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A Longitudinal Analysis Of Shiftwork And Self-Reported Depression In A Police Cohort

Meghan Holst
University of South Carolina

A LONGITUDINAL ANALYSIS OF SHIFTWORK AND SELF-REPORTED DEPRESSION IN A POLICE COHORT

by

Meghan Holst

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Accepted by:

Michael Wirth, Director of Thesis

James Burch, Reader

James Hussey, Reader

Cheryl L. Addy, Vice Provost and Dean of the Graduate School

ABSTRACT

Background: Shiftwork is associated with many chronic diseases stemming from the disruption of circadian rhythms. Police officers have a high risk for many adverse conditions including depression. Abnormal bodily functions, such as increased stress and disturbed sleeping patterns, may play an important role in the development and severity of depression. This study was designed to assess the association between depressive symptoms and shiftwork in a police cohort from Buffalo, NY.

Methods: This longitudinal analysis consists of 470 police officers from the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) study. Data were collected during visit 3 between 2004-2005 and visit 4 in 2010. Officers were classified as working the day, evening, or night shift based on the shift they spent the most of their work hours according to electronic payroll records. Other shift work variables included short-term shiftwork over the previous two weeks and number of shift changes. Two self-reported depression measures were used as the outcomes, the Center for Epidemiological Studies – Depression (CES-D) scale and the Beck Depression Inventory (BDI). Generalized linear models were used to estimate least squares means and odds ratios from repeated data. Possible effect modification was only assessed for the stress measures.

Results: Linear regression models did not produce significant results. With logistic regression, those working the evening/night shift had higher odds for depressive

symptoms according to the BDI than those working the day shift (OR = 4.60, 95% CI = 1.15-18.39). Excluding the evening shift, those working the night shift had higher odds for depressive symptoms according to the BDI than those working the day shift (OR = 4.90, 95% CI = 1.20-19.57).

There were no significant results for short-term shiftwork or number of shift changes in relation to either depression measure. Crude analyses showed highest depressive symptoms in the evening shift for the linear and logistic models. Stratifying by the stress measures did not show significance, however mean values for depressive symptoms were higher in the high stress categories for Impact of Events (IES) and perceived stress score (PSS).

Discussion: Associations were only found in the logistic regression model in regard to long-term shiftwork and depressive symptoms assessed by the BDI. After stratifying by the stress measures, mean values for depressive symptoms were higher in the high-stress categories. This may indicate that depressive symptoms are more influenced by stress than by shiftwork. Further research should include usage of biomarkers for depression, a longer study design, and assessment of total shiftwork history.

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LIST OF ABBREVIATIONS

BCOPS..................................... Buffalo Cardio-Metabolic Occupational Police Stress study

BDI .... Beck Depression Inventory

BMI .... Body Mass Index

CES-D ....Center for Epidemiological Studies Depression scale

IES... Impact of Events

PSQI ....Pittsburgh Sleep Quality Index

PSS..Perceived Stress Scale

SAD .... Seasonal Affective Disorder

SCN .... suprachiasmatic nucleus

SPSS ....Spielberger Police Stress Survey

CHAPTER 1

INTRODUCTION

1.1 Shiftwork

Shiftwork, inevitable in today's society, affects over 15 million Americans and is classified as shifts that are outside the typical working hours of 9:00 am to 5:00 pm (Centers for Disease Control and Prevention [CDC], 2016). Historically known to only affect manufacturing and public safety workers, shiftwork is increasingly prevalent in the food/beverage, medical, and recreation industries within the past decade (Presser, 2004). Many businesses such as gyms, convenience stores and other factory-like businesses are moving towards providing more operating hours such as 24/7 service. A difficult trade-off is then presented: an increase of job opportunities and hours of operation provided to the community results in a higher prevalence of shiftwork. Because of reversed working hours, shift workers are susceptible to sleep-related problems and other detrimental health issues. Working abnormal shifts disrupts the natural 24-hour (24h) cycle that maintains the processes within our bodies, 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. This nucleus, located in the hypothalamus, is the master clock primarily responsible for keeping our bodies in sync and receiving solar signals (Pett et al., 2016; Manoogian & Panda, 2017).

Melatonin, a hormone secreted by the pineal gland, which coincides with solar signals, is also vital for our sleep/wake rhythms and sleep propensity. Levels are the highest during the night time and are gradually suppressed by external light cues which increase alertness (Pandi-Perumal et al., 2006). Melatonin also is responsible for a plethora of physiological functions such as blood pressure regulation, control of tumor growth, and detoxification of free radicals and has even been used to treat depression (Pandi-Perumal et al., 2006).

Over time, mammals evolved to have 24h rhythms, which are run by over 20 genes creating negative (translational) and positive (transcriptional) feedback loops (Pett et al., 2016; Manoogian & Panda, 2017). Transcription, the process of genetic code synthesizing certain proteins, is initiated by CLOCK (circadian locomotor output cycles kaput) and Bmal1 (brain and muscle aryl hydrocarbon receptor nuclear translocator). These factors heterodimerize the target period consisting of Period1 (Per1), Per2 and Per3, in addition to cryptochrome genes Cryptochrome1 (Cry1) and Cry2 (Manoogian & Panda, 2017). These then provide negative feedback on CLCK and Bmal1; one loop of interaction between these proteins and heterodimers creates the length of our internal clock (Haus & Smolensky, 2013). Manoogian and Panda concluded that around 7-13% of genes within our bodies are dominated by circadian control. For example, CRY controls a few pro-inflammatory cytokines and chronic behavioral circadian desynchrony, which leads to inflammation: additionally, low levels of Per2 resulted in tumor growth in mice. (Manoogian & Panda, 2017).

Current research on mental health and shiftwork lacks adequate longitudinal data greater than 4 years. Many studies also do not have the variety of shiftwork measures utilized in this project, including number of shift changes (i.e., shifts between day, evening, and night shifts) quantified over a period of years. Additionally, little research has been done regarding self-reported depression scales and police officers. Therefore, longitudinal data, over 5 years, was utilized to assess the possible relationship between shiftwork and self-reported depression in a police cohort.

Aim 1: To examine the association between (a) long-term shiftwork status and depressive symptoms as well as (b) short-term shiftwork status and depressive symptoms.

(a.) *Hypothesis:* Those working primarily night or evening shift will have higher levels of self-reported depression, measured by the Center for Epidemiological Studies – Depression (CES-D) scale and the Beck Depression Inventory (BDI), compared to those primarily working the day shift.

(b.) *Hypothesis:* Those working primarily night or evening shift over a 2-week period will have higher levels of self-reported depression, measured by the Center for Epidemiological Studies – Depression (CES-D) scale and the Beck Depression Inventory (BDI), compared to those primarily working the day shift

Aim 2: To examine the association between number of shift changes and depressive symptoms.

Hypothesis: Those with a high number of shift changes will have higher levels of self-reported depression, measured by the Center for Epidemiological Studies – Depression (CES-D) scale and the Beck Depression Inventory (BDI), compared to those with fewer shift changes.

Aim 3: To examine stress as an effect modifier between shiftwork status and depressive symptoms.

Hypothesis: Those with higher self-reported stress, measured by the Perceived Stress Scale (PSS), Total Impact of Events (IES), and Spielberger Police Stress Survey (SPSS), will have a stronger association between shiftwork and depression compared to those with less self-reported stress.

CHAPTER 2

LITERATURE REVIEW

2.1 Shiftwork and Adverse Health Outcomes

A plethora of lifestyle factors play a role in the development of negative health outcomes in shift workers. Shift workers are more susceptible to inadequate sleep, physical activity and proper dieting, in addition to smoking and alcohol consumption (Folkard & Tucker, 2003; Harrington, 2001; Fritschi et al., 2011). Proper meals may be difficult to obtain for shift workers due to the availability during their work hours. Additionally, they tend to consume a diet of high energy density to combat fatigue. Nausea and decreased appetite have been observed in shift workers, which may lead to a poor, low-nutrient diet (Fritschi et al., 2011).

Smoking and lack of physical activity are more prevalent in the shift working populations than the general population (Fritschi et al., 2011). Because of disrupted sleep patterns and regulatory factors, physical activity may be a challenge to most shift workers. In turn, shift workers exhibit higher BMI levels than non-shift workers. In a previous meta-analysis, most studies indicated a higher prevalence of smokers in shift working populations than non-shift working populations (van Amelsvoort et al., 2006). Partially due to lifestyle factors, shift workers may experience negative emotional, cognitive, and somatic responses which range from mood fluctuations and depressed states to risk of diabetes and cancer (Wulff et al., 2010).

