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An analysis of shiftwork and self-reported depressive symptoms in a police cohort from Buffalo, New York

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ABSTRACT

Shiftwork has been associated with elevated depressive symptoms; police officers frequently work shifts and may experience depressive symptoms. This study assessed the association between depressive symptoms and shiftwork in a police cohort from Buffalo, New York, USA using a repeated cross-sectional design with data collected in 2004–2009 (n = 428) and 2010–2014 (n = 261). Electronic payroll records were used to quantitatively classify officers on the day, evening, or night shift based on the shift they spent most of their working hours. Two self-reported depressive symptomology measures were used as outcomes – the Center for Epidemiological Studies – Depression (CES-D) scale and the Beck Depression Inventory (BDI). Repeated measures linear and logistic regression analyses were used to estimate least squares means or odds, respectively, of depressive symptom questionnaire scores by shiftwork category. Those working the evening/night shift had higher odds for depressive symptoms according to the BDI (based on a cut-point score of 14) than those working the day shift (OR = 4.60, 95% CI = 1.15–18.39). Similar results were observed for the evening shift group. No differences in mean CES-D or BDI scores were observed between groups for short-term shiftwork, long-term shiftwork, or shift changes. After stratifying by stress, as measured by the Perceived Stress Scale (PSS), total Impact of Events (IES), and the Spielberger Police Stress Survey (SPSS), mean values for depressive symptoms were higher in the high-stress categories regardless of shiftwork status. Further research should include biomarkers for depression, a longitudinal study design with a larger cohort, and joint effects of shiftwork and stress on depressive symptoms.

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Introduction

Shiftwork is inevitable in today's society. It is classified as shifts that are outside the typical working hours of 09:00 h to 17:00 h and affects over 15 million Americans (National Institute for Occupational Safety and Health 2013). Because of reversed working hours, shift workers are susceptible to sleep-related problems and other detrimental health issues, such as an increased risk for cardiovascular disease (CVD), decreased alertness and concentration, depression, suicide, and lower quality of life (Harrington 2001; Ma et al. 2015).

Working atypical shifts disrupts the natural 24 h cycle that maintains the processes within the human body, such as body temperature, hormone production, cell division, and respiratory rate (Harrington 2001). This endogenous cycle, also known as our circadian rhythm, is governed by light cues from the environment that are sent to the suprachiasmatic nucleus (SCN) via retino-geniculo-hypothalamic pathways (Pett et al. 2016). Shift workers are not exposed to environmental light cues in the usual way due to their reversed sleeping patterns or, at least, their cues are different from those working a traditional day shift. The disruption of this sleep-wake cycle increases the chances of developing numerous morbidities such as depression (Pandi-Perumal et al. 2006).

Many observational studies have found a relationship between the risk of mental illnesses and night shiftwork (Bildt and Michélsen 2002; Driesen et al. 2011). A recent meta-analysis by Lee et al. not only found a relationship between overall night shiftwork and increased levels of depressive symptoms but also within subgroups based on gender, night shift duration, and type of occupation (Lee et al. 2017). Several mechanisms that can lead to

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depression have been shown to be affected by night shiftwork, such as the reduction of melatonin production, increased stress, and increased inflammation. Located in the SCN, melatonin receptors are heavily dependent on a regulated sleep-wake cycle and work with other neurotransmitters that greatly affect mood (Monteleone et al. 2011; Salgado-Delgado et al. 2011). Stress also can be a result of poor sleep patterns often associated with night shiftwork and is a precedent to the development of depression (Ramey et al. 2012). Increases in inflammatory biomarkers, such as interleukin-6, tumor necrosis factor-alpha, and c-reactive protein, are associated with working the night shift as well as major depression (Khosro et al. 2011; Leonard 2007; Puttonen et al. 2011).

One occupation that includes a significant degree of shiftwork is law enforcement. Generally, police officers have worse health prognoses than the general population (Habersaat et al. 2015; Ma et al. 2015; Wirth et al. 2012). Many studies have concluded that police officers have a high rate of obesity, which could be due to stress and poor sleep habits, and cause a variety of adverse health outcomes (Charles et al. 2007; Thayyil et al. 2012). Officers working the night shift and who slept <6 h had a higher risk of developing metabolic syndrome components that are accompanied by several anthropological and biochemical abnormalities, such as high blood pressure and adiposity (Thayyil et al. 2012; Violanti et al. 2009a). Additionally, it has been shown that officers have an increased risk for developing psychological problems, with much of the stress exposure and depressive symptoms occurring as early as their first year of service (Habersaat et al. 2015; Wang et al. 2010). A previous study of the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) cohort identified a three-fold higher risk of suicide compared to a population of municipal workers (Violanti et al. 2009b).

