Document Title:	**Shifts, Extended Work Hours, and Fatigue: An Assessment of Health and Personal Risks for Police Officers**
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Document No.:	**237964**
Date Received:	**March 2012**
Award Number:	**2005-FS-BX-0004**

NIJ FINAL REPORT

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ABSTRACT

The physical health, psychological well-being, safety and efficiency at work are important factors for any police agency to consider. When one considers the monetary and human costs of fatigued officers, it is essential to promote scientific awareness and subsequent plausible interventions. The rate of officers dying from health related problems and accidents for example have surpassed the rate of officers dying from homicide. Fatigued or tired police officers are also a danger to themselves as well as the public they serve. Little is known of the long term impact of shift work and extended work hours on police officers, and no direct scientifically rigorous exposure assessment of shift work has yet been done. The goal of this investigation was to examine police officer exposure to shift work and the association of such exposure with adverse health and psychological outcomes. This study examined two groups of police officers. The first group consisted of 464 currently employed police officers. We assessed shift work impact on health and psychological well-being on this group based on *objective* day-today payroll work record data. The second group consisted of a mortality cohort (deceased officers) of ever employed police officers, 1950-2005. The cohort covered an estimated 100,000 person-years of observation and was utilized to assess the impact of shift work on causes of police officer deaths. This information was obtained from the U.S. National Death Index (classified by the International Classification of Diseases (ICD), 9th edition). Risk analysis among currently employed officers was performed for outcomes of subclinical disease based on independent variables of shift work, sleep quality, stress biomarkers (cortisol), and lifestyle covariates such as physical activity, diet, smoking and alcohol abuse. Additional analysis involved calculation of risk for specific causes of death in police officers compared to the U.S. General Population and internal police comparisons by shift work patterns.

EXECUTIVE SUMMARY

The physical health, psychological well-being, safety and efficiency at work are important factors for any police agency to consider. When one considers the monetary and human costs of fatigued officers, it is essential to promote scientific awareness and subsequent plausible interventions. The rate of officers dying from police accidents for example has surpassed the rate of officers dying from homicide. Fatigued or tired police officers are a danger to themselves as well as the public they serve. Little is known of the long term health impact of shift work and extended work hours on police officers, and no direct detailed exposure assessment of work/shift hours has yet been done.

The primary purpose of this investigation was to examine police shift work exposure and the association of such exposure with adverse health outcomes such as disease, stress and depression. To accomplish this goal, we examined the impact of shift work on biomarkers of subclinical cardiovascular and metabolic diseases. We also examined the interaction of objective measures of shift work and sleep quality on stress and subclinical disease biomarkers and work injuries. Standardized measures of psychological well-being, including stress, depression, anxiety, and post traumatic stress disorder (PTSD) were also investigated.

This study examined two groups of police officers. The first group consisted of 464 police officers who are currently employed. We assessed the impact of shift work on health outcomes and psychological well being, based on day-today *objective* payroll work records of each officer. The objective nature of our shift work data is a strong point in this study; most previous work has depended on self-report data to describe shift work hours. The second group consisted of a police mortality cohort of ever employed police officers, 1950-2005. With this group, we were able to develop standardized mortality ratios (SMR's) comparing police to the U.S. general population. The mortality cohort covered an estimated 100,000 person-years of observation. We utilized this data to associate the impact of shift work on causes of police death obtained from the U.S. National Death Index (classified by the International Classification of Diseases (ICD), 9^{th} edition).

Our research design consisted of data from two sources: presently working officers and a cohort of deceased officers. Approximately 71% of the Buffalo police department participated in the study (n=464). Demographic Information including date of birth, gender, race, ethnic background, marital status, children, religion, veteran status, occupational variables (rank, years of police service, year started employment, police duty assignments). The participating officers represented a demographically defined population of police officers in which 1) significant proportion of the cohort represented women as well as men ; 2) at least two racial/ethnic groups; , and 3) a documented natural range of ages for active, as opposed to retired, police officers representative of the population cohort. A demographic sample of non-participating officers was conducted and no significant differences were found between volunteers on non-volunteer officers. In order to determine the impact of shift work on mortality outcome, we compiled a list of deceased officers in the Buffalo, NY Police Department from 1950-2005. A list of officers, identifying information, and causes of death from 1950-1990 were already available from a prior Buffalo police mortality analysis (n=1,035). We extended this base mortality analysis from 1990-

2005. We conducted a search of the National Death Index (NDI) to determine causes of death for the updated police officer mortality cohort (1990-2005; approximate n=600). Mortality software was employed to develop a risk assessment (Standardized Mortality Ratio) of causes of death for police officers as compared to the U.S. general population (see methods section for death identification and collection).

To develop our objective measure of shift work, we accessed Buffalo, NY police payroll records with permission from the police department and the City of Buffalo. Electronic records were available from 1993-2005, but not available prior to 1993. Therefore, we conducted an additional work history search for hard copy records prior to 1993 at the City of Buffalo records center. Due to the different age, condition, sizes and texture of the hard copy records, it became necessary to digitally photograph available records and then input the data from images into an access database file. This turned out to be a labor-intensive process. Unfortunately, hard copy records were not as complete as the electronic data due to age and misplacement by the department. We did, however, manage to get a working sample of shift data prior to 1993.

To obtain an objective measure of sleep quality and quantity, we utilized an actigraph device. The actigraph is a device which measures sleep/wake cycles in order to assess their adaptability to work cycles. The officer was instructed to wear the actigraph watch for 15 days, which is the span of a work and off duty cycle in the Buffalo Police Department: 4 days on shift, 4 days off-duty, 4 days back on shift, and 3 days off duty. This allowed for a comprehensive data collection of the officer's sleep quality through work shifts, changing shifts, and off-duty time. Data obtained from the actigraph was entered into a software provided algorithm to provide a summary statistic of the officer's sleep quality and circadian disruption patterns. This statistic served as an objective physiological measure of sleep quality.

Our health measures included several physiological biomarkers; (1) the stress hormone cortisol. Elevated cortisol has long been considered a biomarker for both acute and chronic stress, fatigue and circadian disturbances. Dysregulated cortisol can lead to a dysfunction of this circadian related hormone secretion; (2) we developed and implemented a protocol for ultrasound examinations of artery health. The protocol specified the techniques to measure wall thickness and lesion characteristics as well as potential physiological characteristics in the carotid arteries. We established appropriate measures and then measured characteristics of brachial forearm endothelial function and vascular stiffness; (3) we measured blood parameters, including white blood cell count, serum, plasma, a comprehensive blood chemistry with a full lipid panel; HgblAC; CBC with differential , sensitive C-reactive protein, insulin levels (4) we measured anthropometric factors, including weight, height, and distribution of body fat; and (5) psychosocial factors including psychological stress, anxiety, depression, PTSD, and police work stressors.

To determine mortality information, we compiled a list of all deceased officers in the Buffalo, NY Police Department from 1950-2005. We had prior information on Buffalo police mortality from a previous study dating up to 1990. The present study allowed us to update this mortality cohort form 1990-2205. Sources of follow-up in our analysis included the benefit and pension programs of the city of Buffalo, the New York State Retirement System, New York State Vital Statistics Division, Buffalo Police employment records, Buffalo Police Association publications, and the National Death Index (NDI). Death certificates were coded by a nosologist according to the International Classification of Diseases (ICD) Revision in effect at the time of death. The age-and time-specific person-years at risk of dying were calculated for each police officer starting with: (1) the year of first employment as a police officer, if the inclusion criteria of 5 years employment with the city of Buffalo were met; (2) the year in which 5 years of employment for the city of Buffalo was completed, if the first year of employment as a police officer was before the five year inclusion criteria was met; or (3) the year 1950 if (1) and (2) above were prior to 1950. Mortality follow-up was carried out using the National Death Index (NDI) *Plus*, from which we obtained cause of death for decedents that are an exact match.

Our investigation resulted in varied findings. We were able to successfully publish articles in peer reviewed journals, present data at professional academic conferences, and present at practitioner conference and publications. Below is a summary of our results.

- Officers working midnight shifts were on average younger and had a slightly higher mean number of metabolic syndrome components (A cardiovascular risk syndrome). Stratification on sleep duration and overtime revealed significant associations between midnight shifts and the mean number of metabolic syndrome components among officers with less sleep ($p = .013$) and more overtime ($p = .007$). Results suggested that shorter sleep duration and more overtime combined with midnight shift work may be important contributors to the metabolic syndrome. The fact that officers with a higher occurrence of metabolic syndrome were younger is disturbing.

- The unadjusted prevalence of snoring was 26% higher in police night shift workers compared to workers on other shifts. After adjustment for years of service, depression, BMI, physical activity and gender, the prevalence ratio for snoring remained significantly elevated, being 16% higher in night shift workers compared to the other workers (PR=1.16; 95% confidence interval (CI) = 1.00 – 1.33). This increased prevalence occurred predominantly in officers with BMI < 30 kg/m^2. Night shift work was not associated with other sleep problems in this study sample. Among police officers, night shift work was significantly and independently associated with snoring. This result suggests that officers on night shifts are more likely to have symptoms of apnea, linked to poor sleep quality.

- Several previous studies have suggested a positive association between obesity and sleep disorders and other studies suggest that police officers are more sleep deprived than the general public, but little is known about the prevalence of obesity and its association with sleep problems among police officers. We found that those officers on the night shift who had sleep problems were at higher risk for obesity.

- We investigated the impact of shift work on suicide and depression in police officers. Among policemen with higher posttraumatic stress disorder (PTSD) symptoms, the prevalence ratio of suicide ideation increased by 13% with every 10-unit increase in the percentage of hours worked on afternoon shift (PR=1.13; 95% CI+1.00–1.22). Prevalence of suicide ideation significantly increased among policewomen with higher depressive symptoms and increasing day shift hours, and among policemen with higher PTSD symptoms with increasing afternoon shift hours.

- Antioxidants protect against cell damage. We tested the impact of sleep deprivation in police officers on antioxidant levels. The objective was to investigate the cross-sectional association between sleep duration and biomarkers of oxidative stress (glutathione (GSH), glutathione peroxidase (GSH-Px), vitamin C, thiobarbituric acid reactive substances (TBARS), and trolox equivalent antioxidant capacity (TEAC)) among police officers. Standardized techniques were used to analyze biomarkers in fasting blood specimens. Positive trends were observed across sleep categories with mean levels of GSH and vitamin C only among women (p trend=0.156 and 0.022 respectively), with attenuation after risk-factor adjustment. Positive trends were observed for vitamin C among older officers (p trend=0.018) but not younger.

- Mortality from all causes of death combined for police officers was significantly higher than expected when compared to the U.S. general population. Significantly increased police mortality was also seen for all malignant neoplasms (cancer), all benign neoplasms and all diseases of the circulatory system combined. A significantly decreased mortality rate was observed for all diseases of nervous system and sense organs, all respiratory diseases all external causes, all accidents, and motor vehicle accidents. Mortality due to cirrhosis of liver and suicide was elevated. From preliminary analysis, it appears as if nearly twice as many day shift workers (6.6%) died during the follow-up period compared with either afternoon (3.3%) or night (3.4%) shift workers. However, since day shift workers were 9-10 years older on average than either afternoon or night shift workers, it is possible that older age was responsible for their elevated mortality. When differences in age were taken into account differences in mortality across shift work categories were notably diminished. There was an unadjusted odds ratio of 2.0 for mortality comparing day versus night shift workers, but the risk was reduced to an odds ratio of 1.0 after adjustment for age. Although assessment of cause-specific mortality is severely limited by relatively small numbers of deaths in our preliminary data, there were increased risks for cancer and cardiovascular disease across shifts. Future analyses will take into account differences in the length of time individual officers were at risk for mortality, duration of shift work, and other demographic or lifestyle factors that may be important to consider.

There were many interesting conclusions resulting from our findings. Results on shift work and cardiovascular disease suggest that police officers working midnight shifts combined with either shorter sleep duration or increased overtime may be at an increased risk for metabolic syndrome. The prevalence of metabolic syndrome among officers working the midnight shift was higher than that found in the National Health and Nutrition Examination Survey (NHANES III) 1988-1994, a national health study in the U.S. NHANES III overall prevalence of metabolic syndrome was 21.8%, while officers in our sample working midnights had an overall prevalence of 30%. In addition, officers who worked the midnight shift were on *average younger* than those officers on the day shift (36.5 and 42.6 years of age respectively). The NHANES national prevalence of metabolic syndrome was 24% for those in this younger comparable age range (30-39 years). This slightly higher prevalence at a younger age coincides with police mortality cohort studies which found a higher risk of CVD among younger officers, an infrequent result in healthy worker populations. Officers on the other two shifts had a lower prevalence of metabolic syndrome compared to NHANES data. One potential explanation for this unusual finding is that midnight shift officers were most likely to be sleep deprived because of difficulties associated with day sleeping and sleep debt has been shown to have a harmful impact on carbohydrate metabolism and endocrine function that could contribute to metabolic disorders.

The prevalence of an elevated waist circumference was nearly 50% and 30% respectively for females and males in NHANES III. In our police sample, the combined prevalence of elevated waist circumference was 55% for those working midnight shifts, higher than NHANES III levels and day or afternoon shift workers. Prevalence of low HDL cholesterol levels were approximately 38% in women and 35% in men in NHANES, while low HDL prevalence in our combined police sample was 50% among those working midnight shifts. Prevalence of hypertension and glucose intolerance for officers working midnights was also higher than found in NHANES.

The significantly elevated prevalence ratio for abdominal obesity found when comparing midnight to day shifts among police may be indicative of future health problems among officers. Even after statistical adjustment for gender, age, and demographic and lifestyle variables, the mean number of metabolic syndrome components was still significantly higher for officers who worked the midnight shift and an increased median number of overtime hours per week (>1.7 hours). Overtime is thought to involve the same metabolic mechanisms suggested for shift work and CVD. Other studies have found that self-reported overtime led to a two-fold excess risk for acute myocardial infarction after adjusting for smoking, age, education, and self-reported exhaustion.

Officers who worked midnights and had less than six hours sleep had a significantly higher mean number of metabolic syndrome components than those who worked day shifts (multivariate-adjusted). Sleep deprivation is a common denominator in most forms of shift work and has serious metabolic and cardiovascular consequences. Also, sleep duration was significantly related to waist circumference, body mass index, percentage of body fat, serum levels of insulin and glucose, and insulin resistance.

We were unable to sufficiently examine policewomen in a separate analysis due to the small number of women who worked midnight shifts (N=3). There is a paucity of research on policewomen and the effects of atypical work hours on their health and well-being. Results from the 1999-2000 NHANES study indicated a sharp increase in the prevalence of metabolic syndrome among women, the age-adjusted prevalence rate increasing by 23.5%. Corresponding increases in men were much smaller and not statistically significant. We plan future work with a larger sample size of policewomen would address the need for research in this area.

Our finding that police officers on shift work do not get sufficient sleep was important. Our study compared the sleep problems of officers who worked night shifts with those who worked both day and afternoon shifts. Night shifts are more disruptive to the circadian system because workers must frequently rotate between diurnal and nocturnal sleep patterns to accommodate family and social activities. This is not the case with afternoon shift workers whose later bedtime hours are seldom a problem biologically. In fact, they may even get more sleep than day shift workers. Second, the pattern of melatonin secretion and its synchronization with sleep is drastically altered in night. Melatonin, a substance that is primarily secreted by the pineal gland, is produced during the night and promotes sleep Thus, night shift workers may face a greater frequency of sleep disruption compared to evening shift workers.

Among police officers, we found a high prevalence of tiredness upon awakening. Symptomatic obstructive sleep apnea may be indicated in our results due to discovered symptoms of snoring and temporary cessation of breathing during sleep, with the usual consequence being hypersomnolence during waking hours. We obtained a wide range of responses to each of these questions. The low response rate to "stop breathing during sleep" may be due to the fact that a number of individuals, especially those without a bed partner, are not aware that they have this problem. Although we collected information on marital status, we did not ask about bed partners nor did we survey the spouses or partners of the participants.

Several covariates were significantly associated with sleep problems. For example, BMI showed a significantly positive trend with snoring, and was significantly and positively associated with restless leg syndrome and tiredness upon awakening. Our study also found that lower physical activity scores were more likely to be seen in officers with more frequent sleep problems although none of the trends were statistically significant. Previous studies have provided evidence that regular physical activity has a protective effect on sleep-disordered breathing.

We examined several psychological and social variables associated with shift work and suicide ideation. Disruptive circadian patterns have been shown to dysregulate biological systems such as the hypothalamic–pituitary–adrenocortical (HPA) axis, which can lead to increased levels of the hormone cortisol found to be prominent in depression.