One potential somatic response resulting from shiftwork is cardiovascular disease (CVD). An increased risk for CVD is present in police officers who work the night shift, including myocardial infarction and ischemic stroke (Ma et al., 2015; Harrington, 2001). Additionally, a variety of metabolic disorders such as visceral obesity and atypical blood pressure are associated with not only current and former shift workers, but also to those exposed to long-term shiftwork of >10 years (Tucker et al., 2012). A meta-analysis by Bradley and Rumsfeld found an increased risk for coronary artery disease in those that had depression (Bradley & Rumsfeld, 2015). Furthermore, depression was observed within 10% for the healthy population, compared to 20-30% in cardiovascular patients (Whooley, 2006). In additional to cardio-vascular disease, other chronic conditions known to be associated with shiftwork include diabetes and colorectal cancer (Gan et al., 2014; Knutsson & Kempe, 2014; Schernhammer et al., 2003).

Decline in cognitive responses are seen more frequently during the night shift than the day shift, such as in the incidences of Chernobyl and Three Mile Island (Folkard & Tucker, 2003). In one study examining this decline, efficiency markers measuring call response, errors, and action response fell below average for those working between 22:00 h and 6:00 h. In comparison to the morning shift, afternoon and night shift workers had an increased risk for detrimental incidences related to alertness and concentration, which could be life-threatening to others on duty: risk was not only the highest in the night shift group but accumulated over working successive night shifts (Folkard & Tucker, 2003).

Emotional responses influenced by shiftwork include poor mental health and lower quality of life (Kalmbach et al., 2015). These altered mental states may stem from an interrupted family and social life in addition to other factors. Certain professions, such as police officers, are particularly susceptible to work-related stress due to the nature of the job description. Stress is of academic importance due to the potential negative effect it has on shift workers, causing a variety of negative outcomes such as alcoholism, physical illness, suicide and depression (Zukauskas et al., 2009). Stress and other health consequences of working night shifts may stem from interrupted and incomplete sleep patterns, which don't allow the body to fully rejuvenate (Harrington, 2001).

2.2 Shiftwork and Sleep Disruption

Maintaining a regular, healthy sleep pattern may be difficult for shift workers, in addition to the difficulty of deceiving the body to reverse external light cues and sustain homeostasis (Costa, 2010). The International Classification of Sleep Disorders, originally used for research, provides diagnoses for sleep disorders including insomnias, sleep-related breathing disorders, sleep-related movement disorders and more. One of the eight sections is dedicated to circadian rhythm sleep disorders which provides a specific type for shiftwork; it is defined by "complaints of insomnia or excessive sleepiness that occur in relation to work hours being scheduled during the usual sleep period" (Thorpy, 2012).

Because shift workers are forced to reverse their circadian rhythms, hours of sleep are not only reduced, but so is the quality (Harrington, 2001; Costa, 2010). Conditions in the environment during the day are not conducive to a proper sleep session due to traffic noises and natural lighting. It is estimated that shift workers have a sleep deficit of around 2 – 4 hours of sleep each day and lack the proper REM (rapid eye movement) sleep needed to rejuvenate the processes of the body (Costa, 2010). Diminished hours of sleep could result in increased on-site fatigue and accidents in addition to decreased job performance (Harrington, 2001). Additionally, cumulative night shifts may cause increased severity of on-site fatigue and accidents (Costa, 2010). One study examining insomnia and fatigue in shift workers estimates the prevalence to be around 32% and 26%, respectively (Drake et al., 2004). The disruption of this sleep-wake cycle increases the chances of developing numerous morbidities including depression (Drake et al., 2004).

2.3 Shiftwork and Depression

In 2008, the World Health Organization (WHO) estimated that around 151 million will suffer from depression and that it will be the leading cause of disability-adjusted life years in 2030 (World Health Organization [WHO], 2008). However, WHO currently estimates the prevalence of depression to be around 300 million people world-wide (WHO, 2017). With depression increasing at such an alarming rate, mental health has become a focus area in public health. Additionally, the Global Burden of Disease Study (2010) calculated 2.5 billion disability-adjusted life years (DALYs), which represents one year of healthy life lost to disability, attributed to mental health. Mental and substance use disorders represented 7.4% of the DALYs in 2010; 3% of them attributed to depressive disorders and 2.5% attributed to major depressive disorder (Ferrari et al., 2013). Depression often does not act alone on the body, but is associated with other co-morbidities such as diabetes, CVD, cancer, and other physical disorders (Wirth et al, 2017a; Hansen et al., 2016; Spiegel & Giese-Davis, 2003).

Among South Korean nurses, there was an association between shiftwork and severity of self-reported symptoms of depression, even after adjusting for socioeconomic status and health behaviors; many other studies found similar results (Lee et al., 2015; Yoon &Kim, 2013;Zhao & Turner, 2008; Eldevik et al., 2013). Other studies noted an association between working hours and depressive symptoms, one stating that symptoms were seen in those who worked >55 hours per week, with another one declaring a 17% increase in depressive symptoms for every 10-hour increase in working hours (Virtanen et al., 2011). Kim et al. (2013) identified a dose-response relationship between shiftwork and depressive symptoms in those working ≥60 hours per week compared to those who worked <60 hours per week. Many observational studies have found a relationship between the risk of mental illnesses and night shiftwork (Bildt & Michélsen, 2002; Driesen et al., 2011; Kim et al., 2011). A recent meta-analysis by Lee et al., not only found a relationship between overall night shift work and increased levels of depression, but also within subgroups such as gender, night shift duration, continent, and type of occupation (Lee et al., 2017).

Driesen et al. designed a study to look at the possible association between work schedule and experiencing a depressed mood. Depression was assessed dichotomously by “Did you feel down every day over the last two weeks?” (Driesen et al., 2010). Mood in shift workers was compared to mood in day workers from a sample of 8,843 participants in the Maastricht Cohort Study. A higher prevalence of depressed mood was observed in shift workers compared to day workers, with more men displaying the symptoms than women (Driesen et al., 2010). In another study, a higher prevalence of major depressive disorder was found in women than men when examining those exposed to shiftwork. An association was not only found in current shift workers, assessed by two psychiatric scales, but also in former shift workers. An increased lifetime risk of the depressive disorder was discovered in those with longer durations of shiftwork (up to 20 years) (Scott et al., 1997).

One study examined the relationship between circadian rhythm sleep disorder and psychiatric complaints in those who are low sensitive sleepers compared to those who are high sensitive sleepers, referring to how well they sleep through sleep disruptions. Findings from this study concluded that highly sensitive sleepers, in relation to work-related sleep issues, were at a higher risk for depressive symptoms (Kalmbach et al., 2015). Therefore, sleep-related disorders, frequently linked to adverse health outcomes, are almost inevitable in shift workers who are sensitive sleepers.

In regard to long-term effects, shiftwork performed for ≥ 4 years increased the risk of poor mental health for men and women (Bara & Arber, 2009). More specifically, men working nights and women working varied shifts for ≥ 4 years experienced the increased risk (Bara & Arber, 2009). This association may be explained by stress and/or disrupted sleep patterns.

2.4 Police Officers and Adverse Health Outcomes

Generally, police officers have worse health prognoses than the general population (Leischik et al., 2015; Ramey et al., 2012). As previously mentioned, many outcomes associated with police work stem from poor sleep patterns and stress. Psychologically speaking, police officers must be in top mental shape in order to excel at their job and minimize work-related stress and injuries. Poor mental health has the potential to cause long-term effects such as physical illness, emotional disorders, family problems such as divorce and domestic violence, excessive drinking and drug use, and suicide (Kelley, 2005). Reports of mental health are usually self-reported or assessed from self-reported depression scales and are therefore are underreported. Our current knowledge of the prevalence of poor mental health and police officers most likely shows a weak relationship compared to the real prevalence. Suicide rates for police officers are two to three times the rate of the general population. These incidences are preceded by depression, feelings of hopelessness, and stressors (Miller, 2005).

Stress, a common factor observed in police officers, plays a major role on sleep and poor sleep plays a major role on on-site fatigue (Collins & Gibbs, 2003). This endless cycle wreaks havoc on the body and has additional after-affects such as irritability, inflammation, and risk of chronic diseases. Additionally, many studies conclude 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; Da Silva et al., 2015). Obesity and depression are co-morbidities that may be a result from stress, displaying a bidirectional relationship (Jantaratnotai et al., 2017). Many studies show a relationship between obesity and depression, one study observing depressive symptoms in >30% of obese subjects compared to healthy subjects (Rosmond 2004; Castanon et al., 2015; Pan et al., 2012; Lin et al., 2013).

2.5 Police Officers and Risk of Chronic Diseases

A higher prevalence of metabolic disorders was observed in a police cohort which has been associated with diabetes and CVD (Thayyil et al., 2012; Hartley et al., 2011). Poor sleep has an impact on carbohydrate metabolism and endocrine function which may explain the high morbidity of metabolic syndrome (Charles et al., 2007). Officers working the midnight shift and who had less than 6 hours of sleep had a higher risk of developing metabolic syndrome components (Violanti et al., 2010). Metabolic syndrome is accompanied by a variety of anthropological and biochemical abnormalities that is a dominant predecessor of CVD-related events.