To our knowledge, this study is unique compared to previous research in its utilization of multiple data collection time points with a variety of shiftwork measures. This study investigated whether exposure to shiftwork over a short period of time (i.e., 2 weeks) and a longer period of time (i.e., years), as well as number of shift changes over a period of years was associated with self-reported depressive symptoms. Additionally, self-reported stress was examined as a potential effect modifier. Specific hypotheses included those working primarily the night or evening shift will have higher levels of self-reported depressive symptoms as measured by the Center for Epidemiological Studies – Depression (CES-D) scale and the Beck Depression Inventory-II, referred to in this study as BDI, compared to those primarily working the day shift. We also hypothesized that those with a high number of shift changes will have higher levels of self-reported depressive symptoms compared to those with fewer shift changes. For the role of stress, we hypothesized that among officers who have high stress levels, the effect of working the night shift on depression may be more profound than officers who work the day or evening shifts.

Methods

Data

The BCOPS study included active officers who were invited to participate and provided informed consent; protocols were approved by the National Institute for Occupational Safety and Health (NIOSH) Human Subjects Review Board (HSRB 10-HELD-01) and the Internal Review Board of the State University of New York at Buffalo (MODCR00000081) (Ma et al. 2015). These approvals indicate that the protocol conforms to international ethical standards (Portaluppi et al. 2010). In this study, data from cross-sectional analyses were collected on all variables (outcome, confounders, and effect modifiers), except shiftwork data, during two time periods. The first wave consisted of a single examination date between 2004 and 2009 (N = 464, reduced to 428 by excluding retirees and new recruits) that corresponded to a training day with a daytime work schedule or a day off. The second wave occurred on a single date between 2010 and 2014 (N = 271, reduced to 261 by excluding retirees and new recruits). Retirees were excluded because the examination date was at least 6 months after their retirement and responses might not be reflective of their exposure to shiftwork. New recruits were excluded because they may not have had any exposure to shiftwork.

Given the dominant shiftwork classification for these officers was based on data from 1994 using City of Buffalo, NY electronic payroll records (see below for more details), we expected the relationship between shiftwork and depression to remain the same over time. To confirm this, the interaction term between shiftwork and the time variable was not found to be statistically significant in any form of the analyzed models. Therefore, data were incorporated from both the 2004–2009 and the 2010–2014 examination dates to include more observations. Since all of the responses in the 2010–2014 survey were from the same officers interviewed in 2004–2009, we wanted to account for the fact that these responses could be correlated. The analysis used a time variable (2004–2009 or 2010–2014) and a compound symmetry covariance structure in a repeated-measures setting to allow for this possible correlation. This model also allowed for time-varying covariates when appropriate.

In general, data collection included basic demographics, lifestyle behaviors, work experience, anthropometric information (e.g., body mass index [BMI], waist circumference, abdominal height, blood pressure), psychometric measures (e.g., stress, depression, social support), biomarkers of subclinical cardiovascular disease (e.g., lipids, fibrinogen, e-selectin), and shiftwork from electronic payroll records (Violanti et al. 2006). Blood samples were collected after each officer had been off-duty for at least 3 days and fasted for a minimum of 8 h. Prior to 08:30 h, blood samples were collected, and an identification number blinded the clinical samples. The University of Vermont Laboratory for Clinical Biochemistry Research assessed the samples for various biomarkers (e.g., stress, obesity, and CVD) and the Kaleida laboratories in Buffalo, NY performed a chemistry panel and a blood lipid panel on the blood samples. Data collection and protocols were consistent throughout the study as described elsewhere (Violanti et al. 2006).

