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Original Article

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Impact of shift work schedules on actigraphy-based measures of sleep in Hispanic workers: results from the Hispanic Community Health Study/Study of Latinos ancillary Sueño study

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Abstract

Study Objectives: To describe sleep characteristics of shift workers compared with day workers from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) Sueño ancillary study and test the hypothesis that shift work is associated with shorter sleep duration, worse sleep quality, greater sleep variability, and other sleep/health-related factors.

Methods: Employed adults (N = 1253, mean age 46.3 years, 36.3% male) from the Sueño study were included. Measures of sleep duration, timing, regularity, and continuity were calculated from 7 days of wrist-activity monitoring. Participants provided information on demographics, employment, work schedule (day, afternoon, night, split, irregular, and rotating), sleepiness, depressive symptoms, medications, caffeine, and alcohol use. Survey linear regression adjusting for age, sex, background, site, number of jobs, and work hours was used.

Results: In age and sex-adjusted models, all shift work schedules were associated with delayed sleep timing. Night and irregular schedules were associated with shorter sleep duration, greater napping, and greater variability of sleep. Afternoon and rotating shifts were associated with lower sleep regularity. In fully adjusted models, night and irregular schedules remained associated with shorter sleep duration, later sleep midpoint, and greater variability in sleep measures compared with day schedules. Split schedules were associated with, less time in bed, less sleep fragmentation, and less wake during the sleep period than day schedules.

Conclusions: Work schedule significantly affects sleep–wake with substantial differences between day work and other types of schedule. Detailed assessment of work schedule type not just night shift should be considered as an important covariate when examining the association between sleep and health outcomes.

Statement of Significance

It is well established that night and early morning work is associated with poor sleep, less is known about how other shift work schedules (afternoon, split, and irregular) affect objectively measured sleep compared with day work. This unique study reports the relationship between work schedules and objective sleep measures in Hispanic/Latino workers across a variety of work schedule types. Overall findings indicate that compared with day work, night and irregular work is associated with the shortest sleep durations, greater napping, and more irregular sleep. Future research on the impact of shift work schedules on sleep and health should consider a variety of work schedules and not just night or rotating schedules.

Key Words: work hours; sleep; shift work; Hispanic; Latinos; actigraphy

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Introduction

Work schedules that either limit the opportunity to sleep or require a person to work at a time when he/she would typically be sleeping can result in changes in the duration, timing, and continuity of sleep [1, 2]. Shift work is a term used very broadly and generally refers to any work schedule outside of the hours of 8 am to 6 pm. There are limited data on shift work and the type of shift work undertaken by U.S. Hispanics/Latinos and how this type of work may influence sleep–wake in this population [3, 4].

In general, night work and rotating schedules that include night work and early morning start times are associated with poor sleep [5]. Night work, for example, is associated with sleep durations that are 2–4 hr shorter on work days than those of day workers [5, 6]. Shift work has also been associated with poor health outcomes including increased risk of diabetes, obesity, hypertension, cancer, and even low birthweights [2, 7–16]. In addition to poor sleep, shift workers are also more likely to report depressive symptoms, poor health behaviors (smoking, alcohol, and caffeine use), greater daytime sleepiness, and greater sleep aid use [5, 17, 18]. These health effects are thought to be the result of a combination of factors including sleep loss, circadian disruption, and altered light/dark patterns [19, 20].

There are now several population-based studies that assess sleep–wake activity over multiple consecutive days; however, most of these studies are in older adults [21–24]. In addition, studies have included primarily Caucasian samples; therefore, data among minority populations are still scarce. The current analysis adds to the literature in several ways by including the assessment of objective measures of sleep–wake activity over many days in a large sample of working age (18–64 years) employed Hispanic/Latino adults. There are known differences in shift work prevalence and sleep characteristics between racial and ethnic groups but many of these studies with objective measures of sleep do not have a large number of Hispanic/Latino adults to allow a detailed examination. It is potentially useful to understand specifically how various shift work schedules affect sleep and other work, sleep, and health-related factors in Hispanics/Latinos. To develop countermeasures or interventions to improve sleep in shift workers, it is important to have an understanding of the characteristics of sleep that are altered and the factors that may be associated with or influence sleep–wake behavior.