Altered circadian rhythms in cortisol and melatonin secretions have been found among those suffering from depression. Melatonin levels in suicide victims have been found to be significantly lower than those of non-suicide controls, consistent with reports of decreased nocturnal plasma melatonin levels in depressed patients

Mediation of brain processes due to sleep deprivation and fatigue may also impact suicidal thinking. Killgore et al. [2007] suggested that sleep deprivation impairs the ability to integrate emotion and cognition to guide moral judgment. Sleep deprived participants showed significantly greater difficulty judging emotionally charged courses of action as ‘‘appropriate’’ relative to judging them as ‘‘inappropriate.’’ These findings suggest that sleep deprivation has a debilitating effect on judgment and decision making processes that depend heavily upon the integration of emotion with cognition, processes which are believed to be mediated by regions of ventromedial prefrontal cortex, the brain region most responsible for judgment and decision making. In such situations, persons may be more likely to consider suicide as an appropriate behavior. In another study on judgment and sleep deprivation Killgore et al., 2005], sleep deprivation was found to reduce regional cerebral metabolism within the prefrontal cortex. After sleep loss, individuals tended to make more risky decisions. These findings suggest that cognitive functions known to be mediated by the ventromedial prefrontal cortex, including decision making under conditions of uncertainty, may be particularly vulnerable to sleep loss. Suicidal thinking could result from shift-work related sleep deprivation that affects clear decision making.

Our research advanced sleep deprivation measurement by determining alternative ways to measure sleep disturbances and awakening times. “Waiting time distribution” (WTD) refers to the statistical distribution, across one or more sleep cycles, of the amount of time it takes for a person to wake after the previous onset of sleep. Waiting times offer an additional method of analyzing sleep data that have the ability to provide even more information on participant sleep patterns. WTD can be used in place of the average wake-after-sleep onset variable, as the 90th percentile of the WTD is more capable of differentiating sleep quality than the average is. Although analyzing sleep patterns with WTD takes more time than using the average wake-after-sleep onset value, it can add valuable, additional information for the researchers, as it not only categorizes sleep quality at least as well as the average wake-after-sleep onset time. Also, as the distribution of wake-after-sleep times is asymmetric, the sleep-to–wake onset average is an improper parameter to use; higher percentiles differentiate between sleep qualities much better, as the number of longer wake-after-sleep onset times is much greater in people with good sleep quality as opposed to those with poor sleep quality. Waiting time distributions also provide all of the benefits that the theory of probability distributions has to offer, including parameter estimation and survival time analysis. Compared to the average wake-after sleep onset time, waiting time distributions give many more methods of analyzing participant characteristics, comparing sleep quality between groups, and modeling sleep.

The increased risk of certain diseases in our police mortality cohort suggests that police officers are at higher risk than the general population. The present study allowed us to update an already existing police mortality cohort which was collected from 1950-1990 (Violanti, et al, 1998). Our objective was to first determine causes of death and then to relate such causes to variants of shift work. During the 15 years of additional follow-up the number of decedents in the cohort increased from 1,035 to 1,529.

In the police mortality cohort, all-cause Standard Mortality Ratios (SMR) for police officers relative to U.S. national estimates (SMR=1.20; 95%CI=1.14-1.26) was higher. Mortality due to all diseases of the circulatory system (SMR=1.10; 95%CI=1.02-1.19) including arteriosclerotic heart disease was significantly elevated.

The mortality rate for all malignant neoplasms (SMR=1.32; 1.19-1.46) was higher than the U.S. population. SMRs for respiratory system cancer and leukemia were of similar or slightly higher magnitude and were significantly elevated. Higher mortality was consistently observed for officers who started work at the youngest age (<25 years) and for those who had the most years of service.

Our findings related to the association of shift work and specific causes of death were interesting. Unexpectedly, nearly twice as many day shift workers (6.6%) died during the follow-up period compared with either afternoon (3.3%) or night (3.4%) shift workers. However, since day shift workers were 9-10 years older on average than either afternoon or night shift workers. It is therefore possible that older age was responsible for their elevated mortality. When differences in age were taken into account differences in mortality across shift work categories were notably diminished. The unadjusted odds ratio of 2.0 for mortality comparing day versus night shift workers was reduced to an odds ratio of 1.0 after adjustment for age. Although assessment of cause-specific mortality is severely *limited by relatively small numbers of deaths* in this preliminary analysis, mortality due to all cancers and cardiovascular disease were elevated across the shifts. Future analyses with the complete sample will take into account differences in the length of time individual officers were at risk for mortality, duration of shift work, and other demographic or lifestyle factors that may be important to consider.

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I. INTRODUCTION

A. STATEMENT OF THE PROBLEM

The physical health, psychological well-being, safety and efficiency at work are important factors for any police agency to consider. When one considers the monetary and human costs of fatigued officers, it is essential to first promote scientific awareness and subsequent plausible interventions. The rate of officers dying from police accidents for example has surpassed the rate of officers dying from homicide. Fatigued or tired police officers are a danger to themselves as well as the public they serve. Little is known of the long term impact of shift work and extended work hours on police officers, and no direct detailed exposure assessment of work/shift hours has yet been done.

The primary goal of this investigation was to examine shift work that police officers have worked and the association of such exposure with adverse health outcomes such as disease and anomalies as stress and depression. This study examined two groups of police officers. The first group consisted of 464 police officers who were currently employed. We assessed work hour/shift impact on health outcomes and psychological impact, based on day-today objective payroll work records of each officer. These records provided time at work and shifts over a period of ten years. The second group consisted of a mortality cohort of ever employed police officers, 1950 to 2005. The cohort will cover an estimated 100,000 person-years of mortality observation to assess the impact of work /shift hours on causes of death obtained from the U.S. National Death Index (classified by the International Classification of Diseases (ICD), 9th edition).

Data collection of shift records dating back to the 1980's was obtained from police department and city payroll record depositories. Statistical health risk analysis among currently employed officers was performed for outcomes of subclinical disease based on independent variables of shift work, sleep quality, stress biomarkers (cortisol) and other work and lifestyle covariates such as physical activity, diet, smoking and alcohol abuse. Analysis involved calculation of risk for specific causes of death in police officers compared to the U.S. General population and internal comparisons by shift work patterns. We considered relationships of work hours/shift work with causes of death which posed an increased risk among police officers

B. LITERATURE REVIEW

Shift Work and Health

There are approximately 860,000 sworn police officers in the United States represented by 17,784 agencies (Reaves, 2006). Despite the large size of this workforce and strain of this occupation, the police are understudied in terms of the impact of extended work hours, shift work, and fatigue on health and costs to successful operation of policing.

Data from industrialized countries suggest that irregular patterns of work, such as shift work and extensive overtime work, have become increasingly common. The pathways between shift work and disease are only partly understood. Social factors, stress, and behavioral variables may all play a synergistic role, as well as disturbance of circadian rhythms and physiological regulatory systems. In conjunction with this trend, there are more epidemiologic studies of the health effects of such irregular patterns of work (Steenland, 2000). Taken as a whole, the epidemiologic data suggest that a modest association between shift work and disease may exist. There are plausible biological mechanisms (via disruption of circadian rhythms) by which shift work could result in disease. However, the epidemiologic studies are still relatively few in number, and they are not consistent, and there are none on police officers. Furthermore, there may be effects of shift work that are not well understood and are not well explained by current proposed mechanisms. (Steenland, 2000).

The impact of shift work and extended hours on cardiovascular disease has been frequently studied. Boggild and Knutsson (1999) reviewed seventeen studies on shift work and cardiovascular disease and found that on balance shift workers had a 40% increased risk of cardiovascular disease. Skipper et al (1990) in their study of nurses found that rotating shift workers reported more job stress than non-shifters. Kawachi et.al (1995) studied nurses who previously worked shifts and found higher rates of smoking, high blood pressure, diabetes, and physical activity. Lasfargues et al (1996) compared female night shift workers with matched controls and found significantly higher triglycerides, smoking and obesity. Night workers had more difficulty with sleep. Knuttson and Nillson (1998) found a 1.3 odds-ratio for smoking among night shift workers when compared to non-shift workers. Tekanen et al (1997) found that shift workers reported more stress than non-shift personnel. Prunier-Poulmaire, et al (1998) in their analysis of French custom official shift workers, found reported health problems for 16 of 19 listed health conditions. Nakamura, et al (1999) found shift workers to have significantly higher cholesterol levels and obesity than day shift workers.

Sokejima and Kagamimori (1999) conducted a well designed study which compared survivors of first heart attacks to controls who were free of heart disease and matched by age and occupation to the patients. Data on medical history, blood pressure, cholesterol, glucose tolerance, body mass, and smoking habits were obtained for both cases and controls, as were data on psychosocial conditions at work and time spent in sedentary work. The authors also found that there was a significant increased risk for heart attacks with a larger increase in working hours during the year prior to the event, indicating that a change to longer working hours increased risk.

There are some studies that suggest that shift work may affect metabolic factors such as triglycerides, cholesterol, BMI, abdominal fat distribution and coagulation (Knutsson & Boggild, 2000). Karlsson, Knutsson and Lindahl (2001) found that shift workers had a cluster of obesity, high triglycerides, and lower concentrations of HDL cholesterol than day workers. Ayas, et al (2003) examined self reported irregular sleep durations in the Nurses Health Study cohort and found the relative risk for diabetes was increased (RR=1.57 for short sleepers and RR=1.47 for long sleepers).

Cancer incidence among shift workers has also been studied. Hansen (2001) investigated breast cancer risk among Danish Women as compared to matched controls and found an odds-ratio of 1.5 among night shifters. There was a tendency for increased odds ratios for cancer with increased nighttime employment. Schernhammer et al (2003) prospectively examined night shift work and the risk of colorectal cancer in the Nurses Health Study. Their results indicated a 1.35 increased risk for colorectal cancer in nurses who worked night shifts for 15 or more years. Schernhammer et al (2001) also found an increased risk of breast cancer in this same cohort (RR=1.36) in nurses who worked night shift 30 or more years.

There is evidence that new shift workers switchback to day work because they cannot tolerate shift work. Harma (1993) provided evidence that 20% of shift workers switched back to day work within a year due to intolerance of shift work. Koller reported cross-sectional data indicating 22% of workers with a history of shift work had abandoned shift work due to health or family problems. Akerstedt, et al. cite evidence from Sweden in the 1940's that approximately10% of workers with a history of shift work had transferred back to day work for health reasons within 10 years. Angersbach, et al. (1980) report in a study of 600 workers that 11 % had switched from shift work to day work, two-thirds of whom did so for health reasons.

These same authors found a higher prevalence of health problems in these workers who had dropped out of shift work, compared with day workers or workers who had stayed in shiftwork. McNamee, et al. found an increased risk of heart disease death in the first 5 years after a shift worker switched back to day work (odds ratio 2.69). Nachreiner (1998) provided an overview of the recent literature on workers' tolerance of shift work. The phenomenon of workers, particularly unhealthier workers, switching back from shift work to day work is an example of a healthy shift-worker survivor bias, which tends to create a bias towards the null in studies of shift work and disease.

The present study was comprised of approximately 20% police officers who are women. Few studies have been conducted in women involved in shift work, and none have been done on women police officers. In a case control study, Knutsson, et al. (2000) found that women exposed to shift work had higher risk of MI than unexposed women (OR 1.3, 95% CI, 0.9-1.8). For women aged 45-70 and OR 3, 95% CI, 1.4-6.5 for women aged 45-55). Alfredsson, et al. (1996) reported that at 1-year followup, the SMR for hospitalization for MI was 131 (95% CI, 105-162) for women working in occupations with long working hours and 152 (95% CI, 119-191) for women in occupations with irregular working hours. In another prospective study, the age-adjusted relative risk of CHD was 1.4 (95% CI, 1.1-1.8) in nurses who reported ever doing shift work. This excess risk persisted after adjustment for smoking and other CV risk factors. Among nurses reporting 6 or more years of shift work, the adjusted relative risk was 1.5 (95% CI, 1.1-2.0). Brugere, et al. (1997) have observed no association between shift work and the prevalence of hypertension among 8928 women followed by occupational medicine specialists. Potentially stressful exposures related to family responsibilities are also more prevalent in women than in men. Indeed, despite their increasing involvement in paid work, women spend more hours than men in child caring and housework.

Overtime as well as shift work is commonly thought to be stressful and fatiguing and may be correlated with sleep deprivation, thereby involving the same mechanisms hypothesized for disease and shift work. There are data indicating that, in general, being at work (versus not being at work) increases blood pressure, so that longer working hours implies more time with increased blood pressure (Hayashi, et al 1996). Recent data indicating that long hours of overtime may increase average blood pressure as measured over 24 hours.

Early studies suggest that long working hours are among the stressful factors that increase the risk of heart disease. More recently, Falger and Shouten (1992) studied cases of male acute myocardial infarction versus hospital and neighborhood controls. With hospital controls (but not neighborhood controls), they found that self-reported prolonged overtime (time period not defined) caused a significant two-fold excess risk for acute myocardial infarction after controlling for smoking, age, education, and self-reported exhaustion. The most important studies to date attempt to separate the independent effects of long hours and stress, either by explicit attempts to measure both these variables and by matching, or by quantitatively measuring hours worked (Hayashi, et.al, 1996).

Police Mortality

Fatigue and circadian disturbances which lead to stress have been identified as possible factors in the etiology of disease. Although this association is controversial, stress may be a catalyst for malignancy at selected sites, as stress may be mediated immunologically and lead to the onset of cancer (Burgess, 1987; Eysenck, 1988; Fox; 1995). Our findings indicated a significantly elevated overall mortality for malignant neoplasms in police officers and elevated mortality at specific sites (Violanti, et al, 1998). Stress has also been implicated in heart disease (Henry, 1986; Eli and Mostardi, 1986; Eysenck, et al, 1991), and our recent mortality findings indicate an elevated risk of arteriosclerotic heart disease in police officers. What is interesting is that both malignant neoplasms and arteriosclerotic heart disease rates are higher in officers with fewer years of service. This is infrequently found in a healthy worker population (McMichael, 1976). Perhaps stress and stressful traumatic events in police work, among other factors, exacerbate disease states such as cancer or arteriosclerotic heart disease (Paton and Violanti, 1996).

The Helsinki Police study (Pyorala, et.al 1998) was one of the first prospective studies on the risk of coronary heart disease among police officers. The study investigated an association between hyperinsulinemia and CHD after a 22 year follow-up, and was based on a cohort of 970 police officer males. Covariates included BMI, anthropometric values, and blood parameters. Results indicated that hyperinsulinemia predicted CHD risk in police officers over a 22 year follow-up independently of other risk factors.

Police officers have increased rates of other mortality as a result of their occupation. Guralnick (1963), using U.S. census data from 1950, found standardized mortality ratios (SMRs) for policemen, sheriffs, and marshals to be elevated for arteriosclerotic heart disease, suicide, and homicide. Richard and Fell (1976) found Tennessee police officers to have a high rate of premature death, suicide, and admission to hospitals. Milham (1983) found increased rates for cancers of the colon and liver, diabetes mellitus, arteriosclerotic heart disease, pulmonary embolism, and homicide in Washington state police officers. Age-specific proportionate mortality ratios for arteriosclerotic heart disease were highest for younger officers.

Vena et al (1986) found city of Buffalo police officers had increased rates for arterioslcerotic heart disease, digestive cancers, cancers of the lymphatic and hematopoietic tissues (10-19 years employment), brain cancer, and esophageal cancer. Police had a three-fold rate of suicide compared to municipal worker controls. Feuer and Rosenman (1986) reported that police and firefighters in New Jersey had significant increased proportionate mortality ratios (PMRs) for arteriosclerotic heart disease, digestive and skin cancers, and skin diseases. PMRs for cirrhosis of the liver and digestive diseases increased as duration of police service increased. An inverse relationship was noted between arteriosclerotic heart disease and latency, indicating that police officers most susceptible to heart disease were affected early in their careers (Violanti, et al, 1998). Demers, et al (1992) compared police and firefighters in three cities in the United States and found police to have higher rates for all causes of death combined. An overall increased rate of suicide was noted in the police, with the highest standardized mortality ratios (SMRs) recorded for officers over the age of 65 (SMR=301), at least 30 years of service since first employment (SMR=318), or after 30 years of employment (SMR=318). Forastiere et al. (1994) studied a cohort of urban policemen in Rome, Italy and found increased rates for ischemic heart disease in officers less than 50 years of age (SMR=163), colon cancer (SMR=147), bladder cancer (SMR=127), non-Hodgkin's lymphoma (SMR=151) and melanoma (SMR=234). Bladder cancer rates were significantly increased for patrol car drivers (Odds Ratio=5.14) and kidney cancer for motorcycle officers (Odds Ratio=2.27). Additional studies have found police to have higher rates for heart disease, homicide, and suicide (Sardinas et al, 1986; Hill and Clawson, 1988; Dubrow et al, 1988; Quire and Blount, 1990; Violanti et al, 1996).