Shiftwork

Daily shiftwork information was obtained via the Buffalo, New York Police Department electronic payroll records. Shifts were classified by their start time and categorized into day/morning shift, evening shift, and night shift, using data spanning the period from the first day of work or when electronic records first became available (1994) until their date of examination (Wirth et al. 2017). Officers were scheduled on 10 h permanent (non-rotating) shifts. Although officers were scheduled on permanent shifts since 1994, they occasionally worked on shifts other than their permanent shift in their districts or other districts to cover for other officers who may be on sick or injury leave or on vacation. The total hours worked by each participant during the time period spanning from 1994 to date of exam was partitioned into hours worked on the day, afternoon, and night shift. For 99% of the records, work start times were consistent with standard shift start times of 07:00 or 08:00 h (for day shift), 16:00 h (for evening shift), and 20:00 or 21:00 h (for night shift). For the 1% of shifts that did not follow the standard shift start times, the following ranges were used for categorization based on shift start time: day shift if start times between 04:00 and 11:00 h; evening shift if start times between 12:00 and 19:59 h; and night shift if start times between 20:00 and 03:59 h. A dominant shift for each officer was defined as the shift that had the largest percentage of the total hours worked. For example, officer who worked 25% on the day, 65% on the afternoon, and 10% on the night shift was classified as an afternoon shift worker (the dominant shift). For about 85% of officers, 70% of work hours were spent primarily in one shift type. This method of shift categorization revealed consistency over 30, 60, or 90 days (Wirth et al. 2011). A similar mechanism was used to derive the short-term shiftwork variables over a two-week time period prior to each assessment. Number of shift changes was defined as the number of times an officer switched shifts from the first day of work, or when records became available in 1994, until the examination date.

Self-reported depression scales

Depression was measured from two self-reported questionnaires, the BDI and the CES-D. The BDI consists of 21 items scored on a 4-point scale; it measures severity of symptoms of depression as listed in the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* Fourth Addition (American Psychiatry Association 1994). It is tailored to the general population, and can be completed in approximately 10 min (Beck et al. 1961; Groth-Marnat 2009). Potential cutoff points greatly varied between populations with limited research being conducted to validate cutoff points for the BDI against a general population as well as this study's specific population. Therefore, a cutoff score cannot be calculated to differentiate between patients with and without a depressive disorder. For this study, a value of ≥14 was chosen as the cutoff point to dichotomize results, comparing officers who had no depressive symptoms to those who had mild to severe depressive symptoms, because it encompassed all levels of depressive symptoms (mild, moderate, and severe)(Dolle et al. 2012).

The CES-D consists of 20 items scored on a 4-point scale according to how often each symptom occurred in the past week: 0 (rarely or none of the time [less than 1 day]), 1 (some or little of the time [1–2 days]), 2 (occasionally or a moderate amount of the time [3–-4 days]), and 3 (most of the time [5–7 days]). Items are related to sadness, loss of interest, appetite, sleep, thinking, guilt, fatigue, agitation, and suicidal ideation to measure symptoms of depression. After reverse coding selected items, the sum of the scores represents the overall CES-D score that ranges from 0 to 60. According to the tool, clinical depression is indicated by a score of ≥16 (Radloff 1977; Smarr and Keefer 2011).

Stress and additional covariates

Stress was examined as a potential effect modifier. The stress measures included the Spielberger Police Stress

Survey (SPSS), Perceived Stress Scale (PSS), and Total impact of events (IES). The SPSS inventory consists of stress ratings applied to 60 common events prevalent in police work and can be scored from 0 to 100 (Spielberger et al. 1981). Stress indices are then calculated by multiplying the rating by the frequency from the past year or the past month for a score that represents recent events, then creating an overall stress index. The PSS measures global stress levels instead of event-specific stress. The 14 questions are scored on a 5-point scale ranging from "never" to "very often" and assess situations over the past month (Cohen et al. 1983). The IES measures post-traumatic stress disorder (PTSD) symptoms and is responded to on a scale of 1–5 (Horowitz et al. 1979).

Potential covariates consisted of demographic information (age, sex, race/ethnicity, education, officer rank), BMI (kg/m^2), the Dietary Inflammatory Index (DII, an established index of dietary inflammatory potential), cigarette and alcohol usage, lipid biomarkers (glucose and triglycerides (mg/dl)), blood pressure (mmHg), and measures of sleep quality (Pittsburgh Sleep Quality Index [PSQI]). Speaking to lipid biomarkers and the DII as they may not be obvious confounders, the DII and lipid biomarkers have previously been shown to be associated with both shiftwork and depressive symptoms (Harrington 2001; Lassale et al. 2019; Wirth et al. 2014). Hence, they were collected at both examinations dates and were examined as potential confounders.