The aims of this study are to understand the relationship among shift work schedules, objective (actigraphy) sleep characteristics, and demographic and health characteristics in employed adults from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) Sueño ancillary study. In particular, we sought to test the hypothesis that shift work is associated with shorter sleep duration, lower sleep efficiency, longer wake after sleep onset, greater variability in sleep duration and sleep timing, and other sleep/health-related factors compared with day workers.

Methods

Hispanic Community Health Study/Study of Latinos

The HCHS/SOL is a multicenter community-based cohort study examining the prevalence and risk factors of chronic disease among Hispanic/Latinos. HCHS/SOL used a two-stage probability-based sampling technique to randomly select household addresses based on census block groups within four cities (Bronx, NY; Miami, FL; Chicago, IL; and San Diego, CA) in order to provide a representative sample of the target population [25, 26]. A total of 16 145 adults aged 18–74 years were recruited between May 2008 and June 2011. Participants provided information on demographics (including self-identified Hispanic/Latino background) and socioeconomic status (including highest level of education attained and household income) [25]. As part of the baseline HCHS/SOL exam, participants underwent unattended sleep apnea monitoring (ARES Unicorder 5.2;B-Alert, Carlsbad, CA) at home for one night, and the apnea–hypopnea index (AHI) was calculated as a measure of sleep apnea severity [27, 28].

Sueño ancillary study

Between December 2010 and December 2013, the Sueño ancillary study recruited 2189 HCHS/SOL participants aged 18–64 years who had an AHI of <50 events/hr, no treatment for sleep apnea, and no diagnosis of narcolepsy. Recruitment was limited to HCHS/SOL participants who self-identified as Cuban, Dominican, Mexican, Puerto Rican, Central American, and South American. The participation rate for the Sueño ancillary study was 77 per cent. The study protocol was approved by the Institutional Review Boards at each of the participating sites and all participants provided written informed consent for both the baseline HCHS/SOL and Sueño exams [29].

Sueño study protocol

At the Sueño visit, participants completed questionnaires including items assessing employment status, work schedule, education, caffeine use, alcohol use, smoking history, use of sleep medications, depressive symptoms, daytime sleepiness, and acculturation in either English or Spanish based on participant preference. Height and weight were measured and body mass index (BMI) calculated (obesity defined as BMI ≥ 30 kg/m^2). At the end of the visit, participants were sent home with a wrist actigraph and daily sleep diaries for assessment of sleep–wake.

Questionnaire measures

Employment status and work schedule were determined by questionnaire at the Sueño study visit. Participants were asked whether they were currently employed, how many hours they worked in a typical week, how many jobs they had, and which work category best described their usual work schedule. For work category, there were six options including the following: day shift, afternoon shift, night shift, split shift, irregular shift/on call, and rotating shift. We will use the term shift work to refer to all schedules (afternoon shift, night shift, split shift, irregular shift/on call, and rotating shift) other than day shift. Participants were asked to select only one option. The following definitions were provided if a participant required clarification on the meaning of these groups with the understanding that the times may vary by 1–2 hr: the day shift will typically be between 6 am and 2 pm or 9 am and 5 pm; the afternoon shift will typically be 2 pm–10 pm or 3 pm–11 pm; the night shift will typically be 10 pm–6 am or 11 pm–7 am; a person with a split shift works twice over a day with 2 or more hours between work periods (for example, they might regularly work both 4 hr in the day and 4 hr in night shift on some days); a person with an irregular shift is one who works when called and never knows his/her shift for certain; a rotating shift means that you work one type of shift sometimes and another at other times. However, this is systematic. You know which shift you will work on each day.

Education and household income were used as indicators of socioeconomic status with education categorized as having a high school diploma or not, and household income dichotomized at the median of $20 000 per year.