Police Morbidity

Given the variety of exposures in this occupation, it is important for police agencies to monitor officers for physical fitness and good health. Persons who enter police work are generally part of a healthy work population, but appear to deteriorate physically and psychologically as years of police service increase (Violanti, 1983).

Williams et al, (1987) found that a substantial number of officers in their sample were at elevated risk for atherosclerotic heart disease. 22% were smokers, 76% had elevated cholesterol, 26% had elevated triglycerides, and 60% elevated body fat composition. Stamford, et al (1978) concluded that the physical demands associated with police work were too low for officers to maintain good physical fitness. Pollack et al (1978) concluded that middle-aged police officers had coronary heart disease risk above that of the general population. Franke et al (1997) found that public safety officers had a higher probability of developing coronary heart disease than did the Framingham study population.

Intervention such as medical screening and fitness evaluations can reliably evaluate an officer's ability to perform job-related tasks. Such tests should be performed on a regular basis during the course of employment. Franke and Anderson (1994) found that officers over the age of 48 who maintained good physical conditioning had a reduced risk of cardiovascular disease risk. Harrell et al (1996) conducted a randomized controlled trial of 1,504 police officers and found that those enrolled in an occupational based health and fitness program improved significantly in cardiovascular fitness, flexibility, and body fat. Lechner et al (1997) , in a multi-center clinical trial study, found that police officers enrolled in an employee wellness program had significantly less sick days than other groups. Briley et al (1992) found that employee wellness intervention helped police officers to learn proper nutrition habits and subsequently reduced weight and blood lipid levels. Phillips et al (1991) found that changing police shifts from rotating to permanent improved sleep habits and psychological well-being among officers. Norris et al (1990) concluded that fitness interventions decreased measured levels of stress and increased feelings of well-being among a sample of police officers.

Police Fatigue and Health

Fatigue is a general rubric which refers to a state of tiredness. Fatigue is a feeling of weariness, tiredness, or lack of energy. It may be related to both physical and mental strain, leading to the inability of an organism to respond to stimuli. For purposes of the present study, fatigue is defined as a general state of tiredness affected by perturbations in "allostasis". Perturbations may be a result of both disruption in physiological circadian rhythms and cortisol . Sterling and Eyer (1988) refer to allostasis as the maintenance of physiological stability through change. "Allostatic load" refers to the wear and tear that the body experiences due to repeated cycles of allostasis as well as the inefficient turning on or shutting off of these responses (McEwen & Seeman, 1999). Allostatic load appears to be more useful that previous concepts in describing the wear and tear on the body, not only across stressful life events but also daily stress that activates physiological systems such as the circadian cycle (McEwen & Seeman, 1999. McEwen, 2002). Also involved in this process are lifestyle factors such as diet, exercise, substance abuse, and social experiences.

Fatigue Physiology

Human beings have physiologic systems that are timed rhythmically to synchronize enzyme, hormone, and energy levels with organ activity (Moore, 1999; Winget, DeRoshia, Markley, et.al, 1984) This period, which is usually stable under normal conditions, is the amount of time required to complete a single repetition of the rhythm. If the period is approximately 24 hours, it is termed circadian (about a day). In essence, this bodily rhythm translates environmental information to the internal milieu through several sensory systems (ie, the retina), integrates the information, and then broadcasts this information to the rest of the body so that other systems can respond and the organism can efficiently interact with the external environment.

One of the most dramatic examples of circadian rhythm is the sleep-wake cycle because it is the most obvious to people, and its disruption is the most distressing. The processes that control alertness and sleep produce an increased sleep tendency and diminished capacity to function during the early morning hours (approximately 2 to 7 AM) (Akerstedt & Gillberg, 1981) and, to a lesser extent, during a period in the mid-afternoon (approximately noon to 5 PM). This period during the very early morning hours corresponds to the period of minimum core body temperature.

When circadian rhythms are upset, there may be profound medical implications, both in terms of health and disease. Circadian variation has been demonstrated in a number of diseases, such as sudden cardiac death (Muller, 1985) acute myocardial infarction (AMI), (Muller, Stone, & Turi, 1999) and stroke. Angina pectoris and AMI are more common from 6 AM to noon, with AMI occurring most frequently within 4 hours of awakening. Stroke is also most frequent in the hours from 6 AM to noon.

There is an increase in illness, both physical and emotional, when physiologic systems are out of synchronization with environmental clues (Harrington, 1994). A shortened sleep period has been found in connection with both morning and night shifts. Morning workers need to terminate sleep very early but are unable to advance sleep time to compensate for earlier rising, and night workers have difficulty sleeping during the day (Akerstadt & Folkard, 1997). Even those individuals who work only at night tend to adopt a diurnal schedule on off days, and therefore adaptation never fully occurs (Akersatdt, 1990).

Studies of adjustment to night work show that most people do not adjust fully after circadian rhythms are upset. This may be explained by the fact that the circadian system needs a longer time for adjustment than night workers ever have a chance at, because most revert to a normal life when off duty or when scheduled for a different shift. Most of the minor adjustment that will take place tends to occur during the first 1 to 3 days of night shift work and then proceeds at a slower pace (Akersatdt, 1990).

The most pervasive and severe consequence of shift work is a decrease in the quantity and quality of sleep (Dement, Seidel, & Cohen, 1986). Between 40% and 80% of night workers report disturbed sleep compared with only 10% to 15% of day workers. Sleep for shift workers is reduced in length by 1 to 4 hours, with the reduction mainly affecting stage 2 and REM sleep (Akersatdt, 1990). The average length of sleep in the morning is 4.5 hours.

The reason for the truncated sleep time and change in pattern is not understood completely. Night shift workers are attempting to sleep out of phase with their intrinsic circadian sleep-wake rhythm, as well as social cues. A study of emergency physicians found that total time in bed, as well as total sleep time, including REM sleep, is significantly decreased during the day compared with the night.

Fatigue and Stress

Fatigue, shift work, and long work hours may serve to exacerbate psychological well-being. Fatigue coupled with psychological stress suggests a double-barreled effect: both disrupt physiological systems and both may act upon the other. Other studies have suggested that fatigue may also be associated with depression (Garbarino, et al, 2002; Vandeputte, 2003).

Several epidemiological studies have linked chronic stress to a number of disorders including cardiovascular disease, a variety of cancers, abuse of alcohol/ drugs and depression. Members of the police force are an ideal population to study the relationships between chronic stress and health outcomes as they are considered to be a highly stressed work population due to both the type of work and the status of this work within our society. Police officers suffer from higher all-cause mortality as compared to the expected rate for the general U.S. white male population (SMR = 110; 95%CI = 1.04-1.17) (Violanti et al., 1998). Notably, there are higher rates reported for suicide, arteriosclerotic heart disease and various cancers. Further, heart disease and cancers occurred at a higher rate in men with fewer years of service suggesting certain work-related factors such as stress or the stress associated with traumatic events may exacerbate disease. Sources of stress in police work are many including psychological stress (coping with death, human misery negative public image, etc.) danger, rotating shifts, disruption of home life and exposure to chemicals.

The chronic nature of stress in police work may also prove important in the exacerbation of disease. In studies concerning the impact of work-related stress in police populations, as in other populations where there is concern over this issue, the stress status of these individuals has most often been determined through a questionnaire format. While these instruments provide valuable insight into the perceptions of stress as well as the traits (e.g., loneliness) linked to the biological consequences of stress they provide scant information as to the possible biological events associated with stress. A comprehensive evaluation of workplace stress would include psychological as well as biological indices of stress.

The hypothalamic-pituitary-adrenal (HPA) axis is a primary body system that responds to disturbances of homeostasis. Cortisol is a primary hormone released in a pulsatile fashion with the frequency and amplitude of these episodes declining over the course of the day resulting in a well-characterized diurnal pattern of cortisol secretion (i.e. high in the morning, low in the evening). Activation of this system by a stressor results in release of cortisol, the hormone that helps the organism to maintain basal and stress-related homeostasis of the central nervous system, as well as cardiovascular, metabolic, and immune functions. Protracted or repeated challenge to this system by such factors as chronic exposure to stressful situations, upsetting of the normal circadian pattern, and generalized fatigue is hypothesized to cause reduced resilience or less flexible functioning of this system.

This reduced flexibility can result in inappropriate levels and control of the hormone cortisol and further dysfunction of the HPA axis. Clinical conditions associated with uncontrolled cortisol secretion (e.g., Cushing's disease) result in certain somatic sequelae including central obesity, insulin resistance, cardiovascular problems, hypertension, depression, etc. These somatic sequelae can have detrimental health consequences such as cardiovascular disease and published work has shown certain of these (e.g., increased BMI, blood pressure) can be seen in a nonCushingoid population of middle-aged men (Rosmond et al., 1998). Further, these somatic sequelae were directly correlated with the degree of stress perception and stress related cortisol secretion in this population (Rosmond et al., 1998). Thus, the HPA axis of a healthy individual would be described as having a high degree of variation with a morning peak and an evening nadir and appropriate response to challenge (e.g., physiological or psychological stressors; dexamethasone suppression). It is speculated that an abnormal cortisol secretion patterns are a result of frequent or persistent challenges of the HPA axis might constitute a major risk indicator for serious disease (Chrousos, 1998) .

Fatigue and Disease

Between 20% and 30% of workers leave shift work within the first 2 to 3 years because of ill health (Murata, Yano, & Shinozaki, 1999). Gastrointestinal disturbances (eg, dyspepsia, constipation, and diarrhea) are common complaints. Both the risk of preterm birth and retarded fetal growth have been linked to shift work (Boggild, Suadicani, Hein, et.al, 1999). Female shift workers are 1.6 to 1.9 times more likely to give birth prematurely and 1.4 times more likely to have low birth weight infants. The risk of pregnancy loss was 4 times higher among women with fixed evening work schedules and more than twice as high in women working fixed night shifts in comparison with women working fixed day shifts (Infante-Rivard & Gauthier, 1994). A study of 23 young, healthy, male volunteers with sleep deprivation between 3 and 7 AM revealed a statistically significant but reversible decrease in the lytic activity of the natural killer cells of the immune system.

The issue of a possible association between cardiovascular disease (CVD) and shift or night work remains unsettled. Knutsson, Akerstada and Jonsson, 1986) demonstrated a dose-response relationship that increased the risk of CVD by 40% in both men and women shift workers. Possible causal mechanisms for increased CVD include mismatch of circadian rhythms, social disruption, and behavioral changes. Shift workers had higher serum triglycerides levels, which could not be explained by obesity, smoking, or alcohol intake, but which might be related to dietary habits (Knutsson, 1989).

A study of the blood pressure and heart rate variability of emergency physicians showed a significant elevation of diastolic blood pressure during a night shift compared with values after the shift. There was also a significant increase in heart rate before and during work compared with a period after work (Adams, Roxe, & Weiss, 1998). Because the study did not examine blood pressure or heart rate during a day shift, no comparisons between day and night shift parameters could be made.

Telephone interviews of 3,025 workers revealed that men who work variable shifts have higher rates of heavy drinking, job stress, and emotional problems compared with men with fixed schedules; women shift workers reported increased use of sleeping pills, tranquilizers, and alcohol, as well as increased job stress and emotional problems (Gordon, Cleary & Parker. 1986). These findings underscore the heavy psychologic price paid by those working erratic sche

Fatigue and Human Performance

Alertness and performance have a rhythmicity with a maximum in the late afternoon and a trough around 5 AM (Akersatdt & Folkard, 1997). Both cognitive and psychomotor performance parallel the circadian course of core body temperature (Dawson & Campbell, 1991). Laboratory tests of psychomotor performance and mental computation of mathematic problems are at a minimum level during the hours of 3 and 5 AM (Moore-Ede, Sulzman, & Fuller, 1982).

However, investigations and studies have reported the societal consequences of error in human performance, as well as the decline in mental performance and decision making in a number of industries during the hours of midnight to 6 AM (Borland, Rogers, & Nicholson, 1986). The night shift starts 10 to 16 hours after rising if sleep has not occurred during the day, forcing the worker to try and remain alert for a prolonged length of time. This prolonged period of wakefulness may compound the performance trough that occurs as a result of the circadian rhythm (Akersatdt & Folkard, 1997). The largest total number of vehicular crashes occur during the daytime because of increased traffic during this period. However, single-vehicle crashes, such as driving off the road, which may be the result of inadvertent lapses in driver attention or periods of microsleep, have a bimodal temporal pattern. The major peak occurs between midnight and 7 AM and is especially pronounced between 1 and 4 AM, with a small secondary peak between 1 and 4 PM (Dawson & Armstrong, 1996). This results in emergency physicians being called on to treat critically ill patients with multiple trauma when they themselves are fatigued and at a low point in their ability to function on a cognitive level.

A study of errors of response omission by locomotive drivers showed 2 peaks, one between 3 and 6 AM and a second between 1 and 3 AM (Adams, Roxe, & Weiss, 1998). Data on nuclear accidents or near-accidents show similar patterns. For example, the Three Mile Island incident occurred at 4 AM. The Davis-Besse nuclear reactor at Oak Harbor, OH, destabilized at 1:35 AM as a result of mechanical failure, which was then compounded by human error. Control of the Rancho Seco reactor in California was nearly lost as a result of a combination of mechanical factors and human errors at 4:14 AM. Finally, the catastrophe at Chernobyl is officially acknowledged to have begun at 1:23 AM as the result of human error (Mitler, Carskadon, & Czeisler, 1988).

The mean performance levels of tests designed for occupational realism declined by 3% to 4% when compared with preflight tests in pilot and student populations who had crossed 6 time zones in trans-meridian flight. Furthermore, although performance of simpler tasks recovered to baseline levels after 3 days, complex tasks showed decreased performance for up to 5 days (Dawson & Armstrong, 1996).

Research studies have been performed in medicine in an effort to measure the effects of sleep deprivation on house officers and attending physicians. Literature on the effects of lack of sleep documents declines in psychological and emotional parameters (Dawson & Armstrong, 1996). as well as in some cognitive and psychomotor tasks in residents from a number of specialties (Storer, Floyd, & Gill, 1989) a conclusion supported by a number of studies on sleep deprivation in shift workers Sleep deprivation affects information processing, which results in lengthening of response time. This becomes more pronounced in sustained or continuous work tasks compared with brief performance samples. Physiologic and psychomotor responses are more immune to sleep deprivation than emotional and psychological effects (Dawson & Armstrong, 1996).

Decision making is very much affected by fatigue. Recent findings in sleep deprivation show that it still impairs decision making involving the unexpected, innovation, revising plans, competing distraction, and effective communication. Sleep Deprivation presents particular difficulties for sleep-deprived decision makers who require these latter skills during emergency situations (Harrison & Horne, 2000).

Several points are evident from review of the above research. First, further studies and clinical in vivo clarifications are needed to enhance present knowledge about police morbidity and mortality, especially concerning associations among fatigue, stress and disease. Second, baseline data on physiological stress and associated subclinical cardiovascular characteristics among police officers is lacking in previous studies. Once established, such data has the potential for use in future prospective analysis in this occupational group. Third, the complex nexus of stress and subsequent physiological anomalies may be better untangled within a known high stress risk occupational group such as the police. Information gained through the proposed study may be useful not only to aid further investigation of fatigue, shift work, and work consequences, but may be generalizable to other high stress occupations as well. Examples are Firefighters, EMT's (Emergency Medical Technicians), nurses, physicians, air traffic controllers, and the military. In general terms, results found in this study and possible future studies may add to existing knowledge of associations between fatigue, physiological and psychological variations. In addition, the study may help to identify markers of fatigue in police officers and provide for a safer work environment**.**

C. OBJECTIVES

Group 1. Currently Employed Buffalo, NY Police Officers

- Examine the impact of shift work on biomarkers of subclinical cardiovascular and metabolic diseases.
- Examine the impact of an objective measure of shift work on self-report standardized measures of psychological well-being, including stress, depression, anxiety, and post traumatic stress disorder (PTSD).
- Examine the interaction of objective measures of shift work and sleep quality on stress and subclinical disease biomarkers.
- Examine the interaction of shift work and work injuries

Group 2. Mortality Cohort: Buffalo, NY Police Department

- Conduct a search of the National Death Index (NDI) to determine causes of death for the police officer mortality cohort (1990-2005).
- Develop a standardized risk assessment (Standardized Mortality Ratio) of causes of death for police officers as compared to the U.S. general population.
- Conduct a search of shift work records on deceased officers.
- Relate increased risk of specific causes of death among police to shift work.

