Supplemental Materials

Weekly Sleep Trajectories and their Associations with Obesity and Hypertension in the Hispanic/ Latino Population.

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Background for Intranight Instability Index

We proposed to use intranight instability index as a daily level measure to describe the nightly sleep pattern based on both theoretical derivation and data evidence. The pattern of activity during sleep is unique in that an individual aims to sleep but not active. This scenario results in excessive epochs with zero activity count during sleep. It is natural to use zero-inflated Poisson distribution to model the sleep activity count data. Let p_0 be the probability of extra zeros, then mean divided by standard deviation (SD) of zero-inflated Poisson distribution is:

$$\frac{Mean}{SD} = \sqrt{\frac{Mean}{1 + \frac{p_0}{1 - p_0} Mean}} \qquad (S1)$$

We created intranight instability index (mean of activity count in a sleep interval divided by SD of activity count in the same interval) because expression (S1) indicates intranight instability index increase with the increasing of mean activity or the decreasing of p_0. This is observed by the scatterplots for daily Sueño actigraphy data in Supplemental Figure 1. Larger p_0 imply larger sleep efficiency or smaller WASO since a wake threshold activity count of 40 is used to generate sleep/wake status for each epoch in existing actigraphy methods. This also suggests that there might be important health information in the number of epochs with activity count of 0. Our findings support using intranight instability index as a marker of sleep quality. This is evidenced by the linear concordance between intranight instability index and sleep measures including sleep onset latency, WASO, sleep efficiency, wake bouts, and sleep fragmentation index shown in Supplemental Table 1.

As shown in Supplemental Table 2, the stronger associations of intranight instability index with both obesity and hypertension imply intranight instability index provides comprehensive information beyond that in most other single sleep measure. In brief, although it has not been used previously, the results from our study support its use as a marker to describe the activity pattern during the sleep interval.