CVD is a common morbidity/mortality in the police field and is associated with sleep disorders or sleep interruptions, possibly resulting from shiftwork (Ramey et al., 2012). Additionally, police officers tend to exhibit risk factors associated with CVD such as high waist circumference, BMI, percentage of body fat, and serum levels of insulin and glucose (Violanti et al., 2010; Thayyil et al., 2012). The slight alteration of circadian rhythms could result in certain levels of inflammatory biomarkers to fluctuate, resulting in CVD-related events such as CHD, hypertension, and atherosclerosis (Rajaratnam et al., 2011). Commonly studied inflammatory biomarkers include C-reactive protein (CRP) and tumor necrosis factor – α (TNF) and when seen in excess, an injury or infection is assumed to be present such as a chronic disease (Puttonen, 2011; Khosro et al., 2011). Subsequently, inflammation is a warning sign for CVD-related events, which are frequently seen in police officers (Puttonen, 2011; Van Mark et al., 2010).

The prevalence of cancer is high among police officers, more specifically cancers of the colon, bladder, kidney, lung, skin, and digestive organs (Ramirez et al., 2005; Wirth et al., 2013). This could be attributed to many occupational exposures such as radiation from radar guns, exposure to chemical hazards, and ultraviolent radiation (Gu et al., 2011). However, lifestyle factors may play a carcinogenic role from decreased physical activity, poor sleep quality, and smoking habits.

2.6 Police Officers and Lifestyle Factors

Police officers tend to exhibit poor health behaviors and live a relatively sedentary lifestyle, displaying earlier mortality compared to other populations (Violanti et al., 2013) An earlier study found that on average, white male police officers died around 7 years earlier compared to the general U.S white male population (Hartley et al., 2011). Lifestyle factors such as poor diet, lack of beneficial exercise, smoking, and excessive drinking lead to adverse health outcomes associated with the occupation (Thayyil et al., 2012). One study involving the Buffalo Cardio-Metabolic Occupational Police Stress study (BCOPS) observed that the number of current smokers among the cohort of officers was 3.1% higher compared to the general population, and that obesity among officers was 8.4% higher (Hartley et al., 2011). Due to occupational stress, police officers are observed to have decreased physical activity and increased food consumption, therefore consuming a high-fat diet (Violanti et al., 2013). Working night shifts may trigger shift workers to eat unhealthily and consume extra calories. In order to deal with stress, officers frequently utilize coping mechanisms such as excessive alcohol and drugs. When failure to cope appears, a high prevalence of suicide and divorce is seen in police officers (Anderson et al., 2002). Many of the lifestyle factors and adverse health outcomes originate from stress, which is almost inevitable in police officers.

2.7 Stress as a Pathway to Depression

Most literature agrees on the relationship between police officers and stress, some stating that it is the most stressful law enforcement position (He, 2002; Gershon et al., 2009). Officers tend to run into “fight-or-flight” situations, which cause a variety of internal events to happen, including the shutdown of the digestive system, increased muscular tension, and increased heart rate (Anderson et al., 2002). With repetitive exposure to these situations, officer’s bodies experience chronic stress. Officers are particularly susceptible to chronic stress which not only develops into other diseases such as metabolic syndrome and heart disease, but also causes poor job performance and decreased job satisfaction (Garbarino & Magnavita, 2015; Anderson et al., 2002; Habersaat at al., 2015; Gershon et al., 2009). Common sources of police stress include stress from the work environment, availability of peer support and trust, social and family influence, bureaucratic characteristics of police organizations, and accessibility of coping mechanisms (He, 2002). For years, the development of depression has been preceded by long-term psychosocial stress (Chen et al., 2006).

Because officers tend to have poor sleep patterns, they are at a higher risk for stress. In turn, insomnia is a risk factor for depression (Ramey et al., 2012; Rajaratnam et al., 2011; Garbarino & Magnavita, 2015; Gershon et al., 2009). Around 26% of medical retirement in the police forces in due to psychological disorders. Even more alarming, it appears that levels of stress-related mental health disorders has not improved over the past 10 years (Collins & Gibbs, 2003; Gershon et al., 2009). It has been shown that officers have an increased risk for developing psychological problems, with much of the stress and depressive symptoms occurring as early as their first year of service (Wang et al., 2010; Habersaat et al., 2015). Because of the overwhelming evidence of stress leading to depression, stress was examined as a potential effect modifier of depressive symptoms.

2.8 Police Officers and Depression

Rates of depression appear to be higher in police officers compared to the general population, with stress being the main culprit (Wang et al., 2010; Habersaat et al., 2015). Habersaat et al. aimed to look at the health of police officers and dichotomized them into low and high-risk clusters. Those in the high-risk cluster had less subjective social status, less decision latitude, less social support, and increased loneliness. The study found that the high-risk cluster had strong associations with poor mental health and reported more depressive symptoms (Habersaat et al., 2015). Additionally, suicide rates in police officers are alarmingly high, continue to climb, and are most often seen in those with a history of depression (Miller, 2005).

2.9 Supporting Research

Relevant to the BCOPS data set, Hartley et al. found an association between stress and depression in officers. Life events not related to work such as a death of a close one or an argument with a spouse, were associated with higher depression scores (Hartley et al., 2007). Events related to work such as exposure to dead bodies, also displayed monotonic trends with depression scores. This study also observed less traumatic work-related incidences in those who were older compared to the younger officers. This could be because older officers have seniority over shift/area so younger officers are placed in areas with higher criminal activity. In the pilot study from 2001 – 2003, about 16% of the cohort scored 16 points or greater on the CES-D, meaning they experience depressive symptomology.

Another BCOPS study found a higher prevalence of suicide ideation and depression in police officers than the general population (Violanti et al., 2008). Furthermore, Buffalo, NY police officers had a three-fold risk of suicide than a population of municipal workers (Violanti et al., 2009). In the same dataset, exposure to multiple negative life events was significantly associated with a higher depression score (Hartley et al., 2007). Past studies serve as evidence of depression and altered mental states present in police officers.

2.10 Gaps

This study will assess the relationship between shiftwork and self-reported depression with a longitudinal design. There is limited research on this association with the longitudinal design, particularly when using police officers as the study population. Most other studies use nurse cohorts, which are mainly comprised of females, unlike the BCOPS dataset. Because stress is associated with depression, an advantage to this study is the number of stress inventories provided at each visit (PSS, IES, and SPSS). Shiftwork exposures, calculated from electronic payroll records, include long-term and short-term shiftwork as well as number of shift changes. This study hopes to determine whether exposure to certain types of shiftwork, or disruptions of circadian rhythms, modifies scores from self-reported depression inventories

CHAPTER 3

METHODS

3.1 Data

The BCOPS study primarily examined work-related stress in relation to subclinical CVD and metabolic disorders in a cohort of police officers from Buffalo, New York. A total of 710 active officers were invited to voluntarily participate and provided informed consent; protocols were approved by the National Institute for Occupational Safety and Health Human Subjects Review Board (Ma et al., 2015). Data from cross-sectional analyses were collected for each officer for the baseline analysis (visit 3 [v3]) on a single examination date between 2004 and 2005 (N=470). Data was then collected for the second visit (visit 4 [v4]) on a single date in 2010 (N= 271). Collections included biomarkers for stress and CVD in addition to anthropometric and questionnaire data (Violanti et al., 2006).

3.2 Self-reported Depression scales

Depression was measured from two self-reported questionnaires, the Beck Depression Inventory-II (BDI) and the Center for Epidemiological Studies Depression scale (CES-D). Developed in 1961, the BDI consists of 21 items, measuring severity of attitudes and symptoms of depression, is tailored to the general population, and can be completed in approximately 10 minutes (Beck et al., 1961; Groth-Marnat, 1990). Symptoms, including changes in sleep pattern and appetite, are assessed over the previous 2 weeks. Scores range from 0 – 63; interpreted by mild depression (14-19), moderate depression (20-28), and severe depression 29-63 (Smarr & Keefer, 2011).

Reliability for the BDI resulted in high alpha coefficients for outpatients (0.92) and college students (0.93): Coefficients remained significant for most other populations tested. A correlation of 0.92 was observed in a test-retest reliability study in a group of 26 outpatients ($p < .001$) where questionnaires were administered at therapy sessions spaced one week apart (Smarr & Keefer, 2011). To improve the validity, the BDI-II was derived from a previous scale, the BDI-1A. The BDI-II, referred to as "BDI" in this study, is worded differently to accommodate DMS-IV criteria for depression. A previous study evaluated validation between the BDI-II and the BDI-1A (N=191) and resulted with a correlation of 0.92 ($p<.001$), with the mean of the BDI-II being 2.92 points higher than the BDI-1A (Smarr & Keefer, 2011). Additionally, a validity study between the BDI-II and the Hamilton Rating Scale for Depression yielded a correlation of 0.71 in outpatient clinics (Smarr & Keefer, 2011). Assessed in a group of patients who had post-stroke depression, the BDI had an internal consistency of 0.83, sensitivity of 80.0, and specificity of 61.4. In this population, overall accuracy did not differ for minor and major depression (Aben et al., 2002).