Several types of substance use previously shown to be associated with shift work were assessed in this analysis. Ever smoker was defined as lifetime use of ≥100 cigarettes. High alcohol use was defined as ≥7 drinks per week for women and ≥14 drinks per week for men (based on National Institute on Alcohol Abuse and Alcoholism definition of problem drinking) [29, 30]. High caffeine use was defined as drinking ≥3 drinks containing caffeine per day [31]. Use of sleep aids was defined as one or more sleep aids used in the last week.

Depressive symptoms were assessed using a 10-item version of the Center for Epidemiological Studies Depression (CESD-10) questionnaire [32]. A score of ≥10 was used to indicate the presence of elevated depressive symptoms [29]. Daytime sleepiness was assessed using the Epworth Sleepiness Scale, with a score of ≥10 used to indicate excessive daytime sleepiness [33].

Actigraphy data collection

An Actiwatch Spectrum (Philips Respironics, Murrysville, PA) wrist actigraph was placed on the nondominant wrist at the Sueño visit and participants were asked to keep the device on the wrist continuously for 7 days with activity and light data collected in 30 s epochs. Participants also completed a sleep diary upon awakening each day. A centralized reading center at Brigham and Women's Hospital, Boston, MA, scored all records. Rest periods where the participant was trying to sleep were identified following a standardized protocol that made use of event markers, sleep diaries, light exposure, and activity levels [34]. Sleep–wake status for each 30 s epoch within each rest period was computed using the Actiware 5.59 scoring algorithm with sleep onset defined based on 5 immobile minutes, 0 immobile minutes for sleep offset, and a wake threshold of 40 counts. Participants with at least 5 days of valid actigraphy data were included in analyses [34].

Actigraphy measures

All sleep measures were reported as the mean averaged across all valid days in the recording. Sleep duration was defined as the total amount of time scored as sleep during the main rest period, which was night for most participants, though for shift workers the main rest period may have occurred during the day. Participants indicated the main rest period ("main time you choose to sleep") for each day in the daily sleep diary. The 24 hr sleep duration included time scored as sleep in the main rest period as well as all naps. Sleep fragmentation index and sleep efficiency provide measures of sleep quality. The sleep fragmentation index is calculated as the sum of the proportion of all epochs from sleep onset to sleep offset with an activity count of 2 or greater and the proportion of all bouts of immobility (activity count less than 2 in every epoch) that were 1 min or less in duration [34]. Sleep efficiency is calculated as the proportion of time spent in bed for the main rest interval, scored as sleep. Sleep midpoint provides a measure of sleep timing and is defined as the midpoint between sleep onset and sleep offset. The interdaily stability index quantifies the regularity of sleep patterns across days and provides a measure of how stable sleep rhythms are from day to day. A similar metric has been previously described for assessing stability of activity rhythms across the day [35]. In this study, each day is divided into twenty-four 1 hr bins and the variance in sleep–wake explained by these bins is compared with the total variance [29]. For this calculation, only participants with 7 consecutive days of valid actigraphy data were used to derive the interdaily stability. Naps were defined as a self-reported period of sleep (based on event markers or diary) outside of the main rest period containing at least 15 min of actigraphy-scored sleep.

Analysis

Participants included those who had work schedule data, were currently employed, and had valid actigraphy. Shift work schedule was the exposure of interest in all models and eleven sleep outcomes were modeled: the main sleep period time in bed, sleep duration, sleep fragmentation index, sleep efficiency, wake after sleep onset, 24-hr sleep duration, interdaily stability, sleep midpoint, standard deviation of sleep duration, standard deviation of sleep midpoint, and napping. For each of the sleep outcomes, age- and sex-adjusted means were calculated, standardized to 2010 U.S. Census data. Multivariable models were then built for each of the sleep outcomes using survey linear regression and including age, sex, Hispanic/Latino background, site, number of jobs, and work hours as covariates. All analyses used complex survey procedures to account for cluster sampling, stratification, and sampling weights. Analysis of variance (ANOVA) was used to test for differences among means and prevalences by work schedule type. If the null hypothesis of a common mean was rejected at $p < 0.05$, pairwise comparisons were performed with Dunnett–Hsu adjustment to account for the multiple comparisons.