Latent Class Growth Model using Proc Traj

Since approximating 75% of observed value is zero, we use zero-inflated Poisson model for daytime napping duration. The truncated normal model is used for WASO and intranight instability index. Starting with quadratic form for trajectory, we examine models with 5 classes, then compare the Bayesian Information Criterion (BIC) to those with 4, 3, 2, and 1 classes respectively. [1] Supplemental Table 3 shows the BIC values for various sleep measures conditioning on different number of classes. Models with smaller BIC are preferred. Based on BIC values only, the selected number of classes is 5, 4, and 5 for WASO, napping duration, and intranight instability index in sleep interval respectively. However, we choose the number of classes as 4 for intranight instability index since BIC values increase less than 1% from 4 classes to 5 classes. Once identifying the number of classes needed, we compare model fit with different functional form (e.g., linear, quadratic, cubic). The final model is the optimal one with optimal classes and trajectory functional forms. From this final model, we calculate the posterior predicted probability for each individuals of being a member in each of classes. Supplemental Table 4 shows the mean posterior probabilities for each class. It can be seen that the mean posterior probabilities exceed suggested threshold of 0.7. [2] We notice that the mean posterior probability is 0.86 when choose 5 classes for intranight instability index in sleep interval, which is just slightly smaller than 0.87 for 4 classes. This suggests that the selection of 4 classes is superior to that of 5 classes.
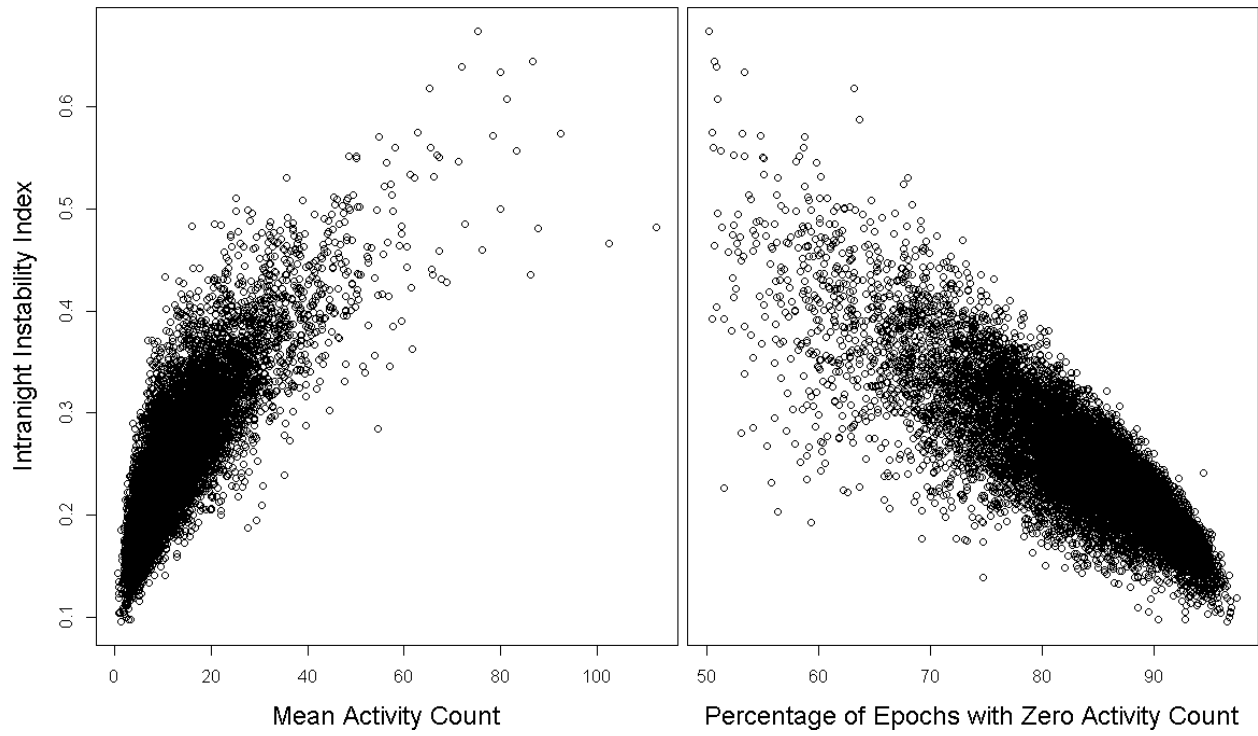
Supplemental Figure 1: Scatterplot of Intranight Instability Index Depending on Daily Mean Activity and Percentage of Epochs with Zero Activity Count for Sueño Actigraphy Data.

Supplemental Table 1: Characteristics by Weekly Trajectory Classes.