In this study, BDI was utilized as both continuous and categorical. A cut-off value of 14 was used to dichotomize results, comparing officers who had no depressive symptoms to those who had mild to severe depressive symptoms. Those with a score of 14 or greater on the BDI were classified as having depressive symptoms. Potential cut-off points greatly varied between populations with limited research being conducted to validate cut-off points for the BDI against this study's specific population (Seignourel et al., 2008; Dolle et al., 2012; Su et al., 2007; Carney et al, 2009). Therefore, a value of 14 was chosen as the cut-off point because it encompassed all levels of depressive symptoms (mild, moderate, and severe). From a population of cardiac inpatients, sensitivity and specificity for a cut off of 14 was 58% and 91%, respectively (Forkmann et al., 2009).

The CES-D was created in 1977, revised in 2004, and consists of 20 items related to sadness, loss of interest, appetite, sleep, thinking, guilt, fatigue, agitation, and suicidal ideation to measure symptoms of depression. Participants respond to the self-administered questionnaire with choices ranging from "not at all or less than one day last week" to "nearly every day for 2 weeks". The responses are scored by an algorithm and dichotomized; clinical depression is indicated by a score of ≥ 16 (Smarr & Keefer, 2011).

Tests of reliability generated a relatively high internal consistency, with a coefficient α of 0.85 for the general population. Because the CES-D assesses current depressive symptoms, the test-retest correlations were between 0.45 and 0.70 with stronger correlations observed in shorter testing times (Smarr & Keefer, 2011). As for validity, the CES-D correlated well with other depression scales including the Bradburn

Negative Affect and the Lubin manual, with coefficients ranging from 0.51 – 0.61. An additional correlation of 0.49 was found between clinical interview ratings of depression and the CES-D (Smarr & Keefer, 2011).

Sensitivity and specificity of the CES-D, which has a current cut-off of 16, were 86.7% and 76.6% respectively (Shean and Baldwin, 2008). One study aimed to assess the generalizability of the scale over many different populations; it determined the scale was appropriate for Black and White English-speaking American populations of both sexes with a wide range of age and socioeconomic status. In this study, a coefficient α of 0.80 or greater was seen across different subgroups. Results declared the scale had high internal consistency, appropriate test-retest stability (0.40 or above), ample construct validity, and concurrent validity by clinical criteria (Radloff, 1977).

3.3 Shiftwork Information

Shiftwork information was obtained via electronic payroll records. Shifts were classified by their start time and categorized into day/morning shift (04:00 -11:00 h), typically the referent group, evening shift (12:00 - 19:59 h) and night shift (20:00 and 03:59 h) (Wirth et al., 2017b). Length of shift and shift category were then collected from the first day of work or when records became available (i.e., 1994) until their date of examination. Shift information was then standardized on a weekly basis and the officers were classified into one of the three shift categories based on where the largest percent of work hours fell. For about 85% of officers, 70% of work hours were spent primarily in one shift type. Consistency of this process was validated over 30, 60, or 90 days, and 5 years prior to examination date (Wirth et al., 2011). Shiftwork was examined as long-term and short-term. Long-term shiftwork was the primary shift the officer worked from 1994 or start of employment until the clinic date, whereas short-term shiftwork was the primary shift the officer worked over the past two weeks prior to their examination. Analyses were done by comparing the day shift to the evening/night shift, in addition to each category (i.e., evening and night) separately. For these analyses, the day shift served as the referent level. Number of shift changes is another shiftwork category utilized in the study which was defined as the number of times an officer switched shifts during the duration of the study.

3.4 Covariates and Confounders

Covariates from the data set include demographic information (age, sex, race, education, officer rank), BMI (kg/m^2), calories, tobacco and alcohol usage, lipid biomarkers (glucose and triglycerides(mg/dl)), blood pressure (mmHg), fruit and vegetable intake, and measures of quality of sleep (Pittsburgh Sleep Quality Index [PSQI]).

The PSQI assesses sleep quality and patterns over the previous month and measures 7 aspects such as sleep duration, disruptions, and medications. Responses are to be applied to the majority of days they experienced the question within the last month. After calculations, results are dichotomized into poor sleep (≥5) and good sleep (≤4) (Buysse et al., 1989). The PSQI has high internal homogeneity, reliability, and validity (Buysse et al., 1989; Grandner et al., 2006). Lipid panels were obtained from a staff phlebotomist after the officer fasted for a minimum of 12 hours. Specimens were then sent to Kaleida laboratories in Buffalo, NY and analyzed on the Beckman Coulter LX20.

The Spielberger Police Stress Survey (SPSS) consists of stress ratings applied to common events prevalent in police work and can be scored from 0 – 100. Scores are then calculated by multiplying the cumulative rating by the frequency of categories from the past year or month depending on the frequency, then creating an overall summary score. The Perceived Stress Scale (PSS) measures global stress levels instead of event-specific stress. The 14 items of this inventory are responded to by a 5-point scale ranging from “never” to “very often” and assess situations over the responder’s past month. Total impact of events (IES) measures PTSD symptoms and is calculated from a revised impact of events scale (IES-R) and the PTSD Checklist Civilian version (PCL-C). The IES-R consists of 22 items addressing impact and symptoms related to traumatic events. Items are assessed over the last 7 days and are rated on a scale of 1 – 5. The PCL-C, which focuses on how much the individual has been bothered by PTSD events, consists of 17 items that are assessed on a scale of 1-5.

3.5 Statistical Analysis

All analyses were conducted in SAS v. 9.4 (SAS Institute, Cary, NC, USA). Outcomes were the CES-D, which ranges from 0-60 with a recommended depression classification ≥16, and the BDI, which ranges from 0-63 with a recommendation of mild depression ≥14. Correlation coefficient between both questionnaires was greater than 0.60 ($p<0.001$). 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 2 levels (day vs evening/night) and 3 levels (day vs evening vs night).

Descriptive statistics for categorical variables were obtained from frequencies and chi-squared tests. Means and standard deviations were calculated for numeric variables. Normality was assessed from skewness (< 3.00), kurtosis (< 7.00), and the Shapiro-Wilks test (>0.90). If normal, the t-test was utilized. If normality was violated, the Wilcoxon rank sum test was used. P-values for descriptive tables compared the day shift to the evening/night shifts. These analyses were repeated for visit 3 (Table 4.1), visit 4 (Table 4.2), and a comparison of visit 3 characteristics of those who did and did not attend visit 4 (Table 4.3).

To build the models, covariates with a p-value of ≤0.20 were added a crude model using PROC MIXED with a compound symmetry covariance matrix. Those with a p-value > 0.20 were not included in further analyses. Based off high p-values (p ≥ 0.05), those that didn't change the beta coefficient for shiftwork more than 10% were removed from the model one at a time. In circumstances where the beta coefficient was extremely small, a change of 30% was utilized for variable removal. This built the final models for the depression scores in numeric form and all 5 exposure variables (long-term shiftwork – 2 level, long-term shiftwork – 3 level, short-term shiftwork – 2 level, short-term shiftwork – 3 level, number of shift changes). Time (i.e., clinic visit in 2004/2005 or 2010) was added to all models. Number of shift changes were transformed into tertiles. This created the shift change category of 0-17 (referent), 18-48, and 49+ shift changes. Final models were used in logistic regression as well.

In the linear regression models, depressive symptoms were assessed as a numeric variable with greater values indicating more depressive symptoms for both the BDI and CES-D. Normality was assessed through residuals and histograms. PROC MIXED was used to calculate least squares means and to obtain mean values and their 95% confidence intervals and compound symmetry as a covariance structure. Long-term shiftwork was evaluated by day, evening, and night, in addition to day and evening/night, with the day shift serving as the referent category (Aim 1). The categorized number of shift changes also was evaluated, with the referent category 0 – 17 shift changes (Aim 1). Short-term shiftwork was assessed by day, evening, and night in addition to day and evening/night, with the day shift serving as the referent category (Aim 2).

In the logistic regression model, results were dichotomized from the CES-D and BDI. For the CES-D the referent group was < 16 and the BDI had a referent group of < 14. Logistic regression was used to measure the possible association between the dichotomized depression measures and the shiftwork measures. PROC GENMOD was used with an estimate statement to obtain ORs and their 95% confidence intervals. Shiftwork variables were the same as described above.