Statistical analysis

All analyses were conducted in SAS v.9.4 (SAS Institute, Cary, NC, USA). Outcomes were from the CES-D and the BDI, both as numeric and dichotomized variables. The main exposure was shiftwork, assessed by long-term shiftwork, short-term shiftwork, and number of shift changes. Analyses examined long- and short-term shiftwork on two levels (day vs. evening/night) and three levels (day vs. evening vs. night). Number of shift changes were transformed into tertiles to obtain least square means of the outcomes with the primary comparison being between tertiles 1 and 3.

Descriptive statistics for categorical variables were obtained from frequencies and chi-square tests. Means and standard deviations were calculated for numeric variables. Models adjusted for only age and sex were run before building the multivariate models. To build the multivariable models, a series of univariate procedures indicated potential confounders associated with the outcome at a p-value of ≤0.20 using PROC MIXED with a compound symmetry covariance structure. A p-value of ≤0.20 was chosen to be more inclusive for the next step in the model building process. All covariates selected through the univariate models were added to a full model. From here, variables were removed one at a time. The final model consisted of all covariates that changed the beta coefficient of shiftwork by at least 10% or were, themselves, statistically significant predictors of the outcome. Time (i.e., clinic visit between 2004–2009 or 2010–2014) was included in all models.

The CES-D and BDI were dichotomized for logistic models using questionnaire-specific categorization. The presence of depressive symptoms according to the CES-D is indicated by a score of ≥16, considered clinical depression. Depressive symptomology according to the BDI is indicated by a score of ≥14, which encompassed mild, moderate, and severe symptoms.

To examine the potential role of stress as an effect modifier on the association between shiftwork and depression (as binary outcome), we a fit a series of models by including the interaction term between shiftwork and stress measure. Cut points, determined from the medians, for the stress measures were 9 on the IES, 27 on the PSS, and 3,285 for the SPSS; higher scores indicate higher levels of self-reported stress for all scales. P-values were obtained for the interaction between stress and independent shiftwork variables for each outcome. It should be noted that the correlation coefficients between the three stress measures were<0.60 indicating only a moderate correlation at best (Schober et al. 2018). Therefore, all three were used as described above as opposed to selection of just one.

Results

At the 2004–2009 visit, the average age of this population was 42.6 ± 7.9 y. Most officers were European-American (78%), never smokers (50%), had a rank of police officers as opposed to captains or detectives (66%), and were overweight (average BMI of 29.3 ± 4.8 kg/m^2). Compared to the day shift, those who worked the evening/night shift during the 2004–2009 visit were more likely to be European-American (89% vs. 68%, $p < .01$), younger (39.9 ± 7.0 y vs. 46.1 ± 7.6 y, $p < .01$), and a rank of police officer (74% vs. 54%, $p < .01$). Triglyceride levels (mg/dl) were significantly higher in the evening/night shift compared to the day shift officers (139.0 ± 99.5 vs. 123.7 ± 108.4, $p < .01$, Table 1). About 11% of officers classified as depressed on the CES-D and 11% of officers had mild, moderate, or severe depressive symptomology on the BDI (data not tabulated).

Those who did not participate in the second visit were more likely to have less than a college education (17% vs. 9%, $p < .01$), a rank categorized as "Other" (18% vs. 4%,

Table 1. Characteristics of the Buffalo cardio-metabolic police stress study (BCOPS), 2004–2009 (N = 428).