Variables	Trajectory Classes for WASO					Trajectory Classes for Daytime Napping Duration				Trajectory Classes for Intranight Instability Index			
	Low-stable Mean or % (95 % CI)	Moderate-stable Mean or % (95 % CI)	High-stable Mean or % (95 % CI)	Increasing Mean or % (95 % CI)	High-concave Mean or % (95 % CI)	Low Mean or % (95 % CI)	Increasing Mean or % (95 % CI)	Decreasing Mean or % (95 % CI)	High-concave Mean or % (95 % CI)	Low Mean or % (95 % CI)	Moderate Mean or % (95 % CI)	High Mean or % (95 % CI)	Highly Variable Mean or % (95 % CI)
Sueño Sleep (Average)													
Duration Sleep (hours)	7.28 (7.2,7.4)	7.94 (7.8,8.1)	8.39 (8.0,8.7)	7.88 (7.3,8.5)	8.12 (7.2,9.1)	7.70 (7.6,7.8)	7.44 (7.2,7.7)	7.62 (7.4,7.8)	6.77 (6.5,7.1)	7.53 (7.4,7.6)	7.65 (7.5,7.8)	7.75 (7.5,8.0)	7.25 (6.7,7.8)
Sleep Onset Latency	8.44 (7.9,8.9)	13.39 (12.2,14.6)	18.70 (13.8,23.6)	12.83 (7.2,18.5)	31.30 (7.8,54.8)	11.94 (10.9,13.0)	8.85 (7.6,10.1)	10.11 (8.6,11.6)	10.00 (7.7,12.3)	6.62 (6.2,7.0)	10.53 (9.9,11.2)	16.97 (14.4,19.6)	28.36 (21.1,35.6)
WASO	37.75 (36.9,38.6)	66.96 (65.9,68.0)	103.83 (100.1,107.6)	86.29 (76.2,96.4)	144.13 (130.6,157.6)	54.84 (52.7,56.9)	52.45 (45.9,59.0)	54.60 (51.7,57.5)	52.13 (45.2,59.1)	34.88 (33.8,36.0)	55.28 (53.7,56.9)	79.09 (75.5,82.7)	101.60 (91.4,111.8)
Sleep Efficiency	88.81 (88.5,89.1)	82.38 (81.8,83.0)	75.50 (74.3,76.7)	78.87 (76.5,81.3)	65.68 (59.9,71.4)	85.17 (84.6,85.7)	85.68 (84.0,87.4)	85.59 (84.8,86.4)	84.47 (82.7,86.2)	90.41 (90.2,90.6)	85.28 (85.0,85.6)	78.66 (77.7,79.6)	71.16 (69.5,72.8)
Sleep Fragmentation	17.35 (17.0,17.7)	25.32 (24.6,26.0)	33.93 (32.6,35.2)	32.37 (28.4,36.3)	42.80 (37.5,48.2)	21.79 (21.1,22.4)	20.70 (18.5,22.9)	21.83 (20.8,22.9)	22.47 (20.3,24.6)	15.55 (15.2,15.9)	22.20 (21.8,22.6)	29.05 (27.8,30.3)	37.13 (35.0,39.2)
Sleep Interval Midpoint	4.01 (3.9,4.2)	4.24 (4.1,4.4)	4.25 (3.8,4.7)	4.11 (3.4,4.8)	4.97 (3.8,6.1)	4.18 (4.0,4.3)	3.62 (3.2,4.0)	3.94 (3.8,4.1)	4.61 (4.0,5.2)	3.95 (3.8,4.1)	4.17 (4.0,4.3)	4.17 (3.9,4.5)	4.56 (4.2,5.0)
Daytime Nap Duration (mins)	15.07 (12.9,17.2)	10.43 (8.2,12.6)	17.42 (10.3,24.6)	11.89 (2.1,21.7)	14.37 (4.7,24.0)	1.65 (1.4,1.9)	25.47 (22.6,28.4)	23.90 (22.4,25.4)	79.67 (72.1,87.3)	14.36 (12.3,16.4)	12.84 (10.6,15.1)	14.64 (10.0,19.3)	13.93 (7.2,20.6)
Mean of Activity in Sleep Intervals	9.63 (9.2,10.1)	15.28 (14.4,16.2)	23.79 (20.7,26.8)	20.00 (16.0,24.0)	43.96 (24.1,63.8)	12.96 (12.2,13.7)	14.10 (10.2,18.0)	13.06 (11.7,14.5)	14.35 (12.1,16.6)	8.03 (7.7,8.4)	12.57 (12.1,13.1)	19.70 (18.0,21.4)	31.18 (26.0,36.4)
SD of Activity in Sleep Intervals	40.15 (39.1,41.2)	52.26 (50.7,53.8)	64.62 (61.2,68.0)	55.90 (48.8,63.0)	83.93 (65.1,102.8)	46.51 (45.3,47.8)	46.95 (42.0,51.9)	46.73 (44.7,48.7)	48.96 (44.3,53.6)	37.61 (36.5,38.7)	47.12 (46.0,48.2)	57.55 (55.0,60.1)	70.94 (65.0,76.9)
Intranight Instability Index	0.23 (0.2,0.2)	0.28 (0.3,0.3)	0.34 (0.3,0.4)	0.32 (0.3,0.3)	0.43 (0.4,0.5)	0.25 (0.2,0.3)	0.27 (0.2,0.3)	0.25 (0.2,0.3)	0.27 (0.2,0.3)	0.21 (0.2,0.2)	0.25 (0.3,0.3)	0.32 (0.3,0.3)	0.39 (0.4,0.4)
Demographic and Clinic													
Age	41.37 (40.3,42.4)	40.20 (38.8,41.6)	39.71 (36.4,43.0)	40.96 (34.5,47.4)	39.18 (31.3,47.1)	40.77 (39.7,41.8)	40.54 (37.5,43.6)	41.56 (39.9,43.2)	39.33 (35.8,42.9)	41.55 (40.2,42.9)	40.34 (39.0,41.6)	40.70 (38.6,42.8)	40.58 (37.3,43.9)
Male	42.41 (38.5,46.3)	50.62 (44.7,56.5)	63.43 (53.5,73.4)	62.93 (39.1,86.8)	90.57 (80.9,100.0)	47.90 (44.0,51.8)	47.64 (35.6,59.7)	44.58 (38.4,50.7)	55.33 (43.7,66.9)	35.61 (31.0,40.2)	48.61 (43.9,53.4)	60.77 (53.5,68.0)	78.45 (68.4,88.5)
Background													
Mexican	39.14 (33.6,44.7)	33.48 (27.6,39.4)	17.86 (8.3,27.4)	28.39 (6.1,50.7)	30.52 (0.0,62.5)	36.84 (31.1,42.6)	38.07 (25.6,50.5)	32.37 (25.5,39.2)	29.08 (16.5,41.7)	41.04 (34.3,47.7)	35.93 (30.5,41.3)	27.34 (19.0,35.7)	17.78 (6.2,29.3)
DOMINICAN	11.60 (8.6,14.6)	14.85 (10.4,19.3)	16.50 (5.7,27.3)	20.56 (0.0,52.6)	2.17 (0.0,6.5)	13.12 (9.6,16.6)	9.97 (2.7,17.3)	11.70 (7.2,16.2)	19.95 (7.3,32.6)	11.86 (8.0,15.7)	13.38 (9.9,16.9)	13.72 (6.9,20.5)	16.21 (4.5,27.9)
Central/South American	10.21 (7.9,12.6)	9.97 (7.2,12.8)	8.89 (4.6,13.2)	6.59 (0.0,13.3)	3.81 (0.0,11.4)	9.42 (6.9,11.9)	12.29 (6.8,17.7)	10.22 (7.0,13.4)	10.80 (5.1,16.5)	9.60 (6.9,12.3)	10.23 (7.7,12.8)	11.55 (7.9,15.2)	4.86 (1.6,8.1)
CUBAN	23.00 (17.5,28.5)	17.09 (12.1,22.1)	24.61 (15.2,34.1)	27.05 (7.5,46.6)	16.36 (0.0,34.5)	20.65 (15.1,26.2)	18.52 (8.2,28.9)	22.76 (16.9,28.7)	24.03 (12.2,35.8)	21.26 (15.5,27.0)	21.15 (16.1,26.1)	20.48 (12.0,28.9)	23.58 (10.7,36.4)

