Shiftwork and pregnancy loss among police officers: a preliminary investigation

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Abstract
Purpose – Policing requires atypical work hours. The present study examined associations between shiftwork and pregnancy loss among female police officers.
Design/methodology/approach – Participants were 91 female officers with a prior history of at least one pregnancy. Shiftwork information was assessed using daily electronic payroll work records. Any prior pregnancy loss (due to miscarriage) was self-reported. Logistic regression estimated odds ratios (OR) and 95% confidence intervals (CI) for main associations.
Findings – On average, the officers were 42 years old, had 14 years of service, and 56% reported a prior pregnancy loss. Officers who worked dominantly on the afternoon or night shift during their career had 96% greater odds of pregnancy loss compared to those on day shift (OR = 1.96, 95% CI:0.71–5.42), but the result was not statistically significant. A 25% increase in percent of hours worked on night shift was associated with 87% increased odds of pregnancy loss (OR = 1.87, 95% CI:1.01–3.47). Associations were adjusted for demographic and lifestyle factors. Objective assessment of shiftwork via electronic records strengthened the study. Limitations include small sample size, cross-sectional design and lack of details on pregnancy loss or the timing of pregnancy loss with regard to shiftwork.
Research limitations/implications – The present study is preliminary and cross-sectional.
Practical implications – With considerable further inquiry and findings into this topic, results may have an impact on police policy affecting shift work and pregnant police officers.
Social implications – Implication on the health and welfare of police officers.
Originality/value – To our knowledge, there are no empirical studies which associate shiftwork and pregnancy loss among police officers. This preliminary study suggested an association between shiftwork and increased odds of pregnancy loss and points out the need for further study.
Keywords Shiftwork, Pregnancy loss, Women, Law enforcement officer, Work history
Paper type Research paper

Introduction
According to the Bureau of Labor Statistics (BLS), 15.3% of police officers in the United States are women (BLS, 2021). To our knowledge, there are no empirical studies which investigated associations between shiftwork and pregnancy loss among police officers. The objective of this preliminary study is to compare a history of pregnancy loss among officers

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who worked predominantly night or afternoon shifts at the time of study survey to those who predominantly worked on day shifts. We hypothesized that night shiftwork would be significantly associated with increased pregnancy loss compared to day shiftwork.

Human circadian rhythms are fluctuations with an approximate 24-h cycle controlled by the suprachiasmatic nucleus located in the anterior hypothalamus. These rhythms are affected by physiological and environmental factors and can become dysregulated (Fishbein et al., 2021). Persons who work shifts during hours of darkness (late afternoon or midnight shifts) are vulnerable to circadian rhythm disruption (Faraut et al., 2013; Proper et al., 2016; Sack et al., 2007; Wyse et al., 2017). Certain circadian rhythm biological factors disrupted by shift work have been associated with pregnancy loss. One example is melatonin which helps to regulate healthy fetal developmental processes (Begtrup et al., 2019). Melatonin passes through the placenta to the embryo and the fetus, which is involved in the placental function (Kennaway, 2000) and helps to regulate healthy fetal developmental processes (Begtrup et al., 2019). Exposure to light during night shifts suppresses the production of melatonin when it should be at its highest level and may cause a melatonin deficiency leading to the development of spontaneous abortions (Voiculescu et al., 2014). Decreased melatonin production may also increase hormones such as estrogen during pregnancy which has been shown to increase the risk of spontaneous abortion. Pregnant women on night shifts also experience disturbances in prolactin, thyroid-stimulating hormone (TSH), luteinizing hormone (LH) and cortisol which contribute to adverse changes in reproductive function (Chung et al., 2009).

