it difficult to detect small effects. Additionally, the longitudinal sample included only couples in the first wave of DUST survey. As such, results from the longitudinal analysis can only apply to a subgroup of older adults who were married in the very beginning of the survey. I was not able to analyze the impact of poverty on older adults' sleep in other types of living arrangements longitudinally. Given this, results from this study may underestimate the impact of poverty on vulnerable populations.

Nevertheless, this study is one of the very first systematic study that examined the relationship between poverty and sleep. As older adults' economic well-being is a critical policy concern and older adults' sleep is increasingly recognized as a risk factor for poor health and mortality, a firm understanding of how economic well-being shapes older adults' sleep outcomes offer critical information to help promote sleep health in later life at the population level. Findings from this project will also energize the study of sleep in older adults, an important area of research that is currently receiving little attention in the social sciences. Findings here

demonstrate to researchers that sleep is an important area of study and encourage other nationally-representative population surveys to collect data on sleep so that deeper, future study is possible. In sum, the study provides the very first evidence that poverty was associated with poorer sleep quality of older adults; a finding that has the potential to inform policy for the estimated more than 4.2 million older adults in the U.S. who are poor (Census Bureau 2014).

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Table 1: Summary Statistics of Sleep Measures of Older Adults (Unweighted)

	2009	2013
Average sleep duration (min)	461	453
Risky sleep duration		
Normal (7~9 hours)	55%	54%
Short (<7 hours)	27%	31%
Long (>9 hours)	18%	15%
Average insomnia symptoms	1.00	0.95
Average sleep rating	2.47	2.54

Table 2: Summary Statistics of Poverty Indicators and Key Variables of Older Adults (Unweighted)

	2009 (Mean or Proportion)	**2013** (Mean or Proportion)
Poverty, 1 year prior	0.04	0.06
Poverty, 3 year prior	0.05	0.07
Poverty, 5 year prior	0.03	0.07
Material hardship, 1 year prior	0.04	0.12
Material hardship, 3 year prior	0.04	0.09
Material hardship, 5 year prior	0.05	0.07
Age	66	67
Male	0.48	0.40
Race and ethnicity		
White	0.78	0.72
African-American	0.13	0.21
Hispanic	0.06	0.05
Other	0.03	0.02
Education		
Less than high school	0.12	0.10
High school	0.37	0.32
Some college	0.19	0.23
College or above	0.14	0.16
Unknown	0.19	0.20
Married	NA	0.67
Retirement status	0.49	0.52
Hours of work	0.51	0.56
Self-rated health	2.76	2.72
K6 scale	1.36	1.40
Interview month		
Fall	0.29	0.39
Winter	NA	0.15
Spring	NA	NA
Summer	0.71	0.46
Sample size	749	1711

Table 3: Coefficients of Multilevel Regressions Linking Recent Poverty and Sleep Outcomes in 2009 DUST

	Sleep duration		Insomnia symptoms scale		Sleep quality rating	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Recent poverty	0.60†	0.64†	0.06	0.04	0.05	0.00
	(0.35)	(0.36)	(0.20)	(0.20)	(0.19)	(0.19)
Age	-0.00	-0.00	0.00	0.00	-0.00	-0.00
	(0.01)	(0.01)	(0.00)	(0.00)	(0.03)	(0.00)
Male	-0.11	-0.11	-0.21**	-0.21**	-0.16*	-0.16*
	(0.11)	(0.11)	(0.07)	(0.07)	(0.07)	(0.06)
Race and ethnicity (ref =White)						
African-American	-0.10	-0.14	-0.07	-0.11	-0.22*	-0.26*
	(0.20)	(0.20)	(0.12)	(0.11)	(0.11)	(0.11)
Hispanic	-0.52†	-0.53†	0.30†	0.29†	0.21	0.20
	(0.27)	(0.27)	(0.16)	(0.15)	(0.15)	(0.14)
Other	-0.13	0.01	-0.26	-0.28	-0.13	-0.14
	(0.23)	(0.41)	(0.23)	(0.22)	(0.21)	(0.20)
Education (ref = less than HS)						
High school	-0.21	-0.14	0.05	0.14	0.15	0.25*
	(0.20)	(0.21)	(0.12)	(0.12)	(0.12)	(0.11)
Some college	-0.27	-0.20	-0.05	0.06	0.00	0.13
	(0.22)	(0.23)	(0.14)	(0.14)	(0.13)	(0.13)
College or above	-0.31	-0.19	-0.12	0.03	-0.13	0.04
	(0.25)	(0.26)	(0.15)	(0.15)	(0.14)	(0.14)
Unknown	-0.13	-0.03	-0.08	0.07	-0.03	0.14
	(0.23)	(0.24)	(0.14)	(0.14)	(0.13)	(0.13)
Married	0.17	0.17	0.11	0.11	0.11	0.11
	(0.19)	(0.19)	(0.11)	(0.11)	(0.11)	(0.10)
Retirement status	0.08	0.02	0.02	0.03	-0.02	-0.01
	(0.14)	(0.06)	(0.08)	(0.08)	(0.08)	(0.07)
Hours of work	-0.10*	-0.09†	-0.02	-0.01	-0.01	0.00
	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)	(0.00)

Material hardship	-0.02	0.21	0.24
	(0.35)	(0.22)	(0.19)
Self-rated health	0.02	0.10**	0.10**
	(0.06)	(0.04)	(0.03)
K6 scale	0.21*	0.13*	0.16**
	(0.09)	(0.05)	(0.05)

Note. † P< .1, * P<.05, ** P<.01, *** P<.001. All regressions controlled for interview season.