II. METHODS

Sample 1: Shift Work and Health Outcomes: Currently Employed Police Officers

Data was collected from Group 1 to assess shift work impact on health outcomes and measurement of physiological stress biomarkers and subclinical disease markers. This data was collected in for this project in conjunction with a NIOSH study. The sample site was the Buffalo, New York Police Department.

Table 1. Population of Working Police Officers. Buffalo, NY Police Department *(At start of study- 2004)*

Age range: 21-65 years of age

	Men (N = 675)	Women (N = 162)	Total (N = 837)
Native- American	0.5%	0.0%	0.4%
Hispanic-American	9.7%	1.6%	8.1%
African-American	21.0%	33.5%	23.4%
European-American	68.7%	64.8%	68.0%

It was anticipated at the start of the study that approximately 700 of 837 City of Buffalo, NY police officers would be asked to participate in the study. After the first year of the study, the Buffalo Police Department entered into an *unplanned phase of attrition among its personnel due to budgetary shortfalls.* Officers who left the force were not replaced and no new hires were initiated. The size of the police department was subsequently reduced during the duration of the study from *837 to 650 eligible officers.* Official recruitment was terminated on December 1, 2009. As of the end of data collection period, n=464 officers currently employed voluntarily participated in the study (approximately 71%).

The participating officers represented a demographically defined population of police officers in which 1) significant proportion of the cohort represented women as well as men ; 2) at least two racial/ethnic groups; , and 3) a documented natural range of ages for active, as opposed to retired, police officers representative of the population cohort. A demographic sample of non-participating officers was conducted and no significant differences were found between volunteers on non-volunteer officers.

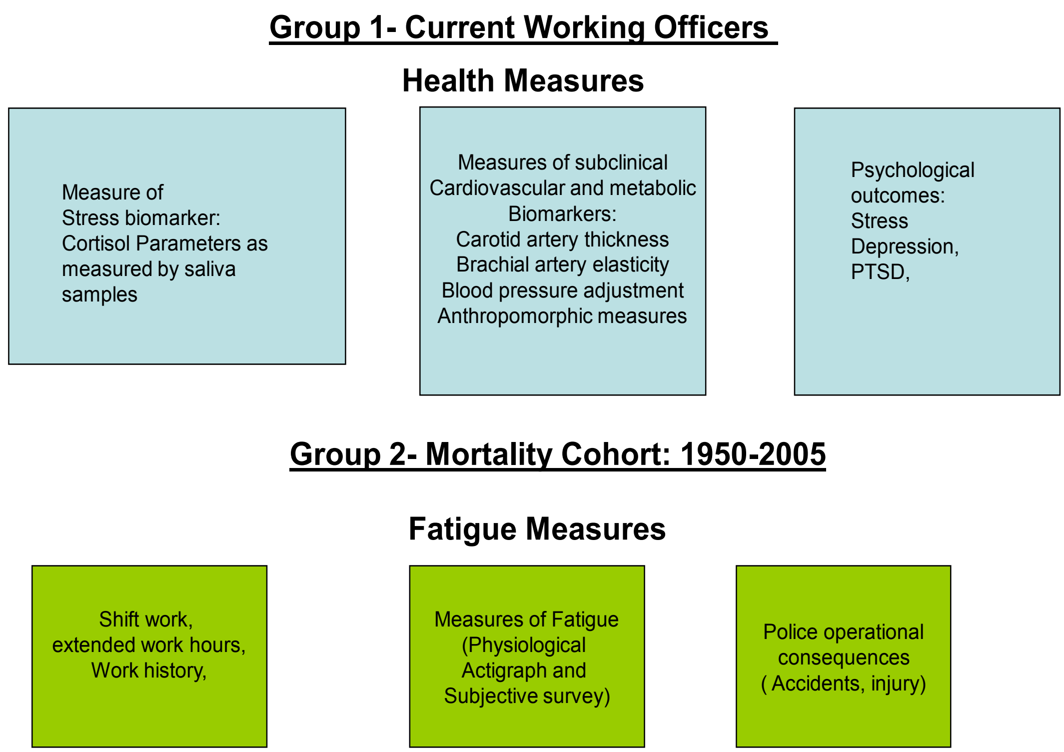
The fundamental analysis design was a statistically rigorous cross-sectional survey derived from this demographically defined population of police officers. The sampling frame consisted of a complete and thorough list of all sworn police officers from the Buffalo, NY police department. Restricting the study sample to one large police department was intended to reduce potential variability caused by different administrative structures. The representative sample followed a sampling strategy that was conceptually justified and operationally tractable. Participant representation requirements of gender, ethnicity, and age were adhered to.

Sample 2: Shift Work and Causes of Death: Buffalo Police Officer Mortality

In order to determine the impact of shift work on mortality outcome, we compiled a list of deceased officers in the Buffalo, NY Police Department from 1950-2005. A list of officers, identifying information, and causes of death from 1950-1990 were already available from a prior Buffalo police mortality analysis (n=1,035). We extended this base mortality analysis from 1990-2005. We conducted a search of the National Death Index (NDI) to determine causes of death for the updated police officer mortality cohort (1990-2005). Mortality software was employed to develop a risk assessment (Standardized Mortality Ratio) of causes of death for police officers as compared to the U.S. general population (*see methods section for death identification and collection).*

A. MEASURES

Figure 1. Measures- Police Groups 1 & 2



Group 1: Current Working Officers Health Measures **

Demographic Information- date of birth, gender, race, ethnic background, marital status, children, religion, veteran status, occupational variables (rank, years of police service, year started employment, police duty assignments).

Objective Physiological and Subjective Measures of Fatigue - The relationship between the work hours and sleep habits of police officers is of importance as it relates to both alertness and avoidance of accidents. The same is true with regard to the long work hours, partial sleep deprivation, and high workload, in that these factors can result in serious consequences of wrong decision-making in crucial situations. The Actigraph is a device which measures sleep/wake cycles in order to assess their adaptability to work cycles. The Actigraph provides a clear data-based picture of Circadian rhythms and their normal or compromised cycles. This information will be used as a variable to assess relationships with outcomes of disease, psychological anomalies, impact on the police family, and police operational consequences such as accidents, sick leave, complaints, and performance. This device is highly portable, and is worn by the participant as a wrist watch. Thus, there are no invasive or intruding parts which might inconvenience or cause discomfort to the officer. Actigraph environmental sensors can monitor light, sound, and temperature levels in an officer's daytime and sleeping environment. Data can be collected in as little at 15 second intervals over an extended time period of as long as 59 days. The American Academy of Sleep Medicine (2003) has found the Actigraph to be reliable and valid for detecting sleep and sleep dysfunction in normal populations.

The participant officer was given an Actigraph watch upon arrival at our clinic for the NIOSH study. The officer was instructed to wear the Actigraph watch for 15 days, which is the span of a work and off duty cycle in the Buffalo Police Department: 4 days on shift, 4 days off-duty, 4 days back on shift, and 3 days off duty. This allowed for a comprehensive data collection of the officer's sleep quality through work shifts, changing shifts, and off-duty time. Data obtained from the Actigraph was entered into a software provided algorithm to provide a summary statistic of the officer's sleep quality and circadian disruption patterns. This statistic served as an objective physiological measure of sleep quality.

In addition to the objective physiological circadian rhythm measure provided by the actigraph, we also obtained a subjective measure of sleep quality for each officer. The Pittsburgh Quality Sleep Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) will be used for this measure. The PSQI has shown good reliability (alpha=.75) as well as an ability to distinguish between good and poor sleepers (sensitivity = 89.6%; specificity= 86.5%).

*** - Group 1 (currently employed officer health outcomes)_measures were collected in conjunction with a National Institute for Occupational Safety and Health (NIOSH), Health Effects Laboratory Division, Morgantown, W VA, for use in this study.*

Stress Biomarkers- Elevated cortisol has long been considered a biomarker for both acute and chronic stress but it has received limited application in studies of human stress outside the laboratory because it has most often been measured in blood. Fatigue and circadian disturbances also affect cortisol and can lead to a dysfunction of this circadian related hormone secretion.

The discovery that cortisol can be measured in saliva has increased the feasibility of using this marker in human stress studies. Cortisol in saliva is unbound so that radioimmunoassay (RIA) of this tissue quantitates the level of active cortisol. Saliva was collected using a Salivette which consisted of a dental roll and a centrifuge tube. The participant removed the roll from the tube and places it in the mouth for a period of approximately 3 minutes. The tube is then centrifuged to provide a nonviscous saliva sample for assay.

High protein cortisol challenge test – Following a saliva cortisol baseline sample, the initial characterization of the cortisol pattern was measured as a response to the physiological challenge of a high protein meal (commercially available powdered high protein drink with 55 g protein).

Off site saliva testing was also conducted by the officers over a period of two days. In addition, a dexamethasone suppression test was requested to provide a more complete picture of the HPA axis in officers. The dose required was 0.5 mg. By utilizing a number of measures of the function of the HPA axis, we were able to evaluate which most adequately captures the function of the system. It was necessity that participants refrain from ingesting caffeine containing beverages from about 8 PM the night before sample collection and during the sample collection period. They must also have refrained from smoking during the collection of samples.

Table 2. Saliva Collection Protocol

Sample number	Day	Approximate time	Cortisol sample characteristics
1	1	7:30 – 8:30 am	Before venipuncture
2	1	7:30 – 8:30 am	After venipuncture
3	1	11:10 am	Baseline (prior to protein lunchtime clinic challenge)
4	1	11:20 – 12:30	15 minutes after lunchtime clinic challenge
5	1	11:20 – 12:30	30 minutes after lunchtime clinic challenge
6	1	11:20 – 12:30	45 minutes after lunchtime clinic challenge
7	1	11:20 – 12:30	60 minutes after lunchtime clinic challenge
8	2	Awakening	First awakening sample
9	2	Awakening	15 minutes after awakening
10	2	Awakening	30 minutes after awakening
11	2	Awakening	45 minutes after awakening
12	2	Lunchtime	Immediately before eating midday meal
13	2	Dinnertime	Immediately before eating evening meal
14	2	Bedtime	Before bedtime and before taking dexamethasone tablet
15	3	Awakening	Post dexamethasone awakening sample
16	3	Awakening	15 minutes after awakening
17	3	Awakening	30 minutes after awakening
18	3	Awakening	45 minutes after awakening

Ultrasound Subclinical Cardiovascular Disease (CVD) Measures

We developed and implemented a final protocol for ultrasound artery examinations. Ultrasound can help to distinguish measurable artery functions. These measures can be utilized to determine the health of arteries and thus potential cardiovascular disease. The protocol specified the techniques to measure wall thickness and lesion characteristics as well as potential physiological characteristics in the carotid arteries in an examination not to exceed 60 minutes of participants' time (examination time). We established appropriate measures and then measured characteristics of brachial forearm endothelial function and vascular stiffness Beginning in the pilot period established, developed, and maintained Reading Center activities for all ultrasound image collections, including carotid arteries and brachial forearm assessment of endothelial function and vascular stiffness. Reading Center and related QC activities were initially established with Dr. Ward Riley at North Carolina Ultrasound Center and then moved to UB after extensive training by Dr. Riley of UB ultrasound technicians.Using standard research-based ultrasonography techniques under direction of an ultrasound Reading Center and a local physician-ultrasonographer, the following measurements were made:

- Vessel interfaces: Near and far wall adventitia-periadventitia, media-adventitia, lumen-intima of both common carotid arteries, carotid bulbs, and internal carotid arteries.
- Wall thicknesses: Mean and maximum intimal-medial thickness of near and far walls of right and left common carotid arteries, carotid bulbs, and internal carotid arteries.
- Minimum residual lumen of the common and internal carotid arteries and internal carotid arteries.
- In the assessment of stenosis, Doppler frequency shift or velocity at point of maximum disease.
- Lesion characteristics, such as homogeneity, density, and regularity of surface. In the right and left internal carotid arteries, images will include two to three longitudinal views centered on the largest lesion, or at bifurcation if there is no lesion, as well as a single lateral view of the distal 10 mm of each common carotid artery.
- Measures of flow mediated endothelial function as well as vascular stiffness, using ultrasound imaging of the forearm or other noninvasive technique. The Contractor, working in collaboration with research-based expertise either within their institution, a subcontractor, and/or Reading Center, will establish the protocol and specific quantitative measures of endothelial function and vascular stiffness. This will include pilot work.
- As part of an overall quality assurance program, trained and supervised quality control monitoring of measurements by ultrasound technicians in the details of the ultrasound examination, including QC protocols. Training and certification was documented and provided to NIOSH.

Blood measures

A phlebotomist obtained fasting blood lipid samples for analyses. Approximately 30 ml of blood was drawn into five tubes and divided into 16 cryovials for long-term storage. We provided for refrigerated centrifugation and storage at low temperature (-80 degrees C).

The following parameters were examined:

- ❑ Appropriate fasting whole blood, white cell buffy coat, serum, plasma, comprehensive blood chemistry with a full lipid panel; HgblAC; CBC with differential , sensitive C-reactive protein, insulin levels

Anthropometric Measures

- ❑ Weight and Height – The proper measurement of weight and height required clear indication of the standardized procedures to be followed by participants and observers (ie., participants shall be shoeless, wearing only undergarments). Scales should be calibrated daily using a known quantity of weight. Calculation of Body Mass Index (BMI) will be made.

- ❑ Body circumferences – Measurement of waist and hip circumference and their ratio and abdominal height will provide information on the distribution of body fat in study participants. Numerous epidemiological studies have shown that these measures can be performed with good reproducibility across observers if the measures are preceded by training (Trevesan, 1990).

Psychosocial – Standardized self-report measures of psychological stress, anxiety, depression, PTSD, police job stressors, resiliency, and others were collected during officers at the clinic visit:

- Perceived Stress Scale
- PTSD Checklist
- Impact of Events Scale (PTSD)
- Critical Incident Survey
- CESD (Depression)
- Hardiness (Resiliency)
- PSQI (Sleep Quality)

Group 2- Causes of Death and Police Mortality

Collection of Mortality Information

We compiled a list of all deceased officers in the Buffalo, NY Police Department from 1950-2005. A list of officers, identifying information, and causes of death from 1950-1990 were already available from a prior analysis (n=1,035). Sources of follow-up in our analysis included the benefit and pension programs of the city of Buffalo, the New York State Retirement System, New York State Vital Statistics Division, Buffalo Police employment records, Buffalo Police Association publications, and the National Death Index (NDI). Death certificates were coded by a nosologist according to the International Classification of Diseases (ICD) Revision in effect at the time of death. The age-and time-specific person-years at risk of dying were calculated for each police officer starting with: (1) the year of first employment as a police officer, if the inclusion criteria of 5 years employment with the city of Buffalo were met; (2) the year in which 5 years of employment for the city of Buffalo was completed, if the first year of employment as a police officer was before the five year inclusion criteria was met; or (3) the year 1950 if (1) and (2) above were prior to 1950.

Within this study, we updated this available base mortality surveillance from 1990-2005. Mortality follow-up was carried out using the National Death Index (NDI) *Plus*, from which we obtained cause of death for decedents that are an exact match. http://www.cdc.gov/nchs/r&d/ndi/what_is_ndi.htm). NDI *Plus* is an efficient option for national searches. Death certificates for incomplete matches on decedent status are obtained from the various states in order to perform additional checks and to verify that the possible decedent is actually from the Buffalo Police cohort, and were then coded by a nosologist for the underlying cause of death according to the *International Classification of Diseases, Ninth Edition* (ICD-09). Cause of death codes were electronically entered and merged with the other data from the cohort. Mortality surveillance was presumed to be nearly 100% complete by this method of ascertainment. Extending mortality surveillance and identifying additional deaths provided greater statistical power to evaluate additional scientific questions such as the relation between shift work to risk of cardiovascular disease and site-specific cancers.

Shift Work Inventory

Work History Database Development

An electronic database on Buffalo Police shift work was available from the City of Buffalo Records Division. Permission was obtained from the department and the City of Buffalo, NY to access these records. The records ranged from 1993-2005 and contained a *day-to-day account* of each officer's shifts. This database provided the methodological advantage of an *objective* (as opposed to a subjective self-report) account of the officer's work schedule.