Previous studies

Several studies show that pregnant women who are required to work night shifts may be exposed to increased risk for adverse pregnancy outcomes (Zhu et al., 2004; Stocker et al., 2014; Axelsson et al., 1996). In an examination of the Danish National Birth Cohort, shift work was found to be associated with post-term birth (Zhu et al., 2004). Night work had a high risk of post term birth (odds ratio = 1.35, 95% CI: 1.01–1.79); Evening work had a high risk of full-term low birth weight (odds ratio = 1.80, 95% CI: 1.10–2.94); and shift work as a group showed a slight excess of small-for-gestational-age babies (odds ratio = 1.09, 95% CI: 1.00–1.18). A systematic analysis by Stocker et al. (2014) found that night shift work was modestly associated with early spontaneous pregnancy loss. In summary, this review provided evidence for an association between performing shift work and early reproductive outcomes. Axelsson et al. (1996) found that women who had two or more night shifts the previous week had a 32% increased risk of miscarriage after pregnancy week eight compared with women on day shifts. The cumulation of night shifts during the early weeks of pregnancy increased the risk of miscarriages. Axelsson et al. (1996) also found that night work among midwives had an odds ratio of 3.3 (95% CI 1.1–9.9) for late pregnancy spontaneous abortion. Bonde et al. (2013) found that fixed night shift work had an increased risk for miscarriage compared to a three-shift rotation schedule. Axelsson et al. (1996) reported a six-fold risk of spontaneous abortion for permanent night workers when compared to day shifts.

Results from systematic reviews and meta-analyses show mixed results in the relationship between shiftwork and early pregnancy loss. The meta-analysis conducted by Stocker et al. (2014) included studies of various shiftwork types. Their results showed that working night shifts was a significant risk factor for increased early spontaneous pregnancy loss. However, these significant findings were only observed in some of the studies that used longitudinal study designs (n = 11,695; OR = 1.33; 95% CI = 1.12–1.58). When their analyses were restricted to cross-sectional or case-control studies, the association between shiftwork and early pregnancy loss was not significant. The review by Stocker et al. (2014) included 15 studies with participants from various occupations (e.g. nurses, factory workers, officer workers, midwives, etc.). A subgroup analysis of five studies (13,018 women) showed a
significantly increased rate of early spontaneous pregnancy loss in night shift workers compared with non-shift workers (OR = 1.29; 95% CI = 1.11–1.50). Restriction to two of the eight cross-sectional studies showed no effect of shiftwork on early spontaneous pregnancy loss rates. However, results from two of the five cohort studies showed a significant and positive effect of night work on early spontaneous pregnancy loss rate (OR = 1.33; 95% CI = 1.12–1.58). Another systematic review reported no association between rotating shifts and miscarriages from 12 studies (Cai et al., 2019). However, results from 10 studies showed that pregnant women who worked fixed night shifts had higher rates of miscarriages than women who worked regular day shifts (OR, 1.23; 95% CI: 1.03–1.47). The only study in this review that focused on stillbirth as the outcome reported that rotating shifts or fixed night shifts was not associated with stillbirth.

A meta-analysis by Quansah and Jaakkola (2010) found an association between night work and miscarriage and an increased risk of miscarriage in fixed compared to rotating shiftwork. Begtrup et al. (2019) found that women who had two or more night shifts the previous week had an increased risk of miscarriage after pregnancy week eight (Hazard Ratio = 1.32, 95% CI: 1.07–1.62) compared with women who did not work night shifts. The cumulated number of night shifts during pregnancy weeks three through twenty-one increased the risk of miscarriages. This study corroborated earlier findings that night work during pregnancy may confer an increased risk of miscarriage and indicates the lowest observed threshold level of two-night shifts per week. Bodin et al. (1999) demonstrated a more substantial increase in risk for miscarriages among permanent rather than rotating shift night workers. Similar findings were seen in the Danish National Birth Cohort studies by Chau et al. (2014).

Methods

Study population
Participants were female police officers enrolled in the BCOPS study (Violanti et al., 2006). The BCOPS study was aimed at investigating the associations of occupational stressors with the psychological and physiological health of police officers. A total of 710 police officers who worked with the sample department were invited to participate in the BCOPS study; 464 (65.4%) officers agreed to participate and were examined during the period of June 4, 2004 to October 2, 2009. Details of the BCOPS study including recruitment, data collection, and variables assessed are described elsewhere (Hartley et al., 2011; Charles et al., 2011). Of the 464 BCOPS study participants, 24.8% (n = 115) were females (23 reported no prior pregnancies, one subject had missing value on pregnancy, and 91 reported one or more pregnancies). For the current analyses, only females who reported one or more pregnancies were included, leaving an analytic sample size of 91 participants (Figure 1). A written informed consent was collected from each participant. The study was approved by the Internal Review Boards of the State University of New York at Buffalo, and the National Institute for Occupational Safety and Health (NIOSH).