Additionally, the stress measures were examined as effect modifiers. Correlations between all stress measures were performed. All correlations were under

0.60 and therefore were assessed separately and treated as effect modifiers. 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.

CHAPTER 4

RESULTS

From the original population of 470 officers, exclusions included those that were missing all exposure and outcome variables. For visit 3, 37 officers were excluded for missing all three shiftwork measures and 5 officers were excluded for missing the two depression measures, resulting in a sample of 428 officers for visit 3. For visit 4, 6 officers were excluded because of missing all three shiftwork measures and 4 officers because of missing depression measures, resulting in a sample of 261. A total of 199 officers were loss to follow up. The visit 3 (baseline) population consisted of 318 males and 110 females and visit 4 consisted of 188 males and 73 females. The average age in this population was 42.6±7.9. Most officers were European-American (78%), never smokers (50%), a rank of police officers as opposed to captains or detectives (66%) and had an average BMI (kg/m^2) of 29.3±4.8. Compared to the day shift, those who worked the evening/night shift were more likely to be European-American (89% vs. 68%, $p < 0.01$), younger (39.9± 7.0 vs. 46.1± 7.6, $p<0.01$), and a police officer (74% vs. 54%, $p<0.01$). Triglyceride levels (mg/dl) were significantly higher in the evening/night shifts compared to the day shift (139.0±99.5 vs. 123.7±108.4, $p<0.01$). 11% of officers classified as depressed on the CES-D and 11% of officers had mild, moderate, or severe depressive symptomology on the BDI (Table 4.1)

Characteristics for the officers in visit 4 were similar, with most officers being European-Americans (79%), never smokers (59%), and had a rank of police officers as opposed to captains or detectives (54%). Compared to the day shift, evening/night shift workers were younger (46.2±6.5 vs. 51.8±7.3, $p<0.01$), had higher BMI levels (kg/m^2) (30.7±5.1 vs. 29.2±4.7, $p = 0.02$), and higher triglyceride levels (133.0±95.7 vs. 113.3±79.1, $p = 0.01$). 13% of officers classified as depressed on the CES-D and 10% of officers had mild, moderate, or severe depressive symptomology on the BDI (Table 4.2)

Table 4.3 compares those who attended visit 4 to the 167 officers who did not follow up. Those who did not attend visit 4 were more likely to have less than a college education (17% vs 9%, $p <0.01$), a rank categorized as "Other" (18% vs 4%, $p <0.01$) and be slightly older (43.8±8.6 vs 41.9±7.3, $p = 0.02$). Compared to those who attended visit 4, those that did not attend had higher scores on the CES-D (8.0±7.5 vs. 7.7±6.5) and BDI (7.5±7.8 vs 6.0±5.8) in the samples, although results were not significant ($p=0.72$,$p=0.71$). Additionally, those that did not attend visit 4 had higher sample scores on IES (12.6±11.8 vs 11.8±13.1, $p=0.15$) and PSS (20.7±7.9 vs 20.1±7.7, $p = 0.51$)(Table 4.3).

No associations were found from the repeated measures linear regression models. When examining the long-term shiftwork and depression measures, no relationship was found for either outcome. The short-term shiftwork measures in relation to the CES-D and BDI did not produce any statistically significant results either. The 3-level long and short-term shiftwork groups for the evening group consistently had the highest crude mean values for depression scores, however, they did not differ from the day shift. There was no association between number of shift changes and depression scores (Table 4.7-4.9)

The logistic regression models yielded statistically significant results for long-term shiftwork and BDI. The odds of having self-reported depressive symptoms by the BDI among those working the evening shift were 4.90 times the same odds in those working the day shift (95% CI = 1.20-19.57, p=0.02), after adjusting for sex, race, age, PSS, IES, and PSQI. Additionally, the odds of BDI-classified mild depression was higher among the evening/night shift groups compared to the day shift (OR = 4.60, 95% CI = 1.15-18.39, p=0.03). Overall, the odds of depressive symptoms were highest among the evening shift group using either the CES-D and BDI to define depressive symptoms.

P-values for interaction terms between stress and shiftwork are listed in Table 4.6. Values were obtained for each stress measure. For the CES-D measures, statistically significant interactions were found between shiftwork and the IES. Statistically significant interactions were also found between shiftwork and the PSS for the BDI measurements.

Pearson correlations coefficients between stress measures were all below 0.60. Because the correlation coefficients were in the low to moderate range, it was assumed that the stress measures were not highly correlated with one another. Therefore, the relationship between shiftwork and depression was assessed between all stress measures separately (Table 4.7-4.9). When stress and sleep measures were removed from models, results did not vary by much. There were no statistically significant results from the SPSS or IES stratified tables. Significant results were observed for stratification by the PSS between long-term shiftwork and BDI: For those who scored > 26 on the PSS, higher depressive symptoms were observed in those who primarily worked the evening/night shift than those who primarily worked the day shift ($p = 0.05$)(Table 4.8). For those that scored ≤ 26 on the PSS, the relationship between 2-level long-term shiftwork and BDI had a much lower mean value, however, it was not statistically significant ($p = 0.99$). Overall, those who scored higher on the stress questionnaires had higher mean values of depressive symptoms.

Table 4.1: Visit 3 Characteristics of the Study Population by Shift Type, Buffalo Cardio-Metabolic Police Stress study (BCOPS), 2004-2005 (N=428)

Characteristics	All (n=428)	Day (n=188)	Evening+Night (n=240)	p-value[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%)	
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-squared 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 - Pittsburg 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

Table 4.2: Characteristics of the Study Population with Follow-up Data by Shift Type, Buffalo Cardio-Metabolic Police Stress study (BCOPS), 2010 (N=261)

Characteristics	All (n=261)	Day (n=126)	Evening+Night (n=135)	p-value[1]
Sex				<0.01
Female	73(28%)	53(42%)	20(15%)	
Male	188(72%)	73(58%)	115(85%)	
Race				<0.01
European-American	204(79%)	85(68%)	119(89%)	
Other	55 (21%)	40(32%)	15(11%)	
Education				0.33
< College	23 (9%)	13(10%)	10(7%)	
Some College	91(35%)	49(39%)	42(32%)	
Associates Degree	49(19%)	23(18%)	26(19%)	
>Bachelor's Degree	98(37%)	41(33%)	57(42%)	
Tobacco Usage				0.21
Never	155(59%)	69(55%)	86(64%)	
Former	80(31%)	45(36%)	35(26%)	
Current	25(10%)	11(9%)	14(10%)	
Rank				0.99
Police Officer	139(54%)	66(53%)	73(55%)	
Serg., Lieut., or Capt.	55(21%)	27(22%)	28(21%)	
Detective	53(21%)	26(21%)	27(20%)	
Other	10(4%)	5(4%)	5(4%)	
Age (years)	48.9±7.4	51.8±7.3	46.2±6.5	<0.01
BMI (kg/m^2)	29.9±5.0	29.2±4.7	30.7±5.1	0.02
DII	-1.2±1.9	-1.3±2.1	-1.1±1.8	0.42
Drinks per week	5.5±9.9	5.6±11.1	5.5±8.6	0.16
Systolic BP (mmHg)	117.2±11.0	118.0±11.4	116.4±10.5	0.25
Diastolic BP (mmHg)	78.4±7.8	77.8±7.8	79.1±7.8	0.18
Glucose (mg/dL)	97.2±22.0	97.1±19.3	97.3±24.2	0.41
Global PSQI	6.5±3.6	6.2±3.8	6.8±3.5	0.17
SPSS	18030.8±14416.9	15986.9±13576.0	19721.3±14916.3	0.04
PSS	18.7±7.7	18.6±7.7	18.7±7.8	0.94
Total Impact of Events	12.0±12.9	12.6±13.1	11.5±12.7	0.56
Triglycerides (mg/dl)	123.5±88.5	113.3±79.1	133.0±95.7	0.01
BDI	5.98±5.82	5.87±5.71	6.06±5.94	0.77
CES-D	8.54±7.29	8.49±6.45	8.60±8.02	0.90

Stratum numbers may not equal column total due to missing data.
p-values based off chi-squared tests for categorical variables and t-test/Wilcoxon ranked sums for continuous variables depending on normality
[1]comparing day vs. evening/night shift groups
Abbreviation: PSQI, Pittsburg Sleep Quality Index, CES-D, The Center for Epidemiological Studies Depression Scale, DII – Dietary Inflammatory Index, BMI – body mass index, SPSS – Spielberger Police Stress Survey, PSS – Perceived Stress Scale, BDI – Beck Depression Inventory

Table 4.3: Population Characteristics by Attendance at 2010 Clinic Visit, Buffalo Cardio-Metabolic Police Stress study (BCOPS) (N=428)