Electronic information on work history was not available prior to 1993. Therefore, we conducted an additional work history search for hard copy records prior to 1993 at the City of Buffalo records center. We first conducted a comprehensive work record pre-inventory of officers involved in the study. We obtained a 10% random sample of data (approximately 300 records) from available records within the scope of data inventory strategies listed above. We considered time epoch changes in record keeping and forms of data in this sampling procedure. We assessed types of records in terms of size, bound or unbound, deterioration due to time, changes in information recorded, methods of data transfer to a database, and other logistical considerations. Due to the different age, condition, sizes and texture of the hard copy records, it became necessary to digitally photograph available records and then input the data from images into an access database file. This turned out to be a labor-intensive process. There were two types of hard copy records available:

1. **Weekly patrol reports** were 18"X19" sheets of heavy paper stacked and rolled together. Each roll represented 1 year of work for the entire precinct. Each precinct was divided into 3 platoons. There was also a section showing the officers who worked in that precinct. Generally four images represented one week of any given precinct's work schedule. Approximately 48,000 pictures were taken of weekly patrol reports.
2. **Daily patrol reports** were on legal sized paper. They were an account of each officers work schedule on a daily basis. These were the precursor of the weekly reports, but because of the vast numbers involved we only used these to fill in the gaps when there were no weekly reports available. There were approximately 90 images per precinct per month or about 12,000 images per year. These were available on a consistent basis after 1985, but essentially they were seven times the work of the weekly reports.

Unfortunately, there were large gaps in hard copy recorded information across precincts and years. This was due to destruction and loss of early work records. Approximately 60% of this data was accessible. It was still possible to statistically adjust available data to suit the data reliability and quality needs of the study.

B. QUALITY ASSURANCE OF MEASURES

Shift Work- Reliability checks were made on shift work record data from the point of first recording to transcription into a database. Comparisons of transcriptions and actual entries were conducted on a regular basis. Data were double entered and range checked. Data collection were strictly supervised and periodically reviewed.

Ultrasound scans - To ensure that the ultrasound data was of consistent high quality and collected according to the study protocol, the following measures was taken. Bi-monthly, and after any service visit, images of a tissue equivalent ultrasound phantom will be recorded and examined for precision according to standard procedures for performing a phantom scan. A log was maintained of all service calls that will include the timing, reason and result of the visit. Sonographer performance was evaluated on a monthly basis by Dr. Ward Riley at the Wake Forest University site, using a previously established protocol. Any sonographer found to deviate from the protocol in a manner likely to affect the availability and/or quality of the arterial measurements had a second study reviewed. If successive studies are deficient, immediate remedial training and re-assessment will take place before the sonographer will be allowed to continue scanning. Ultrasound Technicians were calibrated when they went through training. Schedules were arranged for them to calibrate against each other on a regular basis. A 10% repeat read was conducted on site between sonographers for every 10th officer and then compared for accuracy. A 10% sample of scans were sent to the Wake Forest Center for interpretation as a reliability check.

Blood samples - Blood samples were sent to Kaleida Millard Fillmore laboratory. This lab has been used in all studies associated with center, thus maintaining a consistency across testing facilities. An extra vial of blood involving the same tests involved in the study was drawn on a 5% randomized sample of participants. These were also sent to Millard for blind analysis as a check for consistency in results.

Blood Pressure, height, weight

- At initial training and at least every 6 months, all blood pressure persons are calibrated to a single person. Each interviewer separately measured the same person on the same day (each interviewer measure will 2-3 different individuals). Their measurements were compared for variation. It there is too much variation, they were re-trained. Every 3-4 months, BP cuffs were checked and repaired/replaced, as necessary.

- Stadiometers were checked annually.
- All tape measures were checked annually for "stretching" and replaced as necessary.
- Scales were professionally checked for accuracy once-a-year. In-between

professional checks (i.e., every 6 months), scales are checked using standardized 50 lb weights.

- **Interviewers-** Before they can work with participants, all interviewers were trained together and are observed by supervision to be sure that they were consistent in their interview techniques and in delivery of information to the participants.

Quality Assurance Procedure manuals of operation were available for all personnel. All members associated with this study have extensive experience in setting up and implementing quality control for data collection. Rigorous steps are to be observed in order to ensure the quality of the collected data and their standardization. Dr. Violanti assured that data collection procedures were well defined in all staff training and that all protocol requirements were met. Data monitoring personnel was tracked overall adherence and visit schedules. Quality control issues such as collection of work/shift time and all physiological measures were monitored. Data was double entered and subject to reliability checks.

C. CONFIDENTIALITY AND SECURITY PROVISIONS

All security and confidentiality issues were guided by the federal enacted regulations guiding research. All study personnel have been trained in these new regulations effective February 1, 2005. This study was approved by the State University of NY at Buffalo Internal Review Board (IRB) to ensure that the confidentiality and well-being of all participants is strictly ensured by the researchers. Procedures for management of the data were based upon the extensive experience of the SUNY at Buffalo research investigators at the Department of Social and Preventive Medicine. The department has a long history in epidemiologic research, procedures to manage and maintain participants' clinical files under controlled and secure conditions, and followed established departmental guidelines. Staff are familiar with the importance of maintaining confidential and secure data records. Storage rooms for files are locked and access is limited to those professionals specifically working on the research project. All cabinets are locked and procedures are well established to insure that the cabinets and storage areas remain locked and secure. Special storage space for the proposed trial was established adjacent to the research center. The project coordinator is very experienced in managing secure research files and will supervise staff. Names and identifying information from work/shift records were deleted from data input and kept in a separate locked file. Data was reduced to coded numbers and de-identified. No identifying information was contained in those files.

The following procedures were adhered to in order to protect the confidentiality of participants:

- Human Subject Certification has been obtained from the State University of New York HSIRB (Health Sciences Internal Review Board). Any changes or alterations in the study must first be approved by HSIRB prior to initiation.

- Identifying information will only be used to contact those participants on whom additional information is required and those who have not returned study information. No further use of information was made unless a new proposal is submitted to the Institutional Review Board for the protection of human subjects and duly approved by them.

- Survey responses will have only an identifying number on them. All computer files were password protected and available only to authorized personnel. Passwords were changed once a month for further security. All final reports will contain only aggregate data void of any identifying information.

- Physiological measures do not pose a risk to subjects. Blood pressure measures have the potential to benefit participants by identifying to them the possible presence of undiagnosed hypertension. The only possible risk relates to the taking of blood samples. To minimize this risk, only trained and skilled phlebotomists were employed to draw blood. Potential benefits far outweigh the risks.

- The Actigraph sleep quality measuring device is similar to a wrist watch and was worn as such by participants. The device posed no known risks to participants as it simply measures motion.

- Data tapes containing information on ultrasound brachial artery and CIMT scans contained only ID numbers and no identifying information.

- All data collected on work/shift hours was stored on password secured computer files with limited access to investigators and data management personnel. Identifying information was not included on computer files, but stored separately in locked file cabinets with limited access.

D. STATISTICAL ANALYSIS

Our preliminary analyses included descriptive frequency characteristics of police participants across age, race, and gender. Univariate analyses allowed us to carefully describe the participants and first identify possible covariates to be included in further multivariate analyses. We measured the risk for outcomes of subclinical cardiovascular disease, and measures of adiposity, based on independent variables of fatigue, sleep quality, stress biomarkers (cortisol), as they related to career length work/shift hours. We examined the potential risk of health and mortality outcome with relevant variables. This strategy permitted the simultaneous study of several exposure variables that may be discrete or continuous in scale, in the presence of additional explanatory variables (confounders and effect modifiers). The distributions of all exposure variables, possible confounders and other covariates will be compared. Summary statistics were created during this preliminary stage. Correlations and associations between continuous exposures and other continuous covariates were evaluated, and such bivariate relationships were studied using scatterplot matrices. Associations with the different exposure variables for all primary aims were examined in separate statistical models using one exposure at a time. In the second stage of the analysis, we looked at statistical adjustment for traditional risk factors. The effect of potential confounders was carefully analyzed incorporating variables into the models. Models with multiple exposures were studied in an exploratory stage of the analyses. The sensitivity of the different methods on the results were compared and carefully analyzed.

III. RESULTS

A. SHIFT WORK AND POLICE HEALTH OUTCOMES

Health outcome and shift work data was collected from n=464 Buffalo Police officers. This represented approximately 71% of the entire force that was available for clinic visits. Demographic data of those officers that did not participate was correlated with those officers that did. Table one displays demographic information on this sample.

Table 3. Police Officer Demographic Characteristics by Gender

Characteristic	Men (N=348)		Women (N=116)		Total (N=464)	
	N	%	N	%	N	%
Age Group						
< 40 years	140	40.2	46	39.7	186	40.1
40-49 years	132	37.9	59	50.9	191	41.2
50 + years	76	21.8	11	9.5	87	18.5
Education						
Less than 12 years	1	0.3	0	0.0	1	0.2
High School/GED	44	12.9	5	4.4	49	10.8
College < 4 years	179	52.7	70	61.4	249	54.9
College 4 + years	116	34.1	39	34.2	155	34.1
Marital Status						
Single	29	8.5	26	22.8	55	12.1
Married	272	80.0	66	57.9	338	74.5
Divorced	39	11.5	22	19.3	61	13.4
Years Served						
1-5 years	35	10.3	12	10.5	47	10.4
6-10 years	72	21.2	36	31.6	108	23.8
11-15 years	56	16.5	14	12.3	70	15.4
15+ years	177	52.1	52	45.6	229	50.4
Rank						
Police Officer	223	66.4	89	78.1	312	69.3
Ser/ Lieut/Capt	59	17.6	13	11.4	72	16.0
Detective	39	11.6	11	9.7	50	11.1
Executive	10	2.9	1	0.9	11	2.4
Other	5	1.5	0	0.0	5	1.1
Ethnicity						
White	272	81.2	82	71.9	354	78.8
African American	56	16.7	32	28.1	88	19.6
Other	7	2.1	0	0.0	7	1.6

Females		Males		Total	
n	mean ±SD	n	mean ±SD	n	mean ±SD
116	41.0 ± 6.4	348	42.6± 9.2	464	42.2 ± 8.6
114	13.5 ± 6.7	340	16.1 ± 8.8	454	15.5 ± 8.

The following are a result of publications utilizing *preliminary data* from this study. Future publications and presentations at conferences are planned utilizing the entire police sample of n=464 officers.

Shift Work and Cardiovascular Disease among police officers

This study examined whether atypical work hours are associated with metabolic syndrome among a random sample of police officers. Shift work and overtime data from daily payroll records and reported sleep duration were obtained. *Metabolic syndrome is defined as elevated waist circumference and triglycerides, low HDL cholesterol, hypertension, and glucose intolerance*. Multivariate analysis of variance and analysis of covariance models were used for analyses. Officers working midnight shifts were on average younger and had a slightly higher mean number of metabolic syndrome components. Stratification on sleep duration and overtime revealed significant associations between midnight shifts and the mean number of metabolic syndrome components among officers with less sleep (p = .013) and more overtime (p = .007). Results suggested that shorter sleep duration and more overtime combined with midnight shift work may be important contributors to the metabolic syndrome.

Table 4. Criteria and Prevalence of Metabolic Syndrome and Components

Syndrome component	*n*	%
Elevated waist circumference (≥ 102 cm in men, ≥ 88 cm in women)	30	30.6
Elevated triglycerides (≥ 150 mg/dL)	15	15.3
Reduced HDL cholesterol (< 40 mg/dL in men, < 50 mg/dL in women)	3	38.8
Glucose intolerance (fasting glucose ≥ 100 mg/dL or diabetic medication use)	21	21.4
Hypertension (systolic blood pressure ≥ 130 mm Hg, diastolic blood pressure ≥ 85 mm Hg, or antihypertensive medication use)	15	15.3
Metabolic syndrome		
0 components	37	37.8
1 component	30	30.6
2 components	15	15.3
3 or more of 5 components	16	16.3

Table 5. Mean number of Metabolic Syndrome Components by Shift

	Day (n = 46)		Afternoon (n = 32)		Midnight (n = 20)		
Variable	*M*	*SD* or *SE*	*M*	*SD* or *SE*	*M*	*SD* or *SE*	*p*
Unadjusted	0.97	1.27	1.25	1.37	1.70	1.34	.127
Sex adjusted	1.15	0.19	1.12	0.23	1.51	0.29	.523
Age and sex adjusted	1.04	0.21	1.20	0.24	1.62	0.30	.328
Multivariable adjusted[a]	0.79	0.26	1.00	0.28	1.48	0.34	.213

Note. Values are means standard deviations for the unadjusted model and means and standard errors for the adjusted models; p value is for differences among means.
[a]Adjusted for gender, age, smoking status, alcohol intake, education, marital status, rank, and physical activity score.

Shift Work and Sleep Problems among Police Officers

Working on the night shift is a potential source of occupational stress and has been associated with sleep disorders. The authors investigated the association of shift work with sleep problems in police officers from Buffalo, New York. Randomly selected officers (n=111) responded to questions on the quality and quantity of sleep. Work history data, collected daily from 1994 to the date of exam at baseline (1999-2000), were used to determine shift work status. Prevalence ratios (PR) were obtained from Poisson regression models that examined the association of shift work with sleep quality and quantity. Participants ranged in age from 26 to 61 years old (mean ± S.D. = 39.4 ± 7.5 years). Fifty-three officers (47.8%) worked the day shift at least 50% of the time and 20 officers (18%) worked the night shift. Sleep problems with the highest prevalence were tiredness upon awakening (89.9%) and snoring (83.3%). Sleep apnea had the lowest prevalence (11.4%). Forty-four (39.6%) officers reported sleeping ≥7 hours per 24-hour period during the week and 53 (48.2%) during the weekend. In general, higher depression scores and lower physical activity scores were more likely to be seen in officers who had a higher frequency of sleep problems. The unadjusted prevalence of snoring was 26% higher in night shift workers compared to workers on other shifts. After adjustment for years of service, depression, BMI, physical activity and gender, the prevalence ratio (PR) for snoring remained significantly elevated, being 16% higher in night shift workers compared to the other workers (PR=1.16; 95% confidence interval (CI) = 1.00 – 1.33). This increased prevalence occurred predominantly in officers with BMI < 30 kg/m^2. Night shift work was not associated with other sleep problems in this study sample. Among police officers, night shift work was significantly and independently associated with snoring.

Table 6. Prevalence of Sleep Problems among Police Officers by Shifts

Sleep conditions	All workers *N*	All workers No. of cases	All workers %	Night shift workers *N*	Night shift workers No. of cases	Night shift workers %	Day and afternoon shift workers *N*	Day and afternoon shift workers No. of cases	Day and afternoon shift workers %
At night, my sleep disturbs my bed partner's sleep	75	57	76.0	14	10	71.4	61	47	77.1
I am told I snore in my sleep	90	75	83.3	17	17	100.0	73	58	79.5
I am told I stop breathing in my sleep	79	9	11.4	15	1	6.7	64	8	12.5
I suddenly wake up gasping for breath during the night	95	17	17.9	18	1	5.6	77	16	20.8
I have or have been told that I have restless legs	81	28	34.6	17	7	41.2	64	21	32.8
I feel tired upon awakening and want to go back to sleep	99	89	89.9	18	16	88.9	81	73	90.1
I am very sleepy during the daytime and struggle to stay awake	100	72	72.0	18	12	66.7	82	60	73.2
Hours of sleep per 24-hour period during the previous week*	111			20			91		
0–4.5		13	11.7		1	5.0		12	13.2
5–6.5		53	47.8		15	75.0		38	41.8
≥ 7		45	40.5		4	20.0		41	45.1

Note: *p-values for difference between night and day/afternoon shift workers < 0.05
Source: Charles *et al.* (1999)

Sleep Deprivation and Police Obesity

Several studies have shown a positive association between obesity and sleep disorders and other studies suggest that police officers are more sleep deprived than the general public, but little is known about the prevalence of obesity and its association with sleep problems among police officers. The authors conducted a cross-sectional study of the relationship between obesity and sleep disorders among 110 randomly selected police officers from the Buffalo, New York, Police Department. Participants, who ranged in age from 26 to 61 years (mean±S.D. = 39.5±7.5), responded to sleep-related questions and had anthropometric measurements taken. The reported prevalence of tiredness upon awakening was 89.9%, snoring was 83.2%, and 'stop breathing during sleep', 10.1%. All anthropometric measures (except waist-to-hip ratio) were positively and significantly associated with snoring after adjusting for age, physical activity, smoking, alcohol intake, sex, depression, and shift-work status. Abdominal height was the best predictor of snoring. Five of these measures (BMI, hip circumference, abdominal height, neck circumference, and neck-to-height ratio) were associated with waking up gasping for breath after risk factor adjustment. Additionally, positive stepwise trends were observed between five measures and 'stop breathing during sleep'. Although not statistically significant, inverse stepwise trends were observed between quantity of sleep and waist circumference. Results show that several measures of obesity were significantly associated with sleep-disordered breathing in police officers, but not with other sleep problems.