Puerto Rican	16.05 (12.4,19.7)	24.61 (18.4,30.9)	32.13 (20.2,44.1)	17.41 (1.8,33.0)	47.14 (18.4,75.9)	19.96 (16.1,23.8)	21.14 (9.4,32.9)	22.95 (16.8,29.1)	16.15 (8.3,24.0)	16.25 (12.0,20.5)	19.31 (14.9,23.7)	26.91 (18.6,35.2)	37.57 (23.4,51.8)
Employment													
Not Employed	47.23 (43.2,51.3)	51.91 (46.3,57.5)	65.97 (55.7,76.3)	42.39 (17.7,67.1)	48.09 (19.0,77.2)	50.93 (47.1,54.8)	39.74 (27.5,52.0)	49.32 (42.8,55.9)	55.63 (43.5,67.7)	50.43 (45.2,55.6)	48.41 (43.8,53.0)	54.13 (45.4,62.8)	50.97 (37.3,64.6)
Part-time Shift	12.49 (9.6,15.4)	10.48 (6.5,14.4)	10.96 (3.4,18.5)	8.77 (0.0,19.2)	6.78 (0.0,15.0)	10.80 (8.2,13.4)	8.71 (1.8,15.6)	12.45 (8.4,16.5)	18.83 (7.5,30.2)	11.61 (8.1,15.2)	11.72 (8.5,15.0)	13.79 (7.3,20.2)	4.83 (0.0,11.5)
Part-time Non-Shift	7.72 (5.8,9.7)	5.69 (2.9,8.4)	1.22 (0.0,2.9)	22.37 (0.0,54.1)	----	6.72 (4.6,8.8)	4.59 (1.3,7.8)	8.13 (4.7,11.5)	3.88 (0.5,7.3)	7.59 (4.9,10.2)	5.52 (3.8,7.2)	9.26 (3.0,15.5)	3.66 (0.0,8.4)
Full-time Shift	11.95 (9.8,14.1)	15.87 (11.6,20.1)	13.34 (7.5,19.2)	9.36 (0.0,19.1)	21.86 (0.0,48.7)	13.26 (10.9,15.7)	16.17 (8.4,23.9)	12.99 (8.5,17.5)	13.36 (6.0,20.7)	11.74 (9.1,14.4)	14.13 (11.4,16.9)	10.18 (6.2,14.1)	26.03 (11.9,40.2)
Full-time Non-Shift	20.61 (17.2,24.0)	16.06 (12.5,19.6)	8.51 (1.0,16.0)	17.11 (2.3,31.9)	23.27 (0.0,51.8)	18.29 (15.5,21.0)	30.79 (17.7,43.9)	17.11 (12.8,21.4)	8.30 (1.7,14.9)	18.62 (14.9,22.4)	20.22 (16.8,23.7)	12.65 (7.8,17.5)	14.51 (3.1,26.0)
Hypertension	23.00 (20.2,25.8)	25.89 (21.4,30.4)	33.96 (22.5,45.4)	30.59 (11.9,49.3)	55.67 (26.4,84.9)	23.34 (20.3,26.3)	20.71 (12.2,29.2)	28.88 (23.5,34.3)	36.11 (23.4,48.8)	23.43 (20.0,26.9)	22.01 (18.5,25.5)	35.33 (27.1,43.6)	35.38 (20.7,50.1)
Obesity	41.44 (37.5,45.4)	44.30 (38.3,50.3)	43.85 (31.5,56.2)	66.23 (45.2,87.2)	41.61 (13.4,69.8)	41.96 (37.9,46.0)	45.34 (32.9,57.8)	41.02 (34.5,47.6)	56.41 (44.4,68.4)	38.48 (33.5,43.5)	42.68 (38.1,47.3)	53.25 (45.2,61.4)	45.39 (29.8,61.0)