Characteristics	All (n = 428) N(%)	Day (n = 188) N(%)	Evening+Night (n = 240) N(%)	Pvalue[1]
Sex				<.01
Female	110 (26)	77 (41)	33 (14)	
Male	318 (74)	111 (59)	207 (86)	
Race				<.01
European-American	331 (78)	131 (70)	200 (85)	
Other	91 (22)	55 (30)	36 (15)	
Education				0.33
< College	52 (12)	25 (13)	27 (11)	
Some College	147 (34)	69 (37)	78 (32)	
Associates Degree	88 (21)	41 (22)	47 (20)	
>Bachelor's Degree	141 (33)	53 (28)	88 (37)	
Tobacco Usage				<.01
Never	212 (50)	86 (46)	126 (53)	
Former	96 (23)	57 (31)	39 (16)	
Current	115 (27)	42 (23)	73 (31)	
Rank				<.01
Police Officer	280 (66)	102 (54)	178 (74)	
Serg., Lieut., Capt.	66 (15)	35 (19)	31 (13)	
Detective	42 (10)	22 (12)	20 (8)	
Other	40 (9)	29 (15)	11 (5)	
	Mean (SD)	Mean (SD)	Mean (SD)	
Age (years)	42.6 ± 7.9	46.1 ± 7.6	39.9 ± 7.0	<.01
BMI (kg/m^2)	29.3 ± 4.8	28.9 ± 5.2	29.7 ± 4.5	0.07
DII	−0.7 ± 2.1	−1.0 ± 2.2	−0.4 ± 2.1	<.01
Drinks per week	5.7 ± 9.7	5.9 ± 10.3	5.6 ± 9.3	0.36
Systolic BP (mmHg)	121.4 ± 12.2	121.1 ± 12.9	121.7 ± 11.9	0.65
Diastolic BP (mmHg)	77.8 ± 10.0	77.3 ± 10.1	78.3 ± 9.9	0.31
Glucose (mg/dL)	92.9 ± 11.7	93.4 ± 13.1	92.6 ± 10.5	0.52
Global PSQI[2]	6.5 ± 3.4	6.4 ± 3.7	6.6 ± 3.1	0.46
SPSS	2290.1 ± 1276.1	2332.1 ± 1326.2	2257.9 ± 1238.2	0.55
PSS	20.3 ± 7.8	20.5 ± 7.9	20.2 ± 7.7	0.71
IES	12.1 ± 12.6	12.6 ± 13.2	11.7 ± 12.1	0.46
Triglycerides (mg/dl)	132.3 ± 103.6	123.7 ± 108.4	139.0 ± 99.5	<.01
BDI	5.99 ± 5.76	6.31 ± 5.72	5.75 ± 5.8	0.44
CES-D	7.8 ± 6.92	7.57 ± 6.65	7.99 ± 7.12	0.53

Stratum numbers may not equal column total due to missing data
p-values based off chi-square tests for categorical variables and t-test/Wilcoxon ranked sums for continuous variables depending on normality
[1]comparing day vs. evening and night
Abbreviations: PSQI – Pittsburgh Sleep Quality Index, CES-D – The Center for Epidemiological Studies Depression scale, SPSS – Spielberger Police Stress Survey, PSS – Perceived Stress Scale, DII – Dietary Inflammatory Index, BMI – Body Mass Index, IES – Impact of Events, BDI – Beck Depression Inventory

$p < .01$) and be slightly older (43.8 ± 8.6 vs 41.9 ± 7.3 y, $p = .02$). However, there were no statistically significant differences in depressive symptoms or stress measures between those participants and non-participants (data not shown).

No associations were found between any of the shiftwork measures and self-reported depressive symptoms from the repeated measures linear regression models (Table 2). A model adjusted for only age and sex presented similar results (Supplemental Table 1). Although the decision to stratify results by the stress measures was *a priori, p*-values for the interaction terms between the stress measures and shiftwork were examined. Significant or nearly significant interaction term *p*-values (i.e., $p < .1$) were found between the PSS and three-level short-term shiftwork ($p = .08$) for the CES-D outcome, between the PSS and the 2-level long-term shiftwork ($p = .04$) for the CES-D outcome, and between the PSS and number of shift changes ($p = .07$) for the BDI. Additionally, significant *p*-values were found between the IES and both the 2-level and 3-level short-term shiftwork ($p = .04$ and $p = .07$, respectively) variables for the CES-D outcome.

Upon stratification by the IES, PSS, and SPPS, no statistically significant models were observed, and there were no associations between shiftwork and depressive symptoms within those classified as high stress or within those classified as low stress. Upon inspection, it can be noted that those with higher stress, compared to lower stress, had higher values for the CES-D and BDI (Supplemental Table 3, 4, and 5).

The logistic regression models yielded statistically significant results for long-term shiftwork and BDI. A model adjusted for only age and sex presented similar results (Supplemental Table 2). According to the fully adjusted model, the odds of having self-reported

Table 2. Adjusted mean values and 95% confidence intervals of depression measures for long- and short-term shiftwork and shift changes, Buffalo cardio-metabolic police stress study (BCOPS), 2004–2009 (n = 428) and 2010–2014 (n = 261).