Table 7. Police Obesity by Sleep Problems

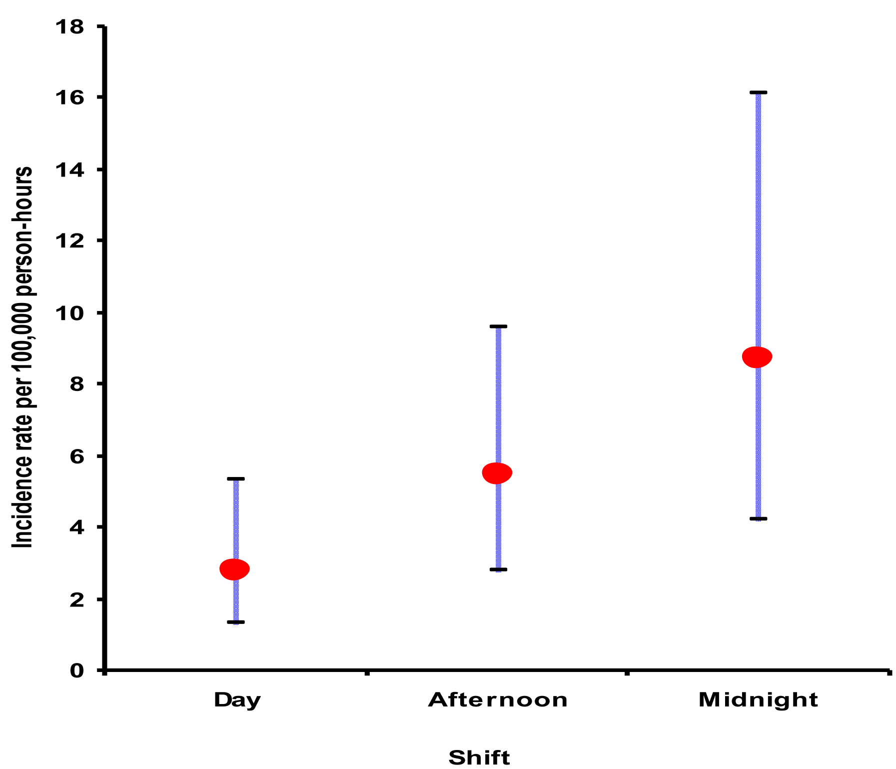
		Snoring					Stop breathing					Gasping for breath				
			Model 1		Model 2			Model 1		Model 2			Model 1		Model 2	
Anthropometric obesity measurements	Frequency of sleep problems	N^a	Mean	(SE)	Mean	(SE)	N^a	Mean	(SE)	Mean	(SE)	N^a	Mean	(SE)	Mean	(SE)
BMI	Never	15	25.9	(1.0)	25.4	(1.2)	71	28.1	(0.5)	27.7	(0.7)	78	27.8	(0.5)	27.1	(0.6)
	<1–2 times/wk	50	27.5	(0.6)	26.8	(0.7)	4	28.3	(2.2)	28.6	(2.0)	13	29.0	(1.2)	28.9	(1.4)
	3–7 times/wk	24	30.9	(0.8)	29.6	(1.0)	4	30.8	(2.2)	29.9	(2.2)	3	32.0	(2.5)	32.3	(2.5)
	P_{trend}			<0.001		0.002			0.235		0.312			0.108		0.036
Hip circumference	Never	15	102.8	(2.2)	100.5	(2.6)	71	107.8	(1.1)	107.0	(1.5)	78	106.8	(1.1)	104.9	(1.4)
	<1–2 times/wk	50	106.2	(1.2)	105.6	(1.6)	4	105.4	(4.6)	106.6	(4.5)	13	107.8	(2.6)	106.5	(3.1)
	3–7 times/wk	24	112.3	(1.8)	109.9	(2.2)	4	112.1	(4.6)	111.0	(4.7)	3	115.9	(5.4)	116.7	(5.5)
	P_{trend}			0.001		0.003			0.366		0.391			0.105		0.036
Waist	Never	15	84.9	(3.0)	85.2	(2.8)	71	91.6	(1.5)	91.6	(1.8)	78	90.6	(1.4)	89.8	(1.6)
	<1–2 times/wk	50	90.2	(1.7)	89.2	(1.7)	4	93.2	(6.5)	93.4	(5.3)	13	91.1	(3.6)	92.8	(3.4)
	3–7 times/wk	24	99.0	(2.4)	95.6	(2.3)	4	92.7	(6.5)	92.7	(5.6)	3	99.2	(7.5)	101.0	(6.1)
	P_{trend}			<0.001		0.002			0.868		0.845			0.265		0.068
Abdominal height	Never	15	19.0	(0.7)	18.7	(0.8)	70	20.9	(0.4)	20.5	(0.5)	77	20.6	(0.4)	20.2	(0.4)
	<1–2 times/wk	50	20.6	(0.4)	20.1	(0.5)	4	21.1	(1.6)	21.0	(1.4)	13	20.6	(0.9)	20.5	(0.9)
	3–7 times/wk	23	22.8	(0.6)	21.7	(0.7)	4	22.6	(1.6)	22.1	(1.5)	3	23.8	(1.8)	24.3	(1.6)
	P_{trend}			<0.001		0.002			0.283		0.254			0.091		0.014
Waist-to-hip ratio	Never	15	0.82	(0.02)	0.85	(0.02)	71	0.85	(0.01)	0.85	(0.01)	78	0.85	(0.01)	0.85	(0.01)
	< 1–2 times/wk	50	0.85	(0.01)	0.85	(0.01)	4	0.88	(0.04)	0.87	(0.03)	13	0.84	(0.02)	0.87	(0.02)
	3–7 times/wk	24	0.88	(0.02)	0.87	(0.01)	4	0.83	(0.04)	0.84	(0.03)	3	0.86	(0.05)	0.87	(0.03)
	P_{trend}			0.038		0.225			0.665		0.622			0.764		0.606
Waist-to-height ratio	Never	15	0.49	(0.01)	0:50	(0.02)	71	0.52	(0.01)	0.53	(0.01)	78	0.52	(0.01)	0.52	(0.01)
	<1–2 times/wk	50	0.52	(0.01)	0.52	(0.01)	4	0.52	(0.03)	0.52	(0.03)	13	0.52	(0.02)	0.53	(0.02)
	3–7 times/wk	24	0.56	(0.01)	0.55	(0.01)	4	0.53	(0.03)	0.54	(0.03)	3	0.57	(0.04)	0.58	(0.04)
	P_{trend}			<0.001		0.006			0.847		0.844			0.200		0.089
Neck circumference	Never	13	38.0	(1.1)	36.8	(1.0)	67	39.4	(0.5)	38.4	(0.6)	74	39.2	(0.5)	38.5	(0.5)
	<1–2 times/wk	48	38.9	(0.6)	37.8	(0.6)	4	403	(2.0)	39.7	(1.7)	13	40.3	(1.2)	41.0	(1.1)
	3–7 times/wk	24	42.0	(0.8)	40.3	(0.8)	4	42.0	(2.0)	40.3	(1.8)	3	43.3	(2.4)	43.2	(2.0)
	P_{trend}			0.004		0.002			0.206		0.275			0.096		0.023
Beck-to-height ratio	Never	13	0.22	(0.006)	0.21	(0.010)	67	0.22	(0.003)	0.22	(0.004)	74	0.22	(0.003)	0.22	(0.003)
	<1–2 times/wk	48	0.22	(0.003)	0.22	(0.003)	4	0.23	(0.011)	0.23	(0.010)	13	0.23	(0.006)	0.24	(0.007)
	3–7 times/wk	24	0.24	(0.004)	0.23	(0.004)	4	0.24	(0.011)	0.23	(0.011)	3	0.25	(0.013)	0.25	(0.013)
	P_{trend}			0.004		0.010			0.156		0.316			0.057		0.042

Notes: [a]The sample sizes are for model 1. Model 1: Adjusted for age; Model 2: Adjusted for age, physical activity, smoking, alcohol intake, sex, depression, and shift-work.
Source: Charles *et al.* (1999)

Shift Work and Injury among Police Officers

The objective of this study was to investigate the association between shift work and the incidence rate of injuries among police officers. A total of 31 injuries occurred among 110 officers over the approximate five year period. The overall injury incidence rate for the study population was 0.47 injuries per 10,000 person-hours (95% CI = 0.33-0.67). Incidence rates of injury on day, afternoon and midnight shifts, expressed per 10,000 person-hours, were 0.37 (95% CI = 0.19- 0.64), 0.53 (95% CI = 0.26-0.94), and 0.68 (95% CI = 0.29-1.3) respectively. The injury incidence rate (IRR) for the midnight shift was about two-fold higher relative to the rate on the day shift (IRR = 1.86, 95% CI = 0.8-4.5), while the incidence rate on the afternoon shift was about 44% larger (IRR = 1.44, 95% CI = 0.6- 3.3). After adjusting for gender and education the IRRs were 2.9 (95% CI=1.1-8.4) for midnight vs. day shift and 1.9 (95% CI=0.8-4.6) for afternoon vs. day shift. Age varied significantly across shift with those working midnight and afternoon shifts, being on average, 6 years younger than day shift workers. Similarly injury rates were significantly associated with age; the injury rate for those in the lowest tertile of age was nearly 5 times higher (IRR =4.88, p=0.003) compared to those in the highest tertile, while the rate in the middle tertile was nearly 3 times higher than the rate for older participants (IRR=2.7, p=0.060). The results of this study show that although midnight shift workers may have a relatively higher injury incidence rate compared to day workers, the association is largely explained by age. Age is relevant because younger less senior officers are more likely to be assigned to night shifts. Fatigue, sleep deprivation, or hazardous police encounters may contribute. Further research is necessary.

Figure 2. Incidence Rate of Injury by Shift



Shift Work and Suicide Ideation

This study assessed the association of shift work with suicide ideation among police officers. Shift work was based on daily payroll records over 5 years .Standardized psychological measures were employed. ANOVA and Poisson regression were used to evaluate associations. Among policewomen with increased depressive symptoms, prevalence of suicide ideation increased by 116% for every 10-unit increase in percentage of hours worked on day shift (prevalence ratio (PR) 2.16; 95% confidence interval (CI)¼1.22–3.71). Among policemen with higher (but not lower) posttraumatic stress disorder (PTSD) symptoms, prevalence of suicide ideation increased by 13% with every 10-unit increase in the percentage of hours worked on afternoon shift (PR¼1.13; 95% CI¼1.00–1.22). Prevalence of suicide ideation significantly increased among policewomen with higher depressive symptoms and increasing day shift hours, and among policemen with higher PTSD symptoms with increasing afternoon shift hours.

Table 8. Prevalence Ratios of Suicide Ideation by Shift Work

			Unadjusted		Model 1		Model 2	
Shift-work variables	N	%	PR	95% CI	PR	95% CI	PR	95% CI
% of hours on day shift								
0.70–6.01	23	34.8	1.00	Referent	1.00	Referent	1.00	Referent
8.09–54.05	24	12.5	0.36	0.11–1.19	0.36	0.11–1.19	0.43	0.13–1.39
58.01–99.82	23	21.7	0.63	0.24–1.62	0.68	0.26–1.83	0.76	0.31–1.87
P-value		0.292	0.335		0.449		0.547	
% of hours on afternoon shift								
0.18–5.21	23	17.4	1.00	Referent	1.00	Referent	1.00	Referent
5.99–63.13	24	33.3	1.92	0.67–5.51	1.98	0.70–5.59	1.59	0.62–4.12
65.43–98.35	23	17.4	1.00	0.28–3.52	0.95	0.27–3.28	1.11	0.30–4.14
P-value		1.000	1.000		0.931		0.872	
% of hours on midnight shift								
0–1.57	23	13.0	1.00	Referent	1.00	Referent	1.00	Referent
1.62–17.58	24	25.0	1.92	0.54–6.77	1.88	0.55–6.37	2.16	0.77–6.06
18.48–96.56	23	30.4	2.33	0.69–7.93	2.26	0.69–7.47	2.12	0.68–6.55
P-value		0.160	0.177		0.180		0.193	
Number of shift changes in regular time								
0–8	25	28.0	1.00	Referent	1.00	Referent	1.00	Referent
9–24	22	18.2	0.65	0.22–1.92	0.62	0.21–1.87	0.64	0.23–1.79
25–286	23	21.7	0.78	0.29–2.11	0.77	0.28–2.11	0.97	0.38–2.43
P-value		0.596	0.619		0.616		0.941	
Total hours per week								
13.52–31.87	23	21.7	1.00	Referent	1.00	Referent	1.00	Referent
31.96–35.57	24	20.8	0.96	0.32–2.88	0.98	0.33–2.89	1.18	0.41–3.43
35.58–38.90	23	26.1	1.20	0.43–3.38	1.21	0.43–3.37	0.94	0.35–2.51
P-value		0.726	0.730		0.717		0.904	

(%) = prevalence; PR = prevalence ratio; CI = confidence interval.
P-values test linear trend in prevalence (%) or prevalence ratios (PRs).
Model 1: age-adjusted.
Model 2: age- and education-adjusted.

Sleep Duration and Oxidative Stress in Police Officers

The objective was to investigate the cross-sectional association between sleep duration and biomarkers of oxidative stress (glutathione (GSH), glutathione peroxidase (GSH-Px), vitamin C, thiobarbituric acid reactive substances (TBARS), and trolox equivalent antioxidant capacity (TEAC) among police officers. Standardized techniques were used to analyze biomarkers in fasting blood specimens. Mean levels of biomarkers were compared across levels of sleep duration (0-4.9, 5.0-6.9, □ 7.0 hours) using ANOVA. Officers' (women=44; men=69) mean age was 39.6 years. Positive trends were observed across sleep categories with mean levels of GSH and vitamin C only among women (p trend=0.156 and 0.022 respectively), with attenuation after risk-factor adjustment. Positive trends were observed for vitamin C among older officers (p trend=0.018) but not younger. No associations were observed between sleep duration and biomarkers among men. Longer sleep duration is associated with higher levels of vitamin C among policewomen and older officers. Additional studies are warranted.

Table 9. Mean Values of Oxidative Stress Biomarkers by Levels of Sleep

Variables	Hours of Sleep			
	0 – 4.9 (n = 13)	5.0 – 6.9 (n = 53)	≥ 7.0 (n = 47)	P_{trend}*
GSH (mg/dL of packed RBCs)				
Unadjusted	55.5 ± 11.5	56.7 ± 9.3	56.7 ± 9.3	0.708
Model 1	54.8 ± 2.6	56.8 ± 1.3	56.7 ± 1.4	0.518
Model 2	55.3 ± 2.8	57.9 ± 1.5	56.4 ± 1.5	0.729
GSH-Px (IU/L)				
Unadjusted	577.7 ± 60.0	601.6 ± 48.2	597.4 ± 52.3	0.223
Model 1	576.9 ± 14.5	601.4 ± 7.1	597.9 ± 7.6	0.201
Model 2	584.8 ± 14.7	603.9 ± 7.8	593.5 ± 7.9	0.612
Vitamin C (mg/dL)				
Unadjusted	0.94 ± 0.45	1.13 ± 0.44	1.30 ± 0.47	0.015
Model 1	0.95 ± 0.13	1.14 ± 0.06	1.28 ± 0.07	0.023
Model 2	1.01 ± 0.13	1.16 ± 0.07	1.22 ± 0.07	0.156
TBARS (nmol/ml)				
Unadjusted	1.06 ± 0.25	1.12 ± 0.28	1.08 ±0.19	0.773
Model 1	1.08 ± 0.07	1.11 ± 0.03	1.08 ± 0.03	0.976
Model 2	1.10 ± 0.07	1.12 ± 0.04	1.08 ± 0.04	0.795
TEAC (%)				
Unadjusted	69.8 ± 1.9	70.7 ± 2.6	70.0 ± 2.4	0.740
Model 1	70.3 ± 0.5	70.6 ± 0.3	70.1 ± 0.3	0.774
Model 2	70.3 ± 0.5	70.5 ± 0.3	69.9 ± 0.3	0.521
OSS				
Unadjusted	5.08 ± 1.71	4.94 ± 1.41	4.51 ± 1.44	0.218
Model 1	5.02 ± 0.41	4.96 ± 0.20	4.51 ± 0.21	0.274
Model 2	5.02 ± 0.40	4.77 ± 0.22	4.63 ± 0.22	0.402

Values are means ± SD for unadjusted models and means ± SE for adjusted models; *p-values from polynomial orthogonal contrasts; For all models except OSS:- Model 1: Adjusted for smoking status; Model 2: Adjusted for age, BMI, education, smoking status, CES-D score, and alcohol consumption; For OSS:- Model 1: Adjusted for BMI; Model 2: Adjusted for age, BMI, education, CES-D score, and alcohol consumption

Dysregulated Cortisol Levels across Shifts

Research indicates shift work may lead to disruption of circadian rhythms and adverse health outcomes. Studies examining the influence of shift work on circadian rhythms, although few in number, have focused on hypothalamic-pituitary adrenal (HPA) axis dysregulation with the awakening cortisol response receiving particular attention as a marker of HPA axis activity. Most of these studies rarely consider long-term shift work information. The objective of the current study was to evaluate how shift work, ascertained using daily long-term records, influences morning salivary cortisol levels in terms of the total hormonal excretion and the dynamics of awakening response over time, among police officers who represent a high stress occupation. Awakening cortisol measures were obtained from four salivary samples taken at 15 minute intervals upon first awakening (at awakening, 15, 30 and 45 minutes after waking). Salivary cortisol concentrations averaged across all four time points and total area under the curve differed significantly across shift; with midnight shift workers showing an attenuated awakening cortisol secretion compared with the afternoon or day shift. On the other hand, the temporal pattern of morning cortisol was similar across the three shifts. The results showed that midnight shift work is associated with decreased mean absolute level and total cortisol response on awakening.