Supplemental Table 2: Associations between Average Sleep Measures and Obesity and Hypertension

adjusted for age, gender, race, site, employment, and sleep duration.

Variable	Response Variables			
	Obesity OR (95% CI)	**p**	**Hypertension** OR (95% CI)	**p**
Intranight Instability Index	1.17(1.02,1.35)	0.027	1.28(1.09,1.51)	0.003
Sleep Duration	0.84(0.74,0.96)	0.005	0.96(0.81,1.14)	0.570
Latency	0.93(0.82,1.07)	0.201	0.93(0.81,1.06)	0.697
WASO	1.13(0.98,1.30)	0.106	1.31(1.10,1.57)	0.002
Efficiency	0.94(0.81,1.08)	0.423	0.80(0.67,0.96)	0.011
Fragmentation	1.14(0.99,1.32)	0.096	1.27(1.08,1.50)	0.003
Mean_activity	1.05(0.92,1.20)	0.484	1.24(1.04,1.47)	0.017
SD_activity	0.98(0.86,1.13)	0.809	1.15(0.98,1.35)	0.085
Intradaily Variability	1.12(0.97,1.29)	0.127	1.20(1.02,1.42)	0.031

All the sleep measures are modeled using standardized z-score. The intradaily variability is calculated based on van Someren et al. (1996). [3]

Supplemental Table 3: BIC for different number of trajectory classes with quadratic form.