Table 4: Coefficients of Multilevel Regressions Linking Recent Poverty and Sleep Outcomes in 2013 DUST

	Sleep duration		Insomnia symptoms scale		Sleep quality rating	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Recent poverty	0.08	0.07	-0.08	-0.11	-0.23*	-0.20**
	(0.18)	(0.19)	(0.07)	(0.07)	(0.09)	(0.09)
Age	-0.01	-0.01	0.00	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Male	-0.24**	-0.24**	-0.01	-0.01	-0.05	-0.05
	(0.08)	(0.08)	(0.03)	(0.03)	(0.04)	(0.04)
Race and ethnicity (ref = White)						
African-American	-0.27*	-0.28*	-0.01	-0.05	-0.08	-0.16**
	(0.11)	(0.11)	(0.05)	(0.05)	(0.06)	(0.06)
Hispanic	-0.27	-0.27	0.09	0.08	0.10	0.08
	(0.20)	(0.20)	(0.08)	(0.08)	(0.11)	(0.10)
Other	-0.35	-0.35	0.22	0.19	-0.08	-0.15
	(0.31)	(0.31)	(0.12)	(0.12)	(0.16)	(0.15)
Education (ref = less than HS)						
High school	-0.00	0.00	-0.18**	-0.14*	0.00	0.10
	(0.15)	(0.16)	(0.06)	(0.06)	(0.08)	(0.08)
Some college	-0.15	-0.14	-0.20**	-0.13*	-0.11	0.02
	(0.16)	(0.17)	(0.07)	(0.07)	(0.09)	(0.08)
College or above	-0.23	-0.21	-0.17*	-0.08	-0.17†	0.02
	(0.18)	(0.18)	(0.07)	(0.07)	(0.09)	(0.09)
Unknown	-0.24	-0.23	-0.16*	-0.08	-0.10	0.07
	(0.17)	(0.17)	(0.07)	(0.07)	(0.09)	(0.09)
Married	-0.02	-0.02	-0.01	0.02	-0.07	0.09†
	(0.09)	(0.09)	(0.04)	(0.04)	(0.05)	(0.05)
Retirement status	0.09	0.08	0.01	0.02	0.08	-0.10
	(0.10)	(0.10)	(0.04)	(0.04)	(0.05)	(0.05)
Hours of work	-0.06	-0.06†	-0.03	-0.03*	-0.02	-0.02
	(0.04)	(0.03)	(0.01)	(0.01)	(0.02)	(0.02)

Material hardship	-0.02	0.01	-0.04
	(0.14)	(0.07)	(0.07)
Self-rated health	0.06	0.07***	0.18***
	(0.05)	(0.02)	(0.02)
K6 scale	-0.08	0.12***	0.20***
	(0.08)	(0.03)	(0.04)

Note. † P< .1, * P<.05, ** P<.01, *** P<.001. All regressions controlled for interview season.

Table 5: Coefficients of Multilevel Regressions Linking Poverty History and Sleep Outcomes

	Sleep duration	Insomnia symptoms	Sleep quality rating
	Panel A: 2009 DUST		
Poverty history (no poverty as ref)			
Short-term	0.74**	-0.18	-0.06
	(0.29)	(0.16)	(0.15)
Long-term	0.61	0.39	-0.21
	(0.64)	(0.38)	(0.32)
	Panel B: 2013 DUST		
Poverty history (no poverty as ref)			
Short-term	0.18	0.05	-0.13†
	(0.16)	(0.06)	(0.08)
Long-term	0.32	-0.17	-0.39**
	(0.28)	(0.11)	(0.14)

Note. † P< .1, * P<.05, ** P<.01, *** P<.001. All regressions controlled for the full set of control variables.

Table 6: Longitudinal Analysis of Poverty and Sleep using Multilevel Model

	Sleep duration	Insomnia symptoms	Sleep quality rating
Poverty status	-0.05	-0.06	-0.31†
	(0.35)	(0.19)	(0.18)
Material hardship	-0.16	0.03	0.12
	(0.24)	(0.13)	(0.12)
Age	-0.01*	-0.00	0.00
	(0.00)	(0.00)	(0.00)
Male	-0.14	-0.06	-0.13*
	(0.12)	(0.05)	(0.06)
Race and ethnicity (ref = White)			
African-American	-0.08	-0.03	-0.09
	(0.20)	(0.11)	(0.11)
Hispanic	-0.22	0.29†	0.13
	(0.27)	(0.15)	(0.15)
Other	-0.36	0.27	-0.20
	(0.48)	(0.25)	(0.26)
Education (ref = less than high school)			
High school	-0.23	-0.03	0.27*
	(0.21)	(0.10)	(0.12)
Some college	-0.01	-0.11	0.04
	(0.23)	(0.11)	(0.13)
College or above	-0.24	-0.03	0.12
	(0.24)	(0.12)	(0.13)
Unknown	-0.15	-0.02	0.23*
	(0.23)	(0.11)	(0.13)
Married	0.38†	0.34**	0.05
	(0.22)	(0.11)	(0.12)
Retirement status	0.06	0.01	0.06
	(0.12)	(0.06)	(0.06)

Hours of work	-0.05	-0.02	-0.01
	(0.05)	(0.02)	(0.02)
Self-rated health	0.07	0.09**	0.13***
	(0.05)	(0.03)	(0.03)
K6 scale	-0.02	-0.01	-0.03**
	(0.13)	(0.01)	(0.01)

Note. † P< .1, * P<.05, ** P<.01, *** P<.001. All regressions controlled for interview season.