B. POLICE MORTALITY

The following concern analyses and manuscript preparation examining results thus far regarding the association between shift work and police mortality.

1. Mortality of a Police Cohort: 1950-2005

Police mortality was compared to a reference population (U.S. general population) in terms of a standardized ratio (the Standardized Mortality Ratio = SMR). An SMR value of greater than one indicates an increased risk for the stated cause of death. Confidence Intervals stated are at the 95% level.

The police cohort consisted of n=3,049 officers who worked a minimum of 5 years for the Buffalo Police Department, New York, between January 1, 1950 and December 31, 2005. Female officers (n=298), officers who did not have either birth data or hire date (n=44), and officers who worked < 5 years (n=33) were excluded from the original data set (N=3,424). Source of follow-up included the benefit and pension programs of the city of Buffalo, the New York State Retirement System, New York State Vital Statistics Division, Buffalo Police employment records, Buffalo Police Association publications, obituaries, and the National Death Index (NDI).

As of December 31, 2005, 50% of the population had died, 46% were alive, 4% were lost to follow-up. The employment status was as follows: 19% were current officers, 60% had retired, 11% died in action, 7% resigned or left service, and 2% were unknown. Death certificates were coded by state nosologists according to the International Classification of Diseases (ICD) revision in effect at the time of death. Codes were subsequently converted for analysis to the 8th ICD Revision (1968).

Table 10. Mortality experience of police officers in Buffalo, New York, 1950-2005.

Underlying cause of death (8th ICD revision)	Observed Deaths	Expected Deaths	SMR	95% CI
All causes of death (001-998)	1529	1272.7	1.20	1.14-1.26
All infective and parasitic diseases (001-139)	14	20.5	0.68	0.37-1.14
All malignant neoplasms (140-209)	387	292.8	1.32	1.19-1.46
Benign neoplasms (210-239)	8	3.2	2.48	1.17-4.89
Allergic, endocrine, nutritional diseases (240-279)	27	29.0	0.93	0.61-1.35
Diabetes Mellitus (250)	23	24.5	0.94	0.59-1.41
All diseases nervous system & sense organs (320-389)	10	19.4	0.52	0.25-0.95
All diseases of circulatory system (390-458)	682	617.5	1.10	1.02-1.19
All respiratory diseases (460-519)	79	99.9	0.79	0.63-0.98
All diseases of digestive system (520-577)	56	52.9	1.06	0.80-1.37
Cirrhosis of liver (571)	35	24.4	1.43	0.99-2.00
All diseases of genitourinary system (580-629)	17	19.8	0.86	0.50-1.38
All external causes (800-998)	62	84.7	0.73	0.56-0.94
All accidents (800-949)	27	54.8	0.49	0.32-0.72
Motor vehicle accidents (810-823)	8	23.5	0.34	0.15-0.67
Suicide (950-959)	30	22.4	1.34	0.90-1.91

SMR: Standardized Mortality Ratio
95% CI: 95% confidence interval

The average survival duration was 25.7 years, average age of entry into follow-up was 36.5 years, average calendar year of entry into follow-up was 1966, *average age of death was 68.3 years,* and the average calendar year of death was 1980.

Mortality from all causes of death combined for police officers was significantly higher than expected (SMR=1.20; 95% confidence interval (CI) =1.14-1.26). Significantly increased police mortality was also seen for all malignant neoplasms combined (SMR=1.32; 1.19-1.46), all benign neoplasms combined (SMR=2.48; 1.17-4.89), and all diseases of the circulatory system combined (SMR=1.10; 1.02-1.19). A significantly decreased mortality rate was observed for all diseases of nervous system and sense organs (SMR=0.52; 0.25-0.95), all respiratory diseases (SMR=0.79; 0.63-0.98), all external causes (SMR=0.73; 0.56-0.94), all accidents (SMR=0.49; 0.32-0.72), and motor vehicle accidents (SMR=0.34; 0.15-0.67). Mortality due to cirrhosis of liver and suicide was slightly but not significantly elevated (SMR=1.43, 0.99-2.00 and SMR=1.34, 0.90-1.91) respectively.

Results for police mortality of specific malignant neoplasm sites -The elevated mortality for all malignant neoplasms was primarily due to statistically significant excesses in cancers of the esophagus (SMR=1.93; 1.08-3.18), colon (SMR=1.83; 1.35-2.42), respiratory system (SMR=1.24; 1.03-1.48), as well as Hodgkin's disease (SMR=3.38; 1.23-7.36) and leukemia (SMR=1.77; 1.08-2.73). Results for mortality from diseases of the circulatory system - from arteriosclerotic heart disease was significantly and slightly elevated (SMR=1.14; 1.04-1.25) and represented the majority of excess deaths among diseases of the circulatory system.

Table 11. Distribution of Mortality in Police Officers From Malignant Neoplasms by Site, 1950-2005.

Underlying cause of death (8th ICD revision)	Observed Deaths	Expected Deaths	SMR	95% CI
All malignant neoplasms (140-209)	387	292.8	1.32	1.19-1.46
Buccal cavity & pharynx (140-149)	12	7.1	1.69	0.87-2.96
Digestive organs & peritoneum (150-159)	125	77.1	1.62	1.35-1.93
Esophagus (150)	15	7.8	1.93	1.08-3.18
Stomach (151)	19	11.9	1.60	0.96-2.50
Colon (153)	48	26.3	1.83	1.35-2.42
Rectum (154)	10	6.9	1.45	0.70-2.67
Liver (155)	9	6.4	1.42	0.65-2.69
Pancreas (157)	22	15.1	1.45	0.91-2.20
Respiratory system (160-163)	125	100.6	1.24	1.03-1.48
Prostate (185)	31	26.4	1.18	0.80-1.67
Bladder (188)	11	8.9	1.23	0.61-2.21
Kidney (189)	12	7.3	1.63	0.84-2.85
Brain & other CNS (191-192)	10	7.3	1.37	0.66-2.52
Thyroid (193)	2	0.55	3.61	0.41-13.03
Lymphatic & hematopoietic (200-209)	38	28.3	1.34	0.95-1.84
Hodgkin's disease (201)	6	1.8	3.38	1.23-7.36
Leukemia (204-207)	20	11.3	1.77	1.08-2.73

SMR: Standardized Mortality Ratio
95% CI: 95% confidence interval

All cause mortality was significantly higher for age at death categories 50-69 years (SMR=1.28; 1.19-1.38) and ≥ 70 years (SMR=1.18; 1.10-1.27) and for all calendar years categories except 1970-1979. The age at which participants started work was inversely associated with all cause mortality. A starting age of <25 years had the highest mortality rate (SMR=1.34; 1.22-1.48) while a starting age of >=30 years had the lowest mortality rate (SMR=1.07; 0.96-1.18); p for trend = 0.003. Regardless of the length of years of police service, all officers experienced higher than expected mortality rates with the largest excess in those serving more than 30 years

(SMR=1.20; 1.16-1.33). The SMR for latency of < 20 years was 1.27 (95% CI=1.16-1.38) and was lower for latency of 20-29 years and ≥ 30 years.

Table 12. Distribution of mortality in police officers from diseases of the circulatory system, 1950-2005.

Underlying cause of death (8th ICD revision)	Observed Deaths	Expected Deaths	SMR	95% CI
All diseases of circulatory system (390-458)	682	617.5	1.10	1.02-1.19
Arteriosclerotic heart disease (410-413)	480	421.1	1.14	1.04-1.25
All CNS vascular lesions (430-438)	75	82.4	0.91	0.72-1.14

SMR: Standardized Mortality Ratio
95% CI: 95% confidence interval

In the category of 1-19 years of police service, significantly elevated mortality rates occurred for cancer of the buccal cavity and pharynx (SMR=4.8; 1.28-12.15), digestive or peritoneum cancer (SMR=2.0; 1.15-3.28), respiratory system cancer (SMR=1.9; 1.13-2.85), lymphatic and hematopoietic cancer (SMR=2.4; 1.14-4.36), and Hodgkin's disease (SMR=5.0; 1.00-14.60). Deaths due to all external causes (SMR=0.58; 0.35-0.90), all accidents (SMR=0.39; 0.17-0.76), and motor vehicle accidents (SMR=0.19; 0.02-0.70) occurred less frequently than expected. In the category of 20-29 years of police service, mortality from digestive or peritoneum cancer combined (SMR=1.5; 1.05-2.01) was significantly elevated while that for all accidents combined (SMR=0.29; 0.09-0.68) occurred less often than expected. In the category of ≥ 30 years of police service, significantly elevated mortality was found for all causes, all infective and parasitic diseases, cancers of the digestive or peritoneum combined, esophagus and colon, as well as for diseases of the circulatory system, arteriosclerotic heart disease, and cirrhosis of the liver.

Mortality across Shifts

There were 1,269 officers who had electronic work history information available between 1994 and 2006. After exclusion of female officers and those who worked less than 5 years there were 986 male officers with electronic work history data who had also been followed for mortality. Among the 980 officers 469 (48%) worked primarily day, 335 (34%) worked primarily afternoon, and 176 (18%) worked primarily night shift. Surprisingly, as shown in table 12, it appears as if nearly twice as many day shift workers (6.6%) died during the follow-up period compared with either afternoon (3.3%) or night (3.4%) shift workers. However, since day shift workers were 9-10 years older on average than either afternoon or night shift workers, it is possible that their older age was responsible for their elevated mortality. When differences in age were taken into account differences in mortality across shift work categories were notably diminished. Assessment of cause-specific mortality is severely limited by relatively small numbers of deaths in this preliminary analysis. Future analyses will take into account differences in the length of time individual officers were at risk for mortality, duration of shift work, and other demographic or lifestyle factors that may be important to consider.

Table 13. All Cause Mortality by Shift Work among Police Officers 1994-2005, Buffalo NY

Work Shift*	Number at Risk	Mean Age	Number of Deaths	Unadjusted Mortality (%)	Age-adjusted Mortality (%)
All Shifts	980	49.9	48	4.90	6.36
Day	469	54.7	31	6.61	6.87
Afternoon	335	45.7	11	3.28	6.24
Night	176	44.7	6	3.41	7.62
P-value**				0.0589	0.8561

* Shift work based on daily payroll records between 1994 and 2006; Officers were categorized into one of three shifts based on the largest percentage of hours worked in each of the shifts.
** Chi-square test for difference in proportions across shift.

Table 14. Unadjusted and Age-adjusted Odds Ratios for Association of Shift Work with All Cause Mortality

		Unadjusted		Age-adjusted	
Shift	N	Odds Ratio	95% CI	Odds Ratio	95% CI
Day	469	2.01	0.82-4.89	1.01	0.39-2.61
Afternoon	335	0.96	0.35-2.65	0.89	0.32-2.46
Night	176	1.00	---	1.00	---

Odds ratios and 95% confidence intervals (CI) obtained from logistic regression

Table15. Cause-specific Mortality by Shift Work among Police Officers, 1994-2005, Buffalo NY

	Work Shift*									
	Day			Afternoon			Night			
Underlying cause of death (8th ICD revision)	No. at Risk	No. of Deaths	Mortality (%)	No. at Risk	No. of Deaths	Mortality (%)	No. at Risk	No. of Deaths	Mortality (%)	P-value**
All cancer (140-209)	469	9	1.92	335	4	1.19	176	3	1.70	0.7939
Digestive cancer (150-159)	469	3	0.64	335	2	0.60	176	2	1.14	0.7730
Respiratory cancer (160-163)	469	3	0.64	335	2	0.60	176	1	0.57	1.0000
All circulatory disease (390-458)	469	8	1.71	335	4	1.19	176	0	0.00	0.2300
Arteriosclerotic heart disease(410-413)	469	4	0.85	335	3	0.90	176	0	0.00	0.6857

* Shift work based on daily payroll records between 1994 and 2006; Officers were categorized into one of three shifts based on the largest percentage of hours worked in each of the shifts.
** Chi-square test for difference in proportions across shift.

IV. CONCLUSIONS

A. DISCUSSION OF FINDINGS

Cardiovascular Disease and Shift work

The results from our study on shift work and cardiovascular disease suggest that police officers working midnight shifts combined with either shorter sleep duration or increased overtime may be at an increased risk for metabolic syndrome. The metabolic syndrome is a cluster of risk factors which predispose officers to cardiovascular disease. The prevalence of metabolic syndrome among officers working the midnight shift was higher than that found in the *National Health and Nutrition Examination Survey* (NHANES III) 1988-1994, a national health study in the U.S. NHANES III overall prevalence of metabolic syndrome was 21.8%, while officers in our sample working midnights had an overall prevalence of 30%. In addition, officers who worked the midnight shift were on *average younger* than those officers on the day shift (36.5 and 42.6 years of age respectively). The NHANES national prevalence of metabolic syndrome was 24% for those in this younger comparable age range (30-39 years). This slightly higher prevalence at a younger age coincides with police mortality cohort studies which found a higher risk of CVD among younger officers, an infrequent result in healthy worker populations. Officers on the other two shifts had a lower prevalence of metabolic syndrome compared to NHANES data. One potential explanation for this unusual finding is that midnight shift officers were most likely to be sleep deprived because of difficulties associated with day sleeping and sleep debt has been shown to have a harmful impact on carbohydrate metabolism and endocrine function that could contribute to metabolic disorders.

The prevalence of an elevated waist circumference was nearly 50% and 30% respectively for females and males in NHANES III. In our police sample, the combined prevalence of elevated waist circumference was 55% for those working midnight shifts, higher than NHANES III levels and day or afternoon shift workers. Prevalence of low HDL cholesterol levels were approximately 38% in women and 35% in men in NHANES, while low HDL prevalence in our combined police sample was 50% among those working midnight shifts. Prevalence of hypertension and glucose intolerance for officers working midnights was also higher than found in NHANES.

The significantly elevated prevalence ratio for abdominal obesity found among police when comparing midnight to day shifts may be indicative of future health problems among officers. Even after statistical adjustment for gender, age, and demographic and lifestyle variables, the mean number of metabolic syndrome components was still significantly higher for officers who worked the midnight shift and an increased median number of overtime hours per week (>1.7 hours). Overtime is thought to involve the same metabolic mechanisms suggested for shift work and CVD. Other studies have found that self-reported overtime led to a two-fold excess risk for acute myocardial infarction after adjusting for smoking, age, education, and self-reported exhaustion.

Officers who worked midnights and had less than six hours sleep had a significantly higher mean number of metabolic syndrome components than those who worked day shifts (multivariate-adjusted). Sleep deprivation is a common denominator in most forms of shift work and has serious metabolic and cardiovascular consequences. Also, sleep duration was significantly related to waist circumference, body mass index, percentage of body fat, serum levels of insulin and glucose, and insulin resistance.

We were unable to sufficiently examine policewomen in a separate analysis due to the small number of women who worked midnight shifts (N=3). There is a paucity of research on policewomen and the effects of atypical work hours on their health and well-being. Results from the 1999-2000 NHANES study indicated a sharp increase in the prevalence of metabolic syndrome among women, the age-adjusted prevalence rate increasing by 23.5%. Corresponding increases in men were much smaller and not statistically significant. We plan future work with a larger sample size of policewomen would address the need for research in this area.