Characteristics	Yes[2] (n=261)	No[2] (n=167)	p-value[1] (Yes vs. No)
Sex			0.18
Female	73(28%)	37(22%)	
Male	188(72%)	130(78%)	
Race			0.84
European-American	204(79%)	127(78%)	
Other	55(21%)	36(22%)	
Education			<0.01
< College	23(9%)	29(17%)	
Some College	91(35%)	56(34%)	
Associates Degree	49(19%)	39(23%)	
>Bachelor's Degree	98(37%)	43(26%)	
Tobacco Usage			0.64
Never	133(51%)	79(48%)	
Former	59(23%)	37(22%)	
Current	66(26%)	49(30%)	
Rank			<0.01
Police Officer	180(69%)	100(60%)	
Sergeant, Lieutenant, or Captain	44(17%)	22(13%)	
Detective	27(10%)	15(9%)	
Other	10(4%)	30(18%)	
Age (years)	41.9±7.3	43.8±8.6	0.02
Body Mass Index (kg/m²)	29.0±4.6	29.9±5.0	0.08
Dietary Inflammatory Index	-0.7±2.1	-0.7±2.2	0.95
Drinks per week	5.6±9.0	5.9±10.9	0.56
Systolic BP (mmHg)	120.9±11.8	122.3±12.9	0.26
Diastolic BP (mmHg)	77.1±9.8	79.0±10.2	0.06
Glucose (mg/dL)	92.1±10.7	94.3±13.0	0.05
Global PSQI	6.5±3.4	6.5±3.2	0.98
Total Spielberger Police Stress score	2339.9±1243.3	2211.0±1326.6	0.31
Total Perceived Stress Score	20.1±7.7	20.7±7.9	0.51
Total Impact of Events (IES)	11.8±13.1	12.6±11.8	0.15
Triglycerides (mg/dl)	124.5±92.6	144.8±118.3	0.11
Beck Depression Inventory (BDI)	6.0±5.8	7.5±7.8	0.71
CES-D	7.7±6.5	8.0±7.5	0.72

Stratum numbers may not equal column total due to missing data.

[1]p-values based on chi-squared tests for categorical variables and t-test/Wilcoxon ranked sums for continuous variables depending on normality

[2]Yes = those that attended both visits, No = those that only attended visit 3

Abbreviation: PSQI, Pittsburg Sleep Quality Index, CES-D, The Center for Epidemiological Studies Depression Scale

Table 4.4: Adjusted Mean Values and 95% Confidence Intervals of Depression Measures for Long-term and Short-term Shiftwork and Shift Changes, Buffalo Cardio-Metabolic Police Stress study (BCOPS), 2004/2005 – 2010 (N=689)

	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-square 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

Table 4.5: Odds Ratios and 95% Confidence Intervals of Depression Measures for Long-term and Short-term Shiftwork and Shift Changes, Buffalo Cardio-Metabolic Police Stress study (BCOPS), 2004/2005 – 2010 (N=689)

	CES-D	p-value[g]	BDI	p-value[g]
Short-Term SW				
Day	Ref.[a]	Ref.	Ref.[c]	Ref.
Evening	0.87(0.30-2.50)	0.80	1.28(0.33-4.88)	0.72
Night	0.51(0.19-1.38)	0.18	0.97(0.23-4.16)	0.97
Evening/Night	0.75(0.29-1.93)	0.55	1.19(0.34-4.12)	0.79
Long-term SW				
Day	Ref.[b]	Ref.	Ref.[d]	Ref.
Evening	1.75(0.64-4.79)	0.28	4.90(1.20-19.57)	0.02
Night	1.39(0.45-4.28)	0.57	3.74(0.68-20.45)	0.13
Evening/Night	1.64(0.63-4.27)	0.31	4.60 (1.15-18.39)	0.03
Shift Changes				
0-17	Ref.[e]	Ref.	Ref.[f]	Ref.
18-48	1.50 (0.66-3.42)	0.34	0.77(0.20-3.00)	0.71
49+	1.09(0.40-2.95)	0.86	1.63(0.41-6.56)	0.49

Exposed groups for the dependent variables are as follows: CES-D ≥ 16 ; BDI ≥ 14
All models adjusted for a time component
[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 PSQI
[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

Table 4.6: Interaction Term P-values of Depression Measures Across Categories of Shiftwork and Stress Measures, Buffalo Cardio-Metabolic Police Stress study (BCOPS), 2004/2005 – 2010 (N=689)

	CES-D[a,b,e]	BDI[c,d,f]
	IES	
Long-term (D vs E/N)	0.63	0.75
Long-term (D v E v N)	0.78	0.90
Short-term (D v E/N)	0.04	0.39
Short-term (D v E v N)	0.07	0.55
Number of Shift Changes	0.37	0.63
	PSS	
Long-term (D vs E/N)	0.34	0.04
Long-term (D v E v N)	0.20	0.10
Short-term (D v E/N)	0.75	0.38
Short-term (D v E v N)	0.08	0.73
Number of Shift Changes	0.19	0.07
	SPSS	
Long-term (D vs E/N)	0.67	0.31
Long-term (D v E v N)	0.88	0.47
Short-term (D v E/N)	0.35	0.68
Short-term (D v E v N)	0.57	0.99
Number of Shift Changes	0.21	0.18

[a]Model adjusted for sex, race, smoke, rank, age, PSS, BMI, DII, SPPS, drinks per week, and PSQI
[b]Model adjusted for sex, race, age, PSS, SPSS, and PSQI
[c]Model adjusted for sex, race, age, PSS, DII, and PSQI
[d]Model adjusted for sex, race, age, PSS, and PSQI
[e]Model adjusted for sex, race, age, rank, PSS , and PSQ
[f]Model adjusted for sex, race, age, DII, triglycerides, PSS, and PSQI
All models adjusted for a time component
[g]p-value for interaction between depression scales and shiftwork
Abbreviations: CES-D – Center for Epidemiological Studies Depression scale, BDI – Beck Depression Inventory, PSS – perceived stress scale, DII – dietary inflammatory index, SPPS – Spielberger Police Stress Score, IES – total impact of events, PSQI – Pittsburgh Sleep Quality Index

Table 4.6: Adjusted Mean Values and 95% Confidence Intervals of Depression Measures Across Categories of Shiftwork Stratified by Impact of Events, Buffalo Cardio-Metabolic Police Stress study (BCOPS), 2004/2005 – 2010 (N=689)

	CES-D	p-value[g]	BDI	p-value[g]
			IES ≤ 8	
Short-Term				
Day	5.64(4.14-7.13)	Ref.	4.70(3.83-5.58)	Ref.
Evening	6.88(5.08-8.69)	0.11	5.45(4.22-6.69)	0.23
Night	5.88(3.88-7.89)	0.76	5.12(3.68-6.57)	0.54
Evening/Night	6.50(4.84-8.16)	0.22	5.37(4.32-6.41)	0.22
Long-Term				
Day	6.40(5.37-7.43)	Ref.	4.68(3.74-5.62)	Ref.
Evening	7.24(5.97-8.51)	0.30	5.46(4.30-6.62)	0.20
Night	6.46(5.12-7.80)	0.96	4.74(3.49-5.99)	0.80
Evening/Night	6.89(5.85-7.92)	0.49	5.15(4.19-6.11)	0.32
Shift Changes				
0-17	6.90(5.58-8.21)	Ref.	4.75(3.70-5.80)	Ref.
18-48	6.52(5.26-7.77)	0.60	4.41(3.41-5.42)	0.61
49+	7.01(5.76-8.26)	0.89	5.36(4.34-6.37)	0.38
Short-Term				
Day	9.68(8.25-11.11)	Ref.	7.63(6.72-8.56)	Ref.
Evening	8.38(6.59-10.18)	0.12	8.00(6.73-9.25)	0.64
Night	8.97(6.92-11.03)	0.51	6.79(5.15-8.42)	0.33
Evening/Night	8.63(7.01-10.24)	0.16	7.59(6.49-8.70)	0.94
Long-Term				
Day	9.42(8.41-10.43)	Ref.	7.13(6.18-8.08)	Ref.
Evening	9.57(8.37-10.77)	0.86	7.60(6.50-8.71)	0.39
Night	9.32(7.75-10.89)	0.90	7.04(5.54-8.55)	0.97
Evening/Night	9.48(8.44-10.53	0.92	7.43(6.45-8.41)	0.50
Shift Changes				
0-17	9.62(8.30-10.95)	Ref.	7.57(6.44-8.71)	Ref.
18-48	9.96(8.70-11.21)	0.66	6.94(5.90-7.97)	0.37
49+	9.01(7.82-10.21)	0.45	7.31(6.27-8.35)	0.72

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

Table 4.7: Adjusted Mean Values and 95% Confidence Intervals of Depression Measures Across Categories of Shiftwork Stratified by Perceived Stress Score, Buffalo Cardio-Metabolic Police Stress study (BCOPS), 2004/2005 – 2010 (N=689)