Measures

Data for the current analyses originated from two sources. The BCOPS study provided data on demographic, lifestyle, physical, occupational, and psychosocial characteristics of the study participants at study enrollment. The outcome variable (ever had pregnancy loss in your lifetime? yes/no) was assessed via questionnaire administered as part of women’s health in the BCOPS study protocol. Day-by-day electronic work history records of the participants for nearly a 15-year period was available (spanning from 1994 or first date of employment to date of the BCOPS study exam). The work history data were used to derive several variables related to shiftwork (exposure of interest).
Assessment of shiftwork

Work history records were available in an electronic format and contained a day-by-day account of the start time of work and the number of hours worked, for each officer, for the period spanning from May 31, 1994 (or first date of employment) to date of BCOPS study examination. Nearly all officers (99%) started their work at one of the following times: 07:00 h, 08:00 h, 16:00 h, 20:00 h, or 21:00 h, which is consistent with standard shift start times. The start times of work were then used to classify the shift for a given day into one of the following three categories: day shift (start times between 04:00 and 11:00 h); afternoon shift (between 12:00 and 19:00 h); and night shift (between 20:00 and 03:00 h). Although officers were scheduled on permanent non-rotating shifts since 1994, they occasionally worked on shifts other than their permanent shift to cover for other officers who may have been on leave (sick, injury leave or vacation) or to earn additional income by working on their day off. To account for this, we derived a new variable (the dominant shift) that represents the shift during which a participant spent most of her work hours. The dominant shift was derived for period spanning the officer’s career at the Buffalo Police Department. To define the dominant shift, the total hours worked by each participant during that time period was partitioned into hours worked on the day, afternoon, and night shift. Then a dominant shift for each subject was...
defined as the shift that had the largest percentage of the total hours worked. For example, an officer who worked 10% on day, 80% on the afternoon, and 10% on night shift is classified as an afternoon shift worker (the dominant shift). Due to small sample size, dominant shift was re-categorized into two classes by combining afternoon and night shifts into one group (day vs afternoon or night).

Additional derived shiftwork variables include dominant shift category (across career) which identifies whether an officer spent at least 70% of the work hours on day shifts (primarily day ≥70% vs all others – a binary variable), dominant shift start time (7/8 AM vs 4/9 PM – a binary variable), percent of hours on night shift which is the percentage of total work hours spent specifically on night shift (continuous variable) and frequency of shift changes (continuous variable. Wirth et al., 2011) which was defined as the number of times a participant switched between any two of the shift types (day, afternoon, or night).

**Assessment of pregnancy loss**
A medical history questionnaire administered to female officers at the time of enrollment into the BCOPS study contained several items related to pregnancy, including: “How many times have you ever been pregnant?” and “How many pregnancies did you lose?” For officers who reported at least one pregnancy, pregnancy loss was assessed by asking the female officers the following question “How many pregnancies did you lose (due to miscarriage, due to still birth)” to which the officers responded by indicating the total number of pregnancies lost and it ranged from 0 to 4. The variable was then dichotomized (those who reported zero lost pregnancies were coded as “0” while those who reported one or more lost pregnancies were coded as “1” and this binary variable served as the main outcome variable of interest for our analysis (Figure 1). Information on the date of pregnancy loss was not collected. In this manuscript we use the term “pregnancy loss” to refer collectively to any miscarriage.

**Assessment of covariates**
Questionnaires were administered to collect demographic and lifestyle characteristics including age, gender, race/ethnicity, years of police service, rank, years of education, marital status, smoking, workload, alcohol consumption, and physical activity. Height and weight were measured with shoes removed and recorded to the nearest half centimeter and rounded up to the nearest quarter of a pound respectively. Height and weight were converted to meters and kilograms, respectively. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Hours of physical activity were assessed using the Seven-Day Physical Activity Recall questionnaire developed in the Stanford Five-City Project (Sallis et al., 1985). Workload was assessed by asking the officers the question “What is the work activity level at your district?” to which they responded by selecting one of the following: high workload (very busy with frequent complaints, high crime area); moderate workload (moderate complaint rate, average crime); or low workload (precinct not busy, low crime area).