Sleep Deprivation and Shift Work

Our finding that police officers on shift work do not get sufficient sleep was important. Our study compared the sleep problems of officers who worked night shifts with those who worked both day and afternoon shifts. Night shifts are more disruptive to the circadian system because workers must frequently rotate between diurnal and nocturnal sleep patterns to accommodate family and social activities. This is not the case with afternoon shift workers whose later bedtime hours are seldom a problem biologically. In fact, they may even get more sleep than day shift workers. Second, the pattern of melatonin secretion and its synchronization with sleep is drastically altered in night. Melatonin, a substance that is primarily secreted by the pineal gland, is produced during the night and promotes sleep Thus, police officers on night shifts may face a greater frequency of sleep disruption compared to evening or day shift workers.

Among police officers, we found a high prevalence of tiredness upon awakening. Symptomatic obstructive sleep apnea may be indicated in our results due to discovered symptoms of snoring and temporary cessation of breathing during sleep, with the usual consequence being tiredness during waking hours. We obtained a wide range of responses to each of these questions. The low response rate to "stop breathing during sleep" may be due to the fact that a number of individuals, especially those without a bed partner, are not aware that they have this problem. Although we collected information on marital status, we did not ask about bed partners nor did we survey the spouses or partners of the participants. Snoring has been associated with sleep apnea, a condition of breathing difficulties while sleeping.

Several covariates were significantly associated with sleep problems. For example, Body Mass Index (BMI), a measure of weight to height ratio, showed a significantly positive trend with snoring in officers, and was significantly and positively associated with restless leg syndrome and tiredness upon awakening. Our study also found that lower physical activity scores were more likely to be seen in officers with more frequent sleep problems. Previous studies have provided evidence that regular physical activity has a protective effect on sleep-disordered breathing.

Suicide Ideation and Shift Work

We examined several psychological and social variables associated with shift work. Suicide ideation and depression was associated with working shifts. Disruptive circadian patterns have been shown to dysregulate biological systems such as the hypothalamic–pituitary–adrenocortical (HPA) axis, which can lead to increased levels of the hormone cortisol found to be prominent in depression. Altered circadian rhythms in cortisol and melatonin secretions have been found among those suffering from depression. Melatonin levels in suicide victims have been found to be significantly lower than those of non-suicide controls, consistent with reports of decreased nocturnal plasma melatonin levels in depressed patients

Mediation of brain processes due to sleep deprivation and fatigue may also impact suicidal thinking. Killgore et al. [2007] suggested that sleep deprivation impairs the ability to integrate emotion and cognition to guide moral judgment. Sleep deprived participants showed significantly greater difficulty judging emotionally charged courses of action as ''appropriate'' relative to judging them as ''inappropriate.'' These findings suggest that sleep deprivation has a debilitating effect on judgment and decision making processes that depend heavily upon the integration of emotion with cognition, processes which are believed to be mediated by regions of ventromedial prefrontal cortex, the brain region most responsible for judgment and decision making. In such situations, persons may be more likely to consider suicide as an appropriate behavior. In another study on judgment and sleep deprivation Killgore et al., 2005], sleep deprivation was found to reduce regional cerebral metabolism within the prefrontal cortex. After sleep loss, individuals tended to make more risky decisions. These findings suggest that cognitive functions known to be mediated by the ventromedial prefrontal cortex, including decision making under conditions of uncertainty, may be particularly vulnerable to sleep loss. Suicidal thinking could result from shift-work related sleep deprivation that affects clear decision making.

Sleep Deprivation Modeling

Our research advanced sleep deprivation measurement by determining alternative ways to measure sleep disturbances and awakening times. "*Waiting time distributions"* (WTD) refer to the amount of time it takes for a person to resume sleep after awakening. Waiting times offer an additional method of analyzing sleep data that have the ability to provide even more information on participant sleep patterns. WTD can be used in place of the average wake-after-sleep onset variable, as the 90th percentile of the WTD is more capable of differentiating sleep quality than the average is. Although analyzing sleep patterns with WTD takes more time than using the average wake-after-sleep onset value, it can add valuable, additional information for the researchers, as it not only categorizes sleep quality at least as well as the average wake-after-sleep onset time. Also, as the distribution of wake-after-sleep times is asymmetric, the sleep-to–wake onset average is an improper parameter to use; higher percentiles differentiate between sleep qualities much better, as the number of longer wake-after-sleep onset times is much greater in people with good sleep quality as opposed to those with poor sleep quality. Waiting time distributions also provide all of the benefits that the theory of probability distributions has to offer, including parameter estimation and survival time analysis. Compared to the average wake-after sleep onset time, waiting time distributions give many more methods of analyzing participant characteristics, comparing sleep quality between groups, and modeling sleep.

Police Mortality and Shift Work

This portion of our study was conducted to examine the mortality experience of our police cohort and the association with shift work. The present study allowed us to update an already existing police mortality cohort which was collected from 1950-1990 (Violanti, et al, 1998). Our objective was to first determine causes of death and then to relate such causes to variants of shift work. During the 15 years of additional follow-up the number of decedents in the cohort increased from 1,035 to 1,529.

In the updated cohort, all-cause *Standard Mortality Ratios* (SMR) for police officers relative to U.S. national estimates (SMR=1.20; 95%CI=1.14-1.26) was higher than that for 1950-1990 (SMR=1.10; 95%CI=1.04-1.17). For the 1950-2005 period, all diseases of nervous system and sense organs (SMR=0.52; 95%CI=0.25-0.95) showed significantly lower than expected mortality. From 1950 to 1990, the SMR of all diseases of nervous system and sense organs was 0.45; 95%CI=0.12-1.16. Mortality due to all diseases of the circulatory system (SMR=1.10; 95%CI=1.02-1.19) including arteriosclerotic heart disease was significantly elevated with the additional follow-up yet not during the 1950 to 1990 period.

The mortality rate for all malignant neoplasms (SMR=1.32; 1.19-1.46) in the updated cohort was slightly higher than that in the 1950-1990 (SMR=1.25). SMRs for respiratory system cancer and leukemia were of similar or slightly higher magnitude and were significantly elevated for the updated follow-up period compared with the previous period whereas mortality for kidney cancer was no longer significantly elevated. The mortality experience categorized by selected characteristics such as age at death, year of death, age started working, years worked, and latency was similar for the extended follow-up through 2005 relative to the previous follow-up to 1990. Higher mortality was consistently observed for officers who started work at the youngest age (<25 years) and for those who had the most years of service.

Our initial results for mortality across shifts show little differences. However, day shift workers were significantly older than those on other shifts and this may account for increased mortality. There were also a limited number of deaths accounted for in this preliminary investigation. We will examine this association further as entire sample data is finalized.

B. STUDY LIMITATIONS

This project was cross-sectional. Despite the limitation this study will provide novel important insights. This study will serve as the potential baseline examination of a *prospective study* of the relation of stress and fatigue to subclinical biomarkers for disease. Follow-up studies will provide important longitudinal information on the variance among variables through time and circumstance. As a general recommendation, in light of the potential for a latency periods between career length shift work and overt disease, studies as the present proposed one should include follow-up of workers.

One may expect that the next generation of shift work/work hours, occupational mortality, and morbidity studies will focus on changes in relative risk over time. In preparation for possible follow-up of this cohort, we mailed out a newsletter with study-related information and findings from our studies to participants throughout the study. In addition, we collected updated information on current address and the name of next of kin to be contacted in case of a move. A newsletter will be sent to all participants at their last known address. The mailing is sent via first class mail with return address and address forward requested. These procedures have been implemented by other studies in our clinic with excellent success. They have resulted in a very return high response rate.

At present, we focused on *subclinical* disease markers, however, cross-sectional studies of subclinical markers among currently employed officers are limited due to the problem of determining temporal sequence, thus longitudinal studies with baseline measures would be preferable. A single measurement of biomarkers is limited, however longitudinal studies have shown that one measurement of inflammatory markers for example can significantly predict clinical events over time (e.g. CVD), suggesting despite the biological variability, one measurement can characterize well individuals with regard to their long-term inflammatory status. A future goal of this project is to assess these markers-at both baseline and follow-up to better understand their relative importance.

C. IMPLICATIONS FOR POLICY AND PRACTICE

The physical health, psychological well-being, and safety and efficiency at work are important factors for any police agency to consider. When one considers the monetary and human costs of fatigued officers, it is essential to promote awareness and plausible interventions. *The rate of officers prematurely dying from disease for example has surpassed the rate of officers dying from homicide* (Vila, 2000). Fatigue also plays a part in police injuries. It has been determined by studies that the largest total number of single-vehicle crashes, such as driving off the road, which may be the result of inadvertent lapses in driver attention or periods of microsleep. The major peak occurs between midnight and 7 a.m. and is especially pronounced between 1 - 4 a.m. This may result in not only serious injury or death of an officer, but also in other officers being called to the accident scene to investigate and report when they too are fatigued and at a low point in their ability to function.

The duration of shifts may play a role in increasing fatigue and health problems. There is presently a growing popularity of extended-hour shifts in police work. A 12-hr shift, especially one that requires day sleeping, may result in greater risk to safety because of fatigue combined with disturbance to alertness and performance rhythms. Increases in fatigue may be particularly problematic when shift workers are asked to cover a portion of the subsequent shift, or even work a double shift to cover for other officers on sick leave or vacation. Rosa [1995] examined the impact of 12-hr shifts on fatigue. Twelve-hour shifts showed increased discomfort and deterioration in performance as compared with shorter shifts. Work schedules differed by the time of day, fixed versus rotating schedules, speed of rotation, direction of rotation, number of hours worked per week, number of consecutive days worked, number of rest days, and number of weekends off. Relevant for the present study is a sense of social isolation that can occur on extended shifts, a condition conducive to increased depression. Under 8-hr shift systems, workers could be at work for 21 out of 28 days, whereas under many 12-hr shifts, they are at work for only 14 out of 28 days. This may lead to isolation as well as a lack of communication between co-workers and supervisory staff.

Sleep deprivation affects information processing, which results in lengthening of response time. This becomes more pronounced in sustained or continuous work tasks compared with brief performance samples. Physiologic and psychomotor responses are more immune to sleep deprivation than emotional and psychological effects.

Decision making is very much affected by fatigue. Police officers are often called upon to make critical decision on the street, at times involving decisions of life or death. Recent findings in sleep deprivation show that it still impairs decision making involving the unexpected, innovation, revising plans, competing distraction, and effective communication. Sleep Deprivation presents particular difficulties for sleep-deprived decision makers who require these latter skills during emergency situations.

Determining the presence or absence of metabolic syndrome cardiovascular components in a high-risk occupational cohort of police officers provides beneficial information on a work force that is self-selected into their occupation based on good overall physical and mental health. Exploring specific associations such as these involving shift work and CVD adds to the benefit of such investigations. Preventing future diabetes and CVD through efforts focused on the metabolic syndrome and its components could be a worthwhile strategy. Information gained through this study may be useful not only to aid further investigation of police officer health, but may be useful to other first responder occupations as well. Examples are firefighters, EMT's (Emergency Medical Technicians), nurses, physicians, air traffic controllers, and the military. Results of this study and possible future prospective studies may add to existing knowledge of associations between shift work and cardiovascular health in high risk occupations.

The results of this study will provide police policymakers with objective evidence based on rigorous scientific standards to determine the impact of police officers' work hours and their health, safety, and performance. With such evidence in hand, police agencies can better plan specific and detailed interventions to help alleviate adverse work and shift conditions. The present proposed study takes into account the reality that police forces will be increasingly asked to provide emergency coverage for extended durations of time. Recent events such 9/11 and the deployment of working officers into active armed forces combat will ultimately lead to increased work hours for agencies already facing financial and personnel cutbacks. Further attention should also be addressed to major police departments in the nation who are moving away from conventional 8-hour shifts to 10 or 12 hour shifts per work day. During increased work hours there will be a greater risk of accidents and performance decrements, and yet it is during these times that the highest level of vigilance is required. A fatigue management program must have a specific set of strategies for these circumstances, with its operations first based on rigorous scientific information. As we have stated throughout this project, the impact of long work hours and shift work on police is yet to be adequately explored. With future work and prospective studies, we hope to better determine causal factors related to the well –being of persons engaged in this critical occupation.

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VI. DISSEMINATION OF RESEARCH FINDINGS

Thus far, we have published and presented based on our data:

Journal publications

RCMP Gazette, 72, 20-21.
Police beat- 2010
Archives of Environmental & Occupational Health, Vol. 64, No. 3, 2009
American Journal of Industrial Medicine 51:758–768 (2008)
Open Sleep Journal, 2008, 1, 15-25
International Journal of Police Strategies and Management, 30, 203-214
Nonlinear Dynamics, Psychology, and Life Sciences, Vol. 12, No.2, pp. 153-161.

Conference Presentations

Burch, J, Wirth, M., Violanti, J.M. Burchfiel, C.M., Fekedulegn, D. Andrew, M.E., Zhang, H.M., Miller, D.B., & Vena, J.E. Shift work duration and patterns of salivary cortisol among police officers. Presentation at the New York Academy of Sciences conference on circadian disruption and cancer, New York City, NY, June 19, 2009.

Violanti, J.M., Slaven, J.E., Charles, L.E., Mnatsakanova, A., Andrew, M.E., Hartley, T.A., & Burchfiel, C.M. (2009). A prospective study of shift work and depression in police officers. Presented at 42nd Annual SER Meeting, June 23-26, 2009. Anaheim, CA.

Charles, L.E., Violanti, J.M., Fekedulgen, D, Andrew, M.E., & Burchfiel, C.M. Shift work and markers of metabolic abnormalities and among police officers. 29th International Congress on Occupational Health, March 22-27, 2009, Cape Town, South Africa

Charles, L.E., Burchfiel, C.M., Fekedulegn, D., Violanti, J.M., Browne, R.,, McCanlies, E., & Andrew, M.E. Sleep duration, antioxidants, and biological markers of oxidative stress: The Buffalo Police Health Study. Work Stress and Health Conference, Washington, DC, November, 2008.

Slaven, J., Burchfiel, C.M,, Charles, L.E., Mnatsakanova, A., Hartley, T.A., Andrew, M.E., Fekedulgen, D., Vila, B. & Violanti, J.M. sleep quality and depressive symptoms: a prospective analysis from the buffalo cardio-metabolic occupational police stress (BCOPS) study. Work Stress and Health Conference, Washington, DC, November, 2008.

Mnatsakanova, A., Slaven, J.E., Violanti, J.M., Burchfiel, C.M. Vila, B.J., & Andrew, M.E. Waiting time distributions of sleep. 2007 Joint statistical meetings. Salt Lake City, UT, 7/9/2007.

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Charles L., Burchfiel C.M., Fekedulegn D., Hartley T., Slaven J., Violanti J.M. Relationship between shift work and sleep problems among police officers: The Buffalo Police Health Study. American Congress of Epidemiology , Seattle, WA. 6/1/2006.

Violanti J.M., Burchfiel C.M., Andrew M.E., Dorn J., Fekedulegn D., Hartley T., Charles L., Miller D.B. Awakening cortisol and subclinical cardiovascular disease in police officers: The Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) Pilot Study
American Congress of Epidemiology , Seattle, WA, 6/1/2006

Charles L., Burchfiel C.M., Fekedulegn D., Hartley T., Slaven J., Violanti J.M. (2006). Relationship between shift work and sleep problems among police officers: The Buffalo Police Health Study. American Congress of Epidemiology Seattle, WA, June 2006.

Practitioner Presentations

Violanti, J.M. The enemy within: Police suicide. Presentation to the U.S. Secret Service. Washington, DC, February 18, 2009.

Violanti, J.M. Stress and health; The mind-body nexus. Workshop on individual operational readiness. National Defence Research & Development of Canada. Toronto, CA, March, 2009.

Violanti, J.M., The Buffalo cardio-metabolic occupational police stress study. International Police Union Associations annual conference, Orlando, FL, Aug, 2008.

Violanti, J.M. In Harms Way III. Presentation at U.S. Attorney and Florida COPS conference on police suicide. Tampa, Fl, 10/21/2007.

Violanti, J.M. (2006). The epidemiology of police suicide. U.S. Attorney Conference, Wichita, KS, June, 2006.

Violanti, J.M., Vila, B. (2005). Police work hours, stress and discretionary decision making: Reversing a vicious cycle. American Association of Criminology Annual Conference, Toronto, Ontario, Canada, November 2005.

We plan to continue analysis of data and develop future manuscripts and presentations.