	CES-D	*p*-value[g]	BDI	*p*-value[g]
Short-Term SW				
Day	7.29(6.06–8.53)[a]	Ref.	6.02(5.39–6.64)[c]	Ref.
Evening	7.42(5.91–8.92)	0.83	6.70(5.79–7.60)	0.16
Night	6.99(5.24–8.64)	0.66	5.96(4.86–7.07)	0.93
Evening/ Night	7.26(5.84–8.67)	0.95	6.44(5.63–7.24)	0.32
Long-term SW				
Day	7.93(7.19–8.66)[b]	Ref.	5.72(5.06–6.39)[d]	Ref.
Evening	8.35(7.42–9.28)	0.46	6.37(5.51–7.24)	0.21
Night	7.79(6.72–8.87)	0.83	5.81(4.78–6.84)	0.88
Evening/ Night	8.13(7.32–8.94)	0.68	6.16(5.40–6.93)	0.35
Shift Changes				
0–17	8.10(7.07–9.13)[e]	Ref.	6.13(5.35–6.91)[f]	Ref.
18–48	8.02(7.04–9.00)	0.88	5.54(4.79–6.29)	0.22
49+	7.86(6.93–8.79)	0.67	6.21(5.43–6.98)	0.88

Values represent least-squares means and 95% confidence intervals via general linear models
All models adjusted for a time point
[a]Model adjusted for sex, race, smoke, rank, age, PSS, BMI, DII, SPPS, drinks per week, IES, and PSQI
[b]Model adjusted for sex, race, age, PSS, SPSS, IES, and PSQI
[c]Model adjusted for sex, race, age, PSS, IES, DII, and PSQI
[d]Model adjusted for sex, race, age, PSS, IES, and PSQI
[e]Model adjusted for sex, race, age, rank, PSS, IES, and PSQ
[f]Model adjusted for sex, race, age, DII, triglycerides, PSS, IES, and PSQI
[g]p-value comparing day to evening, day to night, or day to evening/night
Abbreviations: CES-D – Center for Epidemiological Studies Depression scale, BDI – Beck Depression Inventory, PSS – perceived stress scale, BMI – body mass index, DII – dietary inflammatory index, SPPS – Spielberger Police Stress Score, IES – total impact of events, PSQI – Pittsburgh Sleep Quality Index

depressive symptoms by the BDI among those working the evening shift were 4.90 times the odds for those working the day shift (95% CI = 1.20–19.57, p = .02), after adjusting for sex, race, age, PSS, IES, and PSQI. Additionally, the odds of BDI-classified mild to severe depression was higher among the evening/night shift groups compared to the day shift (OR = 4.60, 95% CI = 1.15–18.39, p = .03, Table 3). Overall, the odds of depressive symptoms were highest among the evening shift group using either the CES-D or BDI to define depressive symptoms, as compared to the day shift group. No associations were observed between short-term shiftwork or shift changes and depressive symptoms. The evening and night shift groups were combined for the model that included an interaction term between shiftwork and the stress measures. All the interaction p-values were not statistically significant, except for the p-value between PSS and the 2-level long-term shiftwork for the BDI (OR = 4.76, 95% CI = 1.26–17.94, $p < .01$).

Discussion

No associations were observed between the mean raw scores of the CES-D or BDI and shiftwork. It was observed that those with higher stress tended to have

Table 3. Odds ratios and 95% confidence intervals of depression measures for long- and short-term shiftwork and shift changes, Buffalo cardio-metabolic police stress study (BCOPS), 2004–2009 (n = 428) and 2010–2014 (n = 261).