All *p*-values were based on two-tailed testing. All analyses were completed using SAS v. 9.3 (SAS Institute, Cary NC).

Results

Of the 2189 participants in the Sueño ancillary study, 2156 (98%) had ≥5 days of valid actigraphy data. For this analysis, 903 participants were excluded due to unemployment ($n = 901$) or missing work schedule data ($n = 2$). As a result, a total of 1253 participants (mean age 46.3 years, 36.3% male) were included in this analysis.

Sample characteristics

Age- and sex-adjusted demographic characteristics by work schedule are provided in Table 1. A total of 35.6 per cent were employed in some form of shift work schedule, and of those working shift work the bulk were employed in either afternoon (28.6%) or irregular (29.1%) work schedules, compared with night work (16.5%), split schedules (15.2%), and rotating schedules (10.5%). Across work schedule types, there were significant differences

Table 1. Health, wellbeing, socioeconomic, and job-related characteristics (% and SE) by work schedule type

	Day N = 806	Afternoon N = 128	Night N = 74	Split N = 68	Irregular N = 130	Rotating N = 47	
Variables	%	%	%	%	%	%	P
Age, years	47.0 (10.4)	43.9 (13.3)	44.5 (11.8)	46.1 (10.2)	47.6 (11.8)	41.3 (12.3)	0.0004
Female (%)	62.0	56.3	50.0	45.6	66.2	72.3	0.007
Obese (%)	32.8 (1.0)	41.1 (4.0)	**44.9 (3.4)**	38.4 (2.2)	**41.0 (1.4)**	**58.0 (6.8)**	<.0001
Apnea-hypopnea index (AHI)	3.9 (0.1)	3.8 (0.4)	4.5 (0.2	4.1 (0.2)	**4.7 (0.1)**	6.3 (1.2)	<.0001
Elevated depressive symptoms (%)	20.6 (1.1)	24.7 (3.2)	24.7 (2.5)	17.3 (1.3)	19.0 (1.3)	**41.2 (7.8)**	0.0031
Ever smoker (%)	37.0 (1.1)	30.8 (3.2)	43.0 (3.5)	**30.2 (2.4)**	**44.2 (1.4)**	28.3 (7.4)	<.0001
High alcohol use (%)	4.6 (0.3)	9.6 (2.9)	3.3 (0.8)	2.0 (1.6)	5.4 (0.6)	7.3 (1.2)	0.0052
High caffeine use (%)	32.3 (1.1)	40.5 (3.4)	37.0 (3.4)	**22.2 (2.0)**	**40.9 (1.5)**	49.8 (6.8)	<.0001
Sleep aids ≥1 last week (%)	12.1 (0.7)	16.5 (1.7)	10.4 (1.1)	10.6 (0.8)	**20.0 (0.9)**	**35.0 (8.4)**	<.0001
Excessive daytime sleepiness (%)	18.0 (0.9)	23.6 (3.2)	20.7 (1.9)	19.9 (2.2)	19.6 (1.3)	22.2 (6.7)	0.3660
High school diploma (%)	74.6 (1.1)	73.7 (3.4)	66.7 (5.0)	78.0 (2.0)	**81.3 (1.4)**	77.7 (7.1)	0.0012
Household income > 20K (%)	60.5 (1.4)	55.2 (3.2)	54.6 (4.6)	**70.3 (2.6)**	**56.2 (1.2)**	**38.1 (5.4)**	<.0001
Work hours > 40/week (%)	25.7 (1.1)	**13.8 (2.3)**	17.8 (3.2)	31.2 (2.6)	22.2 (1.4)	24.3 (3.4)	<.0001
More than 1 job (%)	8.7 (0.5)	**12.6 (1.0)**	7.2 (2.5)	**28.6 (2.0)**	**27.1 (0.8)**	14.0 (2.4)	<.0001
US born (%)	20.4 (1.0)	12.1 (4.2)	25.6 (4.3)	**28.4 (2.1)**	**29.7 (1.2)**	28.6 (8.6)	<.0001