	CES-D	p-value[g]	BDI	p-value[g]
		PSS ≤ 26		
Short-Term				
Day	6.01(4.65-7.37)	Ref.	5.68(4.94-6.41)	Ref.
Evening	6.29(4.63-7.95)	0.70	5.94(4.91-6.97)	0.61
Night	4.99(3.24-6.75)	0.17	5.18(4.00-6.36)	0.46
Evening/Night	5.70(4.17-7.23)	0.60	5.65(4.76-6.53)	0.98
Long-Term				
Day	6.93(6.07-7.79)	Ref.	5.49(4.70-6.28)	Ref.
Evening	7.08(6.00-8.15)	0.84	5.60(4.61-6.59)	0.74
Night	6.45(5.28-7.63)	0.49	5.10(3.98-6.21)	0.64
Evening/Night	6.80(5.89-7.71)	0.83	5.37(4.55-6.22)	0.99
Shift Changes				
0-17	6.84(5.70-7.98)	Ref.	5.37(4.50-6.25)	Ref.
18-48	7.12(6.00-8.21)	0.66	5.23(4.38-6.08)	0.79
49+	6.82(5.79-7.86)	0.97	5.47(4.61-6.33)	0.86
		PSS > 26		
Short-Term				
Day	11.45(9.61-13.29)	Ref.	7.78(6.55-9.01)	Ref.
Evening	10.02(7.63-12.40)	0.24	8.89(7.17-10.61)	0.25
Night	13.53(9.71-17.35)	0.29	7.75(4.29-11.21)	0.99
Evening/Night	10.75(8.53-12.96)	0.54	8.66(7.08-10.24)	0.34
Long-Term				
Day	11.95(10.39-13.51)	Ref.	7.34(5.91-8.78)	Ref.
Evening	12.41(10.69-14.14)	0.69	9.00(7.53-10.47)	0.09
Night	14.48(11.61-17.35)	0.12	9.88(7.35-12.42)	0.08
Evening/Night	12.90(11.35-14.45)	0.37	9.19(7.87-10.51)	0.05
Shift Changes				
0-17	13.15(11.02-15.27)	Ref.	8.85(6.93-10.77)	Ref.
18-48	11.55(9.88-13.22)	0.19	7.12(5.75-8.50)	0.13
49+	13.47(11.39-15.56)	0.82	9.87(8.21-11.53)	0.43

[a]Model adjusted for sex, race, smoke, rank, age, BMI, DII, SPPS, drinks per week, IES, and PSQI
[b]Model adjusted for sex, race, age, SPSS, IES, and PSQI
[c]Model adjusted for sex, race, age, IES, DII, and PSQI
[d]Model adjusted for sex, race, age, IES, and PSQI
[e]Model adjusted for sex, race, age, rank, IES, and PSQI
[f]Model adjusted for sex, race, age, DII, triglycerides, IES, and PSQI
[g]p-value comparing day to evening, day to night, or day to evening/night
All models adjusted for a time component
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

Table 4.8: Adjusted Mean Values and 95% Confidence Intervals of Depression Measures Across Categories of Shiftwork Stratified by the Spielberger Police Stress Survey, Buffalo Cardio-Metabolic Police Stress study (BCOPS), 2004/2005 – 2010 (N=689)

	CES-D	p-value[g]	BDI	p-value[g]
		SPSS ≤ 3,285		
Short-Term				
Day	7.15(5.69-8.62)	Ref.	6.28(5.37-7.20)	Ref.
Evening	7.84(5.98-9.70)	0.39	6.92(5.54-8.30)	0.39
Night	7.16(7.23-9.10)	0.99	6.13(4.75-7.50)	0.83
Evening/Night	7.54(5.84-9.21)	0.57	6.52(5.42-7.63)	0.69
Long-Term				
Day	7.84(6.79-8.89)	Ref.	6.24(5.24-7.24)	Ref.
Evening	8.42(7.19-9.64)	0.44	6.28(5.12-7.44)	0.95
Night	7.95(6.58-9.31)	0.91	6.08(4.80-7.37)	0.84
Evening/Night	8.22(7.17-9.27)	0.56	6.21(5.23-7.19)	0.99
Shift Changes				
0-17	8.00(6.74-9.27)	Ref.	6.35(5.31-7.39)	Ref.
18-48	8.63(7.37-9.89)	0.35	6.19(5.13-7.25)	0.80
49+	7.62(6.19-9.05)	0.63	5.80(4.51-7.09)	0.47
		SPSS > 3,285		
Short-Term				
Day	7.49(6.09-8.88)	Ref.	5.87(5.07-6.67)	Ref.
Evening	7.12(5.42-8.82)	0.61	6.57(5.51-7.64)	0.23
Night	6.84(4.75-8.93)	0.52	5.87(4.24-7.49)	0.99
Evening/Night	7.03(5.49-8.58)	0.51	6.39(5.42-7.36)	0.32
Long-Term				
Day	8.01(7.05-8.97)	Ref.	5.59(4.75-6.44)	Ref.
Evening	8.29(7.12-9.47)	0.71	6.64(5.59-7.69)	0.10
Night	7.60(6.16-9.04)	0.63	5.73(4.45-7.02)	0.85
Evening/Night	8.04(7.03-9.05)	0.96	6.31(5.39-7.23)	0.22
Shift Changes				
0-17	8.48(7.08-9.89)	Ref.	6.16(5.04-7.28)	Ref.
18-48	7.61(6.36-8.85)	0.28	5.22(4.25-6.19)	0.18
49+	8.18(7.06-9.30)	0.70	6.50(5.59-7.42)	0.62

[a]Model adjusted for sex, race, smoke, rank, age, PSS, BMI, DII, drinks per week, IES, and PSQI
[b]Model adjusted for sex, race, age, PSS, 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 PSQI
[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
All models adjusted for a time component
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

CHAPTER 5

DISCUSSION

There were no significant results in the linear regression models. However, when the outcome was dichotomized, long-term shiftwork increased the odds of depressive symptoms. Significant results between shiftwork and depressive symptoms were not found at stratums of the IES and SPSS. For the high stress category of PSS, there was an increase in depressive symptoms between long-term shiftwork and BDI. The general trend for the stratification of IES 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. However, pursuing this hypothesis was outside the scope of this thesis.

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 a relationship between shiftwork and risk of depressive symptomology. Only 1 of these studies adjusted for level of stress and many were cross-sectional, not being able to assess causality of shiftwork on depression (Lee et al., 2017). Some of these studies consisted of a female population, which may produce different results than the predominantly male population of BCOPS (Bildt & Michelsen 2002; Oyane et al., 2013; Lee et al., 2016). Out of the studies in the meta-analysis, only 2 used the BDI and none used the CES-D. Other inventories used were the GHQ: Anxiety/Depression, DSM-III: sub-clinical depression, 2 different scales from the World Health Organization (Bara & Arber, 2009 ; Bildt & Michelsen, 2002; Ohayon and Hong, 2006; Park et al., 2016). All scales had questions derived from different aspect of depression, decreasing consistency between questionnaires. Even between the two depression questionnaires utilized in this study, there were differences in questions and responses which could account for the variety of results from literature.

From the meta-analysis, the study with the lowest measure of association and most similar to this study was between shiftwork and depressive symptomology was from the Korean Working Conditions Survey. Although their study found an association between shiftwork and depressive symptoms, they also mentioned exposure to stress at work was associated with depressive symptoms. The relationship between work stress and depressive symptoms was even found in a general population of shift workers who may not have as much work-related stress as police officers (Park et al., 2016). Because depression is related to stress, reverse causation is a possibility meaning that stress may cause depression or depression may cause stress. Examining reverse causality was not in the scope of this study but should be assessed in future studies.

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, 12.1% and 10.2% respectively, which could explain why they did not see a relationship (Kim et al., 2013). Our study also had low levels of those who were classified as having depressive symptoms, potentially attenuating results. Although the initial sample size was 470, the final population in this study at time-point two had a relatively small sample size (N=271) due to survival bias and loss-to-follow up. Those who left the force may have had more depressive symptoms or switched to the day shift, which could explain the limited significant results.

Past literature shows a relationship between shiftwork in nurses and depressive symptomology. The Korean Nurses' Health Study (KNHS) found a relationship between shiftwork and depressive symptoms however this study did not have the ability for temporal ordering or causality due to the study design. This study also had a broad definition of shiftwork compared the BCOPS cohort that reported shiftwork electronically (Lee et al., 2015). Another study on nurses that found an association between shiftwork and depression used self-reported data to determine shift changes, questioning the validity of exposure (Lee et al., 2016).