Trajectory Analysis for WASO			
	2 Groups	3 Groups	4 Groups	5 Groups
BIC	-10600.90	-10162.97	-10008.87	-9871.61
Trajectory Analysis for Daytime Napping Duration			
	2 Groups	3 Groups	4 Groups	5 Groups
BIC	-7896.27	-7780.03	-7727.11	-7742.36
Trajectory Analysis for Intranight Instability Index			
	2 Groups	3 Groups	4 Groups	5 Groups
BIC	20069.27	20582.14	20738.14	20805.95

Supplemental Table 4: Mean posterior probability of individuals being member of assigned classes.

WASO						
	ALL	Low-stable	Moderate-stable	High-stable	Increasing	High-concave
Posterior Probability	0.90	0.93	0.85	0.89	0.91	0.99
Daytime Napping Duration						
	ALL	Low-stable	Increasing	Decreasing	High-concave	
Posterior Probability	0.85	0.89	0.74	0.77	0.85	
Intranight Instability Index						
	ALL	Low	Moderate	High	Highly Variable	
Posterior Probability	0.87	0.89	0.84	0.87	0.92	

Supplemental Table 5: Distribution of Trajectory Classes by Employment Status.

	Unemployed N (%)	Non-shift Workers N (%)	Shift Workers N (%)	P	P12	P13	P23
N=	997	552	480				
WASO							
Low-stable	558 (56.0)	378 (68.5)	290 (60.4)	<.001	<.001	0.592	.001
Moderate-stable	323 (32.4)	146 (26.5)	138 (28.8)				
High-stable	87 (8.7)	14 (2.5)	40 (8.3)				
Increasing	18 (1.8)	10 (1.8)	7 (1.5)				
High-concave	11 (1.1)	4 (0.7)	5 (1.0)				
Nap							
Low-stable	642 (64.4)	363 (65.8)	290 (60.4)	.001	<.001	.248	.006
Increasing	48 (4.8)	51 (9.2)	34 (7.1)				
Decreasing	241 (24.2)	122 (22.1)	123 (25.6)				
High-concave	66 (6.6)	16 (2.9)	33 (6.9)				
Intranight Instability Index							
Low	348 (34.9)	237 (42.9)	179 (37.3)	.008	.001	.718	.082
Moderate	432 (43.3)	237 (42.9)	207 (43.1)				
High	165 (16.6)	62 (11.2)	73 (15.2)				
Highly variable	52 (5.2)	16 (2.9)	21 (4.4)				

P: pvalue of chi-square test of association between trajectory classes and three category employment status; P12: pvalue of chi-square test of association between trajectory classes and two category employment status (unemployed and non-shift worker); P13: pvalue of chi-square test of association between trajectory classes and two category employment status (unemployed and shift worker); P23: pvalue of chi-square test of association between trajectory classes and employment status (non-shift and shift workers).

Supplemental Table 6: Power to Detect the Indicated Odds Ratio for Obesity and Hypertension by

Sleep Trajectory Classes.

WASO	Obesity		Hypertension		Daytime Napping Duration	Hypertension		Intranight Instability Index	Obesity		Hypertension	
	OR	Power (%)	OR	Power (%)		OR	Power (%)		OR	Power (%)	OR	Power (%)
Reference	Low-stable				Low-stable			Low				
Moderate-stable	1.13	24	1.10	15.2	Increasing	0.88	22	Moderate	1.30	83	1.01	5
High-stable	1.25	25	1.92	**96**	Decreasing	1.27	31	High	1.90	**99**	1.86	**99**
Increasing	3.64	**97**	1.35	15	High-concave	2.27	**99**	Highly Variable	1.31	22	1.85	76
High-concave			5.25	**95**								

The indicated odds ratio is the odds ratio in tables 1 and 2.