Except for age (mean and standard deviation) and sex, all prevalence's (S.E.) were estimated using linear regression and were adjusted for age and sex standardized to 2010 US Census distributions. Estimated prevalence (S.E.) is presented in each cell for dichotomized outcomes. *p*-Value is for global *F*-statistic.
Bold—Significantly different from day workers adjusted for multiple comparisons.

in almost all of the health, wellbeing, socioeconomic, and job-related factors examined. When compared with day workers, there were no differences for the shift work types in depressive symptoms, alcohol use, or daytime sleepiness, whereas for the remaining factors, there was a difference compared with those who were employed in day work (Table 1). For example, night, rotating, and irregular shift workers were more likely to be obese than day workers, and irregular and rotating shift workers were more likely to use sleep aids than day workers. The estimated age- and sex-adjusted mean apnea/hypopnea index was significantly higher in the irregular shift workers compared with day workers. The schedules that were more likely to have workers that were employed in more than one job were afternoon, split, and irregular shift workers compared with day workers.

Sleep characteristics

The estimated means for all sleep variables in age- and sex-adjusted analyses are presented in Table 2 by work schedule types. All sleep variables differed significantly across the various work schedules. When comparing shift work schedules with the day work schedule after adjustment for multiple comparisons (indicated in bold in Table 2), sleep durations were shorter for night and irregular shift workers ($p < 0.0001$) and later for all shift work schedules ($p < 0.0001$). Individuals with night work schedules had sleep durations that were approximately 30 min shorter ($p < 0.001$) and sleep midpoints that were 1.5 or more hours later ($p < 0.0001$) than those on a day work schedule even after adjustment for multiple comparisons. The regularity or stability of sleep was also different compared with day work for all shift work types except the split shift.

Fully adjusted sleep characteristics by shift work types

In the fully adjusted model (Table 3), irregular shift workers (11.4 min less than day workers) and night shift workers (36.4 min less than day workers) had shorter sleep duration ($p < 0.0001$) when compared with day workers. Time in bed was also shorter for these groups. All shift work types had later sleep timing than day workers, with the delay ranging from 43 to 158 min, but this was only significantly different from day workers after adjustment for night and irregular workers. The regularity or stability of sleep was also different compared with day work for night shift work and irregular shift work. The time spent napping outside of the main sleep period was also greater for night and irregular workers but less for split and rotating workers compared with day workers.

Discussion

The goal of this study was to determine the impact of different types of shift work schedules on sleep and other related sleep/health factors compared with day workers in a large group of Hispanic/Latino workers. Many large studies objectively examining sleep duration either excluded shift workers or used shift work as a covariate, and in many cases the type of shift work schedule was not taken into consideration or was limited to night and rotating work schedules. The findings from the current study show that there are differences in objective measures of sleep compared with day workers in all the categories of shift work examined, even those who worked afternoon shifts. As anticipated compared with day workers, night workers had the shortest sleep duration, longest naps, the latest sleep midpoint, and the greatest variability in sleep.

Night work is typically considered to be the most detrimental to sleep and is often associated with poor health [5, 36]. In the current study, average weekly sleep duration was 37 min shorter, sleep midpoint was more than 2 hr later, and varied by over an hour in night-workers compared with day-workers. Although there was also a significant difference in sleep duration and sleep midpoint for irregular shift workers compared with day workers, the magnitude of the difference was less. Interestingly the shorter sleep duration in night and irregular shift workers

Table 2. Age- and sex-adjusted sleep outcomes from actigraphy for employed adults by shift schedule type