On the other hand, longitudinal studies on shiftwork and depression have mixed results. One study took a nationally representative sample of households in Britain to assess number of years working night shift and number of years working varied shift patterns, which were both self-reported. Outcome data on mental health and anxiety/depression was self-reported as well. With exposure and outcome data self-reported, it is possible to find results that over or underestimate the true association. The study also found that performing shiftwork for greater than 4 years is associated with poor mental health for men and women (Bara & Arber, 2009). A causal relationship between shiftwork and depressive symptoms with the BCOPS data may appear with a longer study design.

A unique study examined nurses who had no shiftwork history and found a drastic increase in psychological symptoms for those who worked the night shift (Bohle & Tilley, 1989). Those that were classified as working the night shift rotated between day, evening and night compared to those that only rotated between day and evening. In relation to this BCOPS study, it is possible that those who have experience with shiftwork have better adapted to the reversal of circadian rhythms and do not have as apparent depressive symptoms (West et al., 2007; Bohle& Tilley, 1989). Those that immediately start shiftwork may see the most dramatic effects of psychological issues (Bohle & Tilley, 1989). We were not able to assess this theory due to the lack of shiftwork history of the officers.

Biological mechanisms such as melatonin production may affect results, however a measurement was not available for the cohort. Because of the disturbed sleep-wake cycle initiated from shiftwork, many physiological functions are disrupted including core temperature, cortisol levels, and melatonin levels (Pandi-Perumal et al., 2006). The release of melatonin is reduced in those with depression which may explain the linkage to an altered sleep/wake cycle. Furthermore, the brain region involved with regulation of the sleep/wake cycle is also involved with depression (Salgado-Delgado et al., 2011). Melatonin receptors are located in the SCN, the “master clock” of the body, highly affected by changes in circadian rhythms. Also located in the SCN are neurotransmitters which greatly affect mood (Monteleone et al., 2011). Light cues are transmitted to the SCN from retinal cells, which then communicate with neurotransmitters such as serotonin as well as melatonin (Arendt, 2009). In those not working shifts, circadian rhythms still alter mood, therefore, by working shifts, this association may become exacerbated. Those with depression typically have worse episodes in the morning (Monteleone et al., 2011). In this study, it is possible that those working the day shift still had relatively high levels of depression occurring in the morning, underestimating the results for the night and/or evening shifts. Furthermore, 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).

Seasonal affective disorder (SAD) may be present in the officers as well, however we did not have a variable to adjust for at the time of analysis. SAD is defined as in increase in depressive symptoms accompanied by hyperinsomnia. Because this disorder is governed by changes in the amount of light between seasons, SAD occurs primarily in the winter, when days are shorter and night is longer, and diminishes in the spring (Sandman et al, 2016; Salgado-Delgado et al., 2011). Those who completed their questionnaires in the winter may have reported higher depressive symptoms than those who completed their questionnaires in the spring, summer, and early autumn, especially those working the night shift. Results from this study may be attenuated if questionnaires were completed in spring or summer.

Other biological mechanisms related to shiftwork include the alteration of inflammatory biomarkers. Increases in biomarkers such as interleukin-6, tumor necrosis factor-alpha, and c-reactive proteins and are associated with working the night shift (Puttonen, 2011; Khosro et al., 2011). These markers have been associated with major depression as well. Chronic inflammation is a pathway to major depression, therefore, the lack of sufficient inflammatory biomarkers for analysis in this longitudinal study may have underestimated the results (Leonard, 2007).

The significant results for 2-level long-term shiftwork and BDI scores in the linear regression models have relatively large confidence intervals (OR = 4.90, 95% CI = (1.20-19.57))(Table 4.5). The large confidence intervals may be due to the relatively small sample size; however, at minimum, we estimate there is a 20% increase in odds for those working the evening/night shift compared to the day shift in regard to depressive symptoms. This same concept can be applied to 3-level long-term shiftwork and BDI (OR = 4.60, 95% CI (1.15-18.39)). We estimate that this group has a least a 15% increase in odds for the night shift compared to the day shift when examining depressive symptoms.

It is possible that by only observing significant ORs for long-term shiftwork and BDI, associations are only present for those exposed to a high-risk long-term shiftwork category. On the contrary, short-term shiftwork and BDI did not produce significant results. Previous studies observed depressive symptoms in those working shiftwork for >4 years and >20 years, establishing a potentially long latency period for depressive symptoms (Scott et al., 1997; Bara & Arber, 2009). An overall trend from the models is that the highest ORs or crude mean values are observed in the evening group compared to the day or night group (Tables 4.4-4.5). Officers who work the night shift and have severe depressive symptoms may be moved to a lower-risk shiftwork category such as the evening which could be a reasoning for these results. Many times, shifts are assigned based on seniority. If day shifts weren't available for those with severe depression or psychological issues, they may be placed on the evening shift or leave the occupation all together.

The two significant results only from the BDI may be due to the design of the questionnaires. Responses 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 of Little of the Time", "Moderately or Much of the time", and "Most or Almost All the Time". It may be that by reading the statement of emotion, officers were better able to assess their lifestyle than the quantitative responses from the CES-D.

Another rationale for observing a relationship in long-term shift and BDI compared to the CES-D is due to the cut-point utilized. Because of the distribution of scores, 14 was used as the cut-off which encompasses mild, moderate, and severe depression. For the BDI, an association was found for the logistic model but not for the linear model. Because most of the data was around the median of the data set, there may not be a linear relationship between the depression scales and shiftwork. For instance, at visit 3, there were no officers who scored between 29 and 63, classified as severe depression. Most scores (89%) were between 0 and 13.

Associations were not present between the number of shift changes and the outcomes. Because the variable only accounts for shift changes, regardless of what shift, it is possible that few of them experienced many night shifts or rapid changes between the night and day shift, which would result in irregular circadian rhythmicity. For BDI, crude results were significantly higher for those at the high-risk groups (49+ shift changes), however for CES-D, the low-risk group had significantly greater depressive symptoms (Table 4.4). This may be further evidence of the difference between each questionnaire. The BDI measures severity of attitudes of depressive symptoms which may provide a better assessment of symptomology than the quantitative responses from the CES-D. The BDI also is tailored to the general population, so those who have many shift changes, may drastically score higher than the average person and higher than the typical cut-points. As for the high crude values for the CES-D in the 0-17 category, it is possible that survivor bias was present because those that don't have many shift changes are assigned to one primary shift and do not move around because they have more depressive symptoms.

Results also were stratified by the stress measures because stress in general is associated with depression (Duman, 2014; Monroe et al, 2014). Those that did not attend visit four had slightly higher scores for the IES and PSS, which could bias results towards the null in addition to the self-reported design of the questionnaires. However, in the stratification tables for IES and PSS, higher crude depression scores were observed in the high stress category compared to the low stress category. This could be due to the variability between stress inventories. SPSS measures events specifically related to police work, PSS measures non-specific stressful events, and IES measures stress related to traumatic events. It is not surprising that scores from these stress measures were not highly correlated due to the different stressful events they assess. It is possible that stress has more of an impact on depression than shiftwork.

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

Responder and survivor bias may have underestimated the outcome. Because the outcomes were self-reported, officers may feel the need to suppress their feelings of depression due to social desirability. Furthermore, it was not possible to clinically define the outcome with the current data. The outcome questionnaires assessed behaviors over the last 2 weeks. Events such as marriage, birth of a child, the death of a close one, or divorce could under or over-estimate results. Because of the nature of this job, survivor bias also may be present, especially since there was a 36% decrease in the population between visits and percentage of those with depressive symptoms were all lower than 15%. Those who would classify as severely depressed may have chosen to leave the occupation or primarily work the day shift, underestimating associations. Another limitation to this study is the absence of total shiftwork history. Because some literature states an exacerbated state of depression for those working shifts greater than 10 years, total shiftwork history may have led to misclassification (Scott et al., 2007).

CHAPTER 6

CONCLUSION

Due to mixed results of associations between shiftwork and mental health problems, there may not have been an association because work in general has a positive effect, monetarily and socially (Hall et al., 2017). Although models were adjusted for sex, it should be noted that previous literature describes different effects of shiftwork on males and females (Bara and Arber, 2009; Driesen et al., 2011; Moon et al., 2015). 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 were present in those who primarily worked the night shift (Violanti et al., 2008). Future studies should examine the effects of shiftwork and the biological differences of males and females, using biomarkers instead of self-reported data.

Future studies should perform a longitudinal analysis over a greater time frame due to literature citing as association for longer durations of shiftwork associated with depression. A study involving the military may help limit confounders due to the probable uniformity of lifestyle factors and documented shiftwork histories. More research is needed on biomarkers of depression to increase validity of the outcome and association with shiftwork. Future action should include policies regulating night shiftwork and irregular patterns of shiftwork not only in police populations but other shift working occupations as well. Interventions should be implemented that target stress reduction, tools for healthy sleep patterns and resources for mental health issues. Partnering with local psychologists may offer an outlet for stress and traumatic events associated with police work in hopes of reducing suicide and the development of depression.

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