	CES-D < 16 n (%)[a]	CES-D ≥ 16 n (%)[a]	CES-D OR (95% CI)	BD < 14 n (%)[a]	BDI ≥ 14 n (%)[a]	BDI OR (95% CI)
Short-Term SW						
Day	272 (52.9)	44 (59.5)	Ref.[b]	223 (56.9)	26 (54.2)	Ref.[d]
Evening	150 (29.2)	23 (31.1)	0.87(0.30–2.50)	105 (26.8)	16 (33.3)	1.28(0.33–4.88)
Night	92 (17.9)	7 (9.4)	0.51(0.19–1.38)	64 (16.3)	6 (12.5)	0.97(0.23–4.16)
Evening/Night	242 (47.1)	30 (40.5)	0.75(0.29–1.93)	169 (43.1)	22 (45.8)	1.19(0.34–4.12)
Long-term SW						
Day	227 (45.8)	36 (43.4)	Ref.[c]	210 (46.2)	21 (41.2)	Ref.[e]
Evening	193 (31.9)	32 (38.5)	1.75(0.64–4.79)	143 (31.4)	21 (41.2)	4.90(1.20–19.57)
Night	135 (22.3)	15 (18.1)	1.39(0.45–4.28)	102 (22.4)	9 (17.6)	3.74(0.68–20.45)
Evening/Night	328 (54.2)	47 (56.6)	1.64(0.63–4.27)	245 (53.8)	30 (58.8)	4.60 (1.15–18.39)
Shift Changes						
0–17	202 (33.4)	24 (28.9)	Ref.[f]	142 (31.2)	17 (33.3)	Ref.[g]
18–48	193 (31.9)	35 (42.2)	1.50 (0.66–3.42)	146 (32.1)	16 (31.4)	0.77(0.20–3.00)
49+	210 (34.7)	24 (28.9)	1.09(0.40–2.95)	167 (36.7)	18 (35.3)	1.63(0.41–6.56)

Exposed groups for the dependent variables are as follows: CES-D ≥ 16; BDI ≥ 14
All models adjusted for a time component
[a]Percents reflect two shiftwork groupings: a.) day, evening, and night and b.) day and evening/night
[b]Model adjusted for sex, race, smoke, rank, age, PSS, BMI, DII, SPPS, drinks per week, IES, and PSQI
[c]Model adjusted for sex, race, age, PSS, SPSS, IES, and PSQI
[d]Model adjusted for sex, race, age, PSS, IES, DII, and PSQI
[e]Model adjusted for sex, race, age, PSS, IES, and PSQI
[f]Model adjusted for sex, race, age, rank, PSS, IES, and PSQI
[g]Model adjusted for sex, race, age, DII, triglycerides, PSS, IES, and PSQI
Abbreviations: CES-D – Center for Epidemiological Studies Depression scale, BDI – Beck Depression Inventory, PSS – perceived stress scale, BMI – body mass index, DII – dietary inflammatory index, SPPS – Spielberger Police Stress Score, IES – total impact of events, PSQI – Pittsburgh Sleep Quality Index

higher mean CES-D and BDI scores. When the BDI was dichotomized, long-term shift work was associated with increased odds of depressive symptoms.

Previous studies have found an association between night shiftwork and depressive symptomology. A meta-analysis of 11 studies that included cross-sectional and longitudinal study designs found an overall relationship between night shiftwork and risk of depression (OR/RR, 1.43; 95% CI, 1.24–1.64). General findings from the meta-analysis concluded that older males were more likely to have depressive symptoms, as well as those exposed to stress at work and hazardous exposures. When examined over time, an increased risk for depression was found as duration (years) of night shiftwork increased (Lee et al. 2017; Luca et al. 2014). A study from the Korean National Health and Nutrition Examination Survey (K-NHANES) did not find an association between shiftwork and depressive symptoms. The prevalence of night shift workers and depressive symptoms was very low, which could explain why they did not detect a relationship (Kim et al. 2013). Our study also had low levels of those who were classified as having depressive symptoms, potentially attenuating results due to healthy worker effect and officers who left the force between time periods. Those who left the occupation may have had more depressive symptoms or switched to the day shift, which could explain the limited significant results.

Biological mechanisms, such as melatonin production and increases in inflammatory biomarkers, are associated with working the night shift (Khosro et al. 2011; Puttonen et al. 2011). Both mechanisms are related to depression and provide biological plausibility for the examined relationships (Leonard 2007; Salgado-Delgado et al. 2011). Those with depression typically have worse episodes in the morning. The time when the questionnaires were administered could affect the results, especially if depressive symptoms were more prevalent in the morning as previous literature states (Monteleone et al. 2011). Because seasonal affective disorder (SAD) may be present in the officers (Salgado-Delgado et al. 2011; Sandman et al. 2016), we adjusted for the season when their assessment took place; however, results did not change.