	Day N = 806	Afternoon N = 128	Night N = 74	Split N = 68	Irregular N = 130	Rotating N = 47	Overall P
Time in bed (min)	465.4 (1.7)	470.4 (4.2)	**429.8 (4.3)**	459.5 (2.6)	**454.3 (1.3)**	464.3 (9.0)	<.0001
Sleep duration (min)	401.2 (1.3)	402.0 (4.0)	**363.9 (4.5)**	403.3 (2.0)	**391.4 (1.0)**	396.9 (7.5)	<.0001
Sleep midpoint (min after 12 am)	202.8 (1.8)	**273.6 (4.8)**	**353.2 (12)**	**256.8 (4.8)**	**244.2 (3.0)**	**258.6 (7.8)**	<.0001
Interday stability*	0.55 (0.004)	**0.53 (0.007)**	**0.45 (0.011)**	0.56 (0.005)	**0.53 (0.002)**	**0.50 (0.007)**	<.0001
Std. Dev, of sleep duration (min)	70.6 (0.8)	**80.1 (1.5)**	**100.4 (2.3)**	72.1 (2.3)	**84.2 (1.0)**	73.4 (3.7)	<.0001
Std. Dev. sleep midpoint (min)	56.0 (0.6)	55.2 (1.9)	**124.9 (4.7)**	56.3 (2.3)	**60.6 (0.7)**	**70.0 (3.8)**	<.0001
Fragmentation index (%)	20.3 (0.2)	21.5 (0.5)	21.6 (0.6)	**19.0 (0.2)**	20.9 (0.2)	21.6 (1.1)	<.0001
Sleep efficiency (%)	86.3 (0.1)	85.2 (0.5)	**84.8 (0.5)**	**87.8 (0.2)**	86.0 (0.2)	85.7 (0.6)	<.0001
Wake after sleep onset (min)	49.6 (0.8)	52.9 (1.4)	51.7 (2.2)	**45.4 (1.0)**	50.1 (0.9)	54.7 (3.1)	0.0002
24-hr sleep duration (min)	410.5 (1.2)	412.5 (4.2)	**385.5 (4.3)**	410.3 (2.1)	408.3 (0.9)	403.7 (8.3)	<.0001
Napping (min/day)	9.3 (0.4)	10.5 (1.4)	**20.6 (1.6)**	**7.0 (0.4)**	**16.9 (0.7)**	6.9 (1.1)	<.0001

Mean and standard error are shown adjusted for age and sex, standardized to the 2010 U.S. Census distributions and accounting for sampling methods. *p*-Value is for global *F*-statistic.
*N = 1008 participants with 7 continuous days of complete actigraphy data.
Bold—Significantly different from day workers adjusted for multiple comparisons.

Table 3. Regression coefficients (SE) for sleep outcomes from actigraphy for employed adults by shift schedule type

	Day N = 806	Afternoon N = 128	Night N = 74	Split N = 68	Irregular N = 130	Rotating N = 47	Overall P
Time in bed (min)	reference	5.9 (4.3)	**−36.2 (4.2)**	**−6.0 (3.0)**	**−11.6 (1.7)**	4.3 (8.8)	<0.0001
Sleep duration (min)	reference	2.6 (3.9)	**−36.4 (4.4)**	1.4 (2.2)	**−11.4 (1.4)**	1.2 (6.1)	<0.001
Sleep midpoint (min after 12 am)	reference	63.0 (4.2)	**146.4 (13.2)**	65.4 (4.2)	**50.4 (3.0)**	43.2 (8.4)	<0.0001
Interday stability	reference	−0.01 (0.01)	**−0.09 (0.01)**	0.02 (0.01)	**−0.01 (0.003)**	−0.04 (0.01)	<0.0001
Std. Dev, of sleep duration (min)	reference	5.7 (1.8)	**27.8 (2.2)**	2.4 (2.7	**14.0 (1.2)**	0.1 (4.2)	<0.0001
Std. Dev. sleep midpoint (min)	reference	−2.3 (2.23)	**68.2 (5.07)**	3.8 (2.20)	**8.2 (1.12)**	12.4 (5.16)	<0.0001
Sleep fragmentation index (%)	reference	**1.2 (0.6)**	1.2 (0.6)	**−1.0 (0.3)**	**1.0 (0.3)**	1.1 (1.1)	<0.0001
Sleep efficiency (%)	reference	−0.7 (0.4)	**−1.1 (0.5)**	**1.4 (0.2)**	−0.4 (0.2)	−0.3 (0.6)	<0.0001
Wake after sleep onset (min)	reference	2.7 (1.5)	1.4 (2.3)	**−3.7 (1.3)**	1.2 (0.9)	5.3 (3.5)	0.0005
24-hr sleep duration (min)	reference	3.4 (4.2)	**−25.6 (4.2)**	0.1 (2.4)	−2.5 (1.6)	−0.8 (7.3)	<0.0001
Napping (min/day)	reference	0.8 (1.5)	**10.8 (1.6)**	**−1.3 (0.5)**	**8.9 (0.8)**	**−2.1 (1.6)**	<0.0001