Supplemental Table 7: Characteristics of Employment by WASO Trajectory Classes.

Variables	Low-stable Mean or % (95 % CI)	Moderate-stable Mean or % (95 % CI)	High-stable Mean or % (95 % CI)	Increasing Mean or % (95 % CI)	High-concave Mean or % (95 % CI)	P
N=2043	1235	610	142	36	20	
currently employed	64.34 (60.2,68.5)	51.06 (45.1,57.0)	33.72 (22.7,44.7)	56.76 (33.5,80.0)	47.34 (17.9,76.7)	<.001
N=1179	780	318	55	17	9	
Working Hours/week	37.13 (35.5,38.7)	37.33 (35.4,39.3)	35.17 (31.3,39.1)	47.54 (34.8,60.2)	39.05 (30.0,48.1)	0.444
More than one job (yes)	12.35 (9.1,15.6)	11.50 (6.6,16.4)	25.52 (9.9,41.2)	8.08 (0.0,19.2)	21.43 (0.0,52.7)	0.199
Working Month/year	10.75 (10.5,11.0)	10.65 (10.2,11.1)	10.16 (9.2,11.1)	10.53 (7.8,13.2)	9.89 (8.5,11.3)	0.568
Working Days/week	4.86 (4.7,5.0)	4.90 (4.7,5.1)	4.60 (4.2,5.0)	5.14 (4.2,6.1)	4.85 (3.9,5.8)	0.705
Regular work schedule (yes)	69.56 (65.2,74.0)	65.88 (58.4,73.3)	67.49 (50.9,84.0)	76.16 (46.7,100.0)	94.28 (82.5,100.0)	0.511
Days (work extra hours)/month	2.45 (1.9,3.0)	2.22 (1.5,2.9)	3.95 (0.9,7.0)	1.43 (0.0,3.5)	1.81 (0.7,3.0)	0.534
Ever Shift in Current Job (yes)	28.33 (23.6,33.1)	25.47 (18.8,32.1)	41.97 (27.1,56.8)	57.67 (19.9,95.5)	78.04 (51.1,100.0)	0.004
Shift ≥ 3 day per week in Current Job (yes)	11.87 (9.1,14.7)	11.45 (6.3,16.6)	18.33 (4.3,32.4)	15.02 (0.0,32.9)	9.74 (0.0,24.8)	0.799
Hours (home-to-work)	0.15 (0.1,0.2)	0.20 (0.1,0.3)	0.27 (0.1,0.4)	0.46 (0.0,0.9)	0.53 (0.1,1.0)	0.079
Hours (work-to-home)	0.19 (0.2,0.2)	0.23 (0.1,0.3)	0.27 (0.1,0.4)	0.86 (0.0,1.7)	0.53 (0.1,1.0)	0.203
N=864	455	292	87	19	11	
Homemaker	44.91 (38.4,51.4)	40.65 (32.1,49.2)	33.38 (19.8,46.9)	40.44 (13.7,67.2)	31.19 (0.0,71.5)	0.603
Student	11.42 (6.6,16.3)	9.67 (3.8,15.6)	12.12 (0.6,23.6)	----------	---------	---------
Retired/Disabled	18.42 (14.2,22.6)	21.10 (15.0,27.2)	25.18 (11.5,38.8)	27.41 (2.1,52.7)	41.05 (3.1,79.0)	0.456

Ever shift: ever late night shift (after midnight) or ever early morning shift (start work before 6 am)

Supplemental References

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2. Nagin DS, Odgers CL. Group-based Trajectory Modeling in Clinical Research. *The Annual Review of Clinical Psychology*. 2010;6:109-138.

3. van Someren EJW, Hagebeuk EEO, Lijzenga C, Scheltens P, deRooij SEA, Jonker G, Pot AM, Mirmiran M, Swaab DF. Circadian rest-activity rhythm disturbance in Alzheimer's disease. *Biological Psychiatry*. 1996;40 (4):259-270.