It is possible that by only observing significant ORs for long-term shiftwork and BDI, long-term shiftwork poses a higher risk for depressive symptoms than short-term shiftwork. Previous studies observed depressive symptoms in those working shiftwork for >4 y and >20 y, establishing a potentially long latency period for depressive symptoms (Bara and Arber 2009; Scott et al. 1997). An overall trend from the models is that the highest ORs or crude mean values were observed in the evening group compared to the day shift group. A suggested, yet unverified mechanism for these results, is the movement of officers who work the night shift and have severe depressive symptoms to a lower-risk shiftwork category, such as the evening shift. It should be noted that this is a suggested mechanism and that we do not have the data to confirm this. Many times, shifts are assigned based on seniority. If day shifts were not available for those with severe depression or psychological issues, they may be placed on the evening shift or leave the occupation all together.

Differences in the design of the questionnaires may explain why significance was observed only from the BDI. Response choices for the BDI are direct such as "0 – I don't feel disappointed in myself", "1 – I'm disappointed in myself", "2 – I am disgusted with myself", and "3 – I hate myself" while the CES-D has frequency responses of "Rarely or None of the Time", "Some or Little of the Time", "Moderately or Much of the time", and "Most or Almost All the Time". The statements of emotion in the BDI may make it a more sensitive instrument to detect depressive symptoms than the quantitative responses in the CES-D (American Psychiatry Association 1994; Smarr and Keefer 2011).

The general trend for the stratification of IES, SPSS, and PSS was that higher mean values of depressive symptoms were associated with the higher stress levels regardless of shiftwork status; indicating that stress may increase depressive symptoms more than shiftwork in this population of police officers. However, pursuing this hypothesis was outside the scope of this study. The relationship between work stress and depressive symptoms was found in a general population of shift workers who may not have as much work-related stress as police officers (Park et al. 2016). Examining the combined impact of shiftwork and stress on depressive symptoms was not in the scope of this study but could be assessed in future studies.

Strengths of this study include the variety of covariates available and the use of repeated measures to more accurately derive the standard errors of our estimated values, leading to more precise testing. Shiftwork status was reported electronically, allowing for accurate quantitative reporting and creation of different shiftwork variables. Additionally, shift duration was known, which minimized exposure misclassification. The results of this study may be generalizable to other police departments, although some utilize different work scheduling. Results also may be applicable to other high-stress, shift-working populations, such as the military. It is unlikely that depressive symptoms led officers to want work on the night shift, therefore, limiting the likelihood of reverse causality.

There are also some limitations to our study. Responder bias may have underestimated the outcome. Because the outcomes were self-reported, officers may have underreported symptoms of depression due to social desirability. Furthermore, it was not possible to use clinical data to define the outcome with the current data. Because of the nature of police officer occupation, healthy worker effect also may be present, especially since there was a 36% decrease in the study population with less than 15% exhibiting depressive symptoms. Those who would classify as severely depressed may have chosen to leave the occupation or primarily work the day shift, possibly underestimating associations. However, this is not a major concern due to the lack of a strict longitudinal study design. Another limitation to this study is the absence of total years of shiftwork history. Some literature indicates an exacerbated state of depression for those working shifts >10 y (Scott et al. 1997). We also did not have information on chronotype at the time of the study, which is known to affect sleep quality and quantity (Mongrain et al. 2005).

Future studies should examine the effects of shiftwork and the biological differences of males and females, using biomarkers instead of self-reported data. Although models were adjusted for sex, it should be noted that previous literature describes different effects of shiftwork on males and females (Driesen et al. 2011; Scott et al. 1997). From a previous study involving the BCOPS data, women who primarily worked the day shift had higher prevalence of suicide ideation than those working the evening or night shifts, whereas an increase in suicide ideations for males was present in those who primarily worked the night shift (Park et al. 2016). Future research should also examine populations primarily comprised of women in addition to general biomarkers of depression to increase validity of the outcome and its association with shiftwork. Furthermore, studies should perform a longitudinal analysis over a greater time frame due to literature citing an association with depression for longer durations of shiftwork. Additionally, future studies should consider starting with recruits who are relatively free of depressive symptoms to assess if long-term exposure to shiftwork is associated with the development of depressive symptoms.

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