Regression coefficients are taken from separate multivariable models (one for each outcome variable) with day workers serving as the reference group, adjusting for age, sex, background, site, jobs (multiple vs single) and work hours (continuous). *p*-Value is for testing the null hypothesis of a common mean across groups.
Bold—Significantly different from day workers adjusted for multiple comparisons.

seems to be due to less time spent attempting to sleep (time in bed) not necessarily more fragmented sleep. When examining the average weekly 24 hr sleep duration, only night shift workers remained significantly different from day workers. Irregular shift workers were presumably able to compensate for the sleep loss with a nap, as they napped approximately 9 min more per day, on average, than day workers. Napping can be a valid strategy to increase total daily sleep time and reduce sleepiness [37].

Another key sleep characteristic that has more recently been shown to be associated with poor health outcomes is sleep timing [38, 39]. As expected, all shift workers regardless of type of shift work had a sleep midpoint that was an hour later compared with day workers. However, after accounting for the number of jobs and hours spent working, sleep midpoint was only significantly later than day workers for those on a night or irregular schedules. In the current study, the average sleep midpoint was at almost 6:00 am in night workers. In nonshift workers, sleep midpoints later than 5:30 am have been associated with alterations in the timing of caloric intake relative to sleep [40, 41] and in pregnant women with greater risk of developing gestational diabetes [38]. The potential health consequences for night and irregular shift workers may be compounded as they have both shorter sleep duration and mistimed sleep which are independently associated with poor health behaviors and outcomes [38, 39].

In addition to studying sleep in relation to work schedule, we also examined other factors that could affect sleep or that could be related to work schedule such as education level, household income, acculturation, hours worked/week, and number of jobs. There was a significant difference across all of these factors based on work schedule type. Long work hours (>40/week) and having multiple jobs are likely to affect the time available each day to sleep. In this study, afternoon, split, and irregular shift workers were more likely to have more than one job compared with day workers. However, the only difference in the percent of individuals working more than 40 hr/week was for afternoon workers who were less likely than day workers to work more than 40 hr/week. Irregular shift workers which made up one of the largest categories of shift work in this Hispanic/Latino cohort were more likely to work more than one job and had shorter and later sleep timing compared with day workers even after controlling for the number jobs and other confounding factors.

Although rotating workers did not have significantly shorter sleep during the week of actigraphy collection, there still appears to be consequences of the schedule. Compared with day workers, significantly more rotating shift workers were obese (25% more), and 20 per cent more used sleep aids. Rotating workers also tended to have a lower income with 22 per cent fewer workers having a household income greater than $20000 per year compared with day workers, even though they were just as likely to work more than 40 hr/week. In addition, 20 per cent more rotating shift workers had elevated depressive symptoms compared with day workers, which is similar to a prior report in nurses on a rotating shift schedule compared with day workers [42]. In this Japanese study, they suggest that the differences between day and shift workers were driven by shorter sleep duration and greater "eveningness." In the current study, rotating shift workers did not have significantly shorter sleep than day workers, although this does not rule out an association between short sleep and depressive symptoms.

The literature indicates a complicated relationship between high use of alcohol amongst shift workers, with many studies failing to find an association, compared with day workers [43]. In this study, we examined high alcohol use since it is not uncommon for some people to use alcohol as a sleep aid [44], but similar to several previous studies we did not find any significant differences in high alcohol use in shift workers compared with day workers. It is possible, however, that differences may be observed in those who report sleep complaints compared with those who do not [45], but this is beyond the scope of the current study. Other poor health behaviors such as diet and smoking have also been associated with shift work schedules and perhaps play a role in the increased cardiovascular disease risk in shift workers. In the current study, only irregular shift workers were significantly more likely (~7%) to ever have smoked than day workers.

A surprising finding was that there were no significant differences in daytime sleepiness by work schedule type [17], with approximately 18%–24% of workers reporting high levels of daytime sleepiness (Epworth Sleepiness Scale ≥10). This could be a function of the sleepiness cutoff used for this study, or a general low level of sleepiness in this population of employed individuals with an AHI of less than 50 or previously diagnosed narcolepsy. Although even in the larger HCHS/SOL study, where sleep-disordered breathing (SDB) or narcolepsy was not exclusionary, excessive sleepiness was present in 18 per cent of the sample [27]. It is of interest, however, that the percentage of those with excessive daytime sleepiness is higher in this study than the mean of 13.6 per cent reported for Hispanics from the Multi-Ethnic Study of Atherosclerosis (MESA) study [22] even though the MESA participants were on average 20 years older than the Sueño participants. In line with this generally low level of excessive daytime sleepiness and despite the shorter sleep duration and later sleep timing, night workers did not use more caffeine or sleep aids than day workers. Alternatively, given the general increase in today's society for ingestion of caffeinated beverages, perhaps, a higher cutoff for caffeine consumption is needed to detect a difference.

For several reasons, it is challenging to compare the findings of this study to other studies, since definitions of shift work may have varied and those with an AHI of less than 50 or previously diagnosed narcolepsy were excluded from participation in the Sueño study. However, this is balanced by the use of objective measures of sleep over a week allowing the exploration of not only sleep amount but also timing and regularity. The percentage of shift workers in this study is comparable to several recent studies that include an adequate number of Hispanics and also report numbers for those employed on shift work schedules, for example, shift work represents between 14% and 22% of workers sampled [3, 4].

Potential limitations of this study to consider are the relatively small sample size for some work schedule types, and that we do not know what shift the participant was working during the week of sleep assessment. Self-reporting typical work schedules via questionnaire may be a limitation for this and many other epidemiology studies and may not always be the best way of determining sleep relative to shift work exposure in real time. Perhaps, it would be better to have participants report work schedule in parallel with actigraphy recording and to record sleep–wake activity for longer than 1 week to ensure a representative assessment of sleep in relation to the work schedule. This would be particularly important for rotating shifts and irregular shift schedules where several weeks might be necessary to examine sleep over a full shift rotation. This failure to examine sleep and work schedule in parallel could also explain why some studies do not see an association with sleep and work schedule. Another factor to consider is the idea of the healthy shift worker [46], it is possible that some individuals adapt/cope better with shift work than others, which this study was not able to assess.

This study builds upon a large body of existing literature on the effects of work schedules on sleep [2] by providing information on objective measures of sleep and sleep/health-related factors in a large group of employed Hispanics/Latinos in the United States. Understanding the relationship between work schedule and sleep is important in this population because atypical work schedules are more prevalent among U.S. Hispanics [3], shiftwork and short sleep are known risk factors for cardiometabolic disease [39] and Hispanic/Latinos are at a greater risk for these same adverse health outcomes [47, 48]. The findings of this current study indicate that consideration should be given to a variety of work schedules when examining contributing factors to poor sleep and when assessing the association between sleep and health outcomes. Furthermore, when developing tools to improve sleep, shift work of any sort, not just night work should be considered and strategies developed and implemented to improve sleep in this growing proportion of the workforce.

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