**Statistical analysis**
Pregnancy loss (yes/no) served as the binary outcome variable. Shiftwork variables derived using work history records were considered as the main exposure variables of interest (these consists of three binary and two continuous variables). Initial analyses included descriptive results to characterize the study sample and examined the association of demographic and lifestyle characteristics with the exposure of interest (shiftwork) and the outcome variable (pregnancy loss) using chi-square tests and analysis of variance (ANOVA).
Binary logistic regression analyses were conducted to examine the main association of interest between shiftwork across career and pregnancy loss (yes/no). Odds ratios (OR) and their 95% confidence intervals (CI) were then computed as measures of association. We fit a crude or unadjusted model (Model 1) and three additional models that adjusted for various set of covariates: Model 2 adjusted only for age, Model 3 adjusted for demographic factors (age, race/ethnicity, education, marital status, and rank), and Model 4 adjusted for covariates in Model 3 plus lifestyle behaviors (smoking status, BMI, and alcohol consumption). Model 4 is an over adjusted model given a sample size of n = 91 participants, however the purpose of model 4 was to conduct a sensitivity analysis to examine the impact of lifestyle behaviors (BMI, smoking, and alcohol, consumption) on the association of interest. A characteristic was considered a potential confounder (covariate) for adjustment in the multivariate model based on prior evidence from the literature and whether it was associated with either the exposure or outcome in the current analyses. For all tests, statistical significance was assessed at the 5% level. All analyses were conducted using the SAS system, version 9.4.

**Results**

**Demographic and lifestyle characteristics**

The demographic and lifestyle characteristics of the sample (n = 91) and their associations with shiftwork are presented in Table 1. On average, participants were 42 years old (SD = 5.8) and served nearly 14 years as law enforcement officers (SD = 6.3). The majority were white (64.8%), married (59.3%), and had a rank of patrol officer (80.2%). A significant association was observed between three characteristics (age, years of service, rank) and shiftwork. Those working on day shift were older and had longer years of experience compared to those on afternoon and night shifts. The proportion of patrol officers among those working the afternoon and night shifts was significantly larger relative to the proportion among those on day shift. Overall, 56.2% (95% CI: 45.9–66.2) of the entire sample reported experiencing pregnancy loss (Figure 2).

**Association between shiftwork and pregnancy loss**

Results from logistic regression examining the association of shiftwork with pregnancy loss are presented in Table 2 (for both categorical and continuous shiftwork variables). Overall, the association between shiftwork and pregnancy loss was in the expected direction; females who worked on afternoon or night shifts were at higher odds for pregnancy loss compared to their counterparts (females who work on day shift). Females who dominantly worked the afternoon or night shifts during their career had a 96% greater odds of ever having a pregnancy loss compared to those who worked on day shift (OR = 1.96, 95% CI: 0.71–5.42, Table 2) but did not reach statistical significance. Further adjustment for demographic factors (age, race/ethnicity, education, marital status, and rank) and lifestyle characteristics (smoking, and alcohol consumption) did not affect statistical significance of the odds ratio (multivariable adjusted OR = 2.90, 95% CI: 0.80–10.64). Females who spent less than 70% of their work hours on day shift (i.e. those who work over 70% on afternoon or night shift, those who rotated between night and afternoon shifts, or night and day shifts, or evening and day shifts, or all three shifts) had a threefold greater odds of pregnancy loss compared to those who spent 70% or more of their work schedule on day shift (OR = 3.18, 95% CI:1.07–9.45, Table 2) after adjustment for age, race/ethnicity, education, marital status, and rank, Table 2. Further adjustment for lifestyle characteristics (smoking, and alcohol consumption) did not attenuate the association (multivariable adjusted OR = 3.54, 95% CI:1.02–12.30, p = 0.0462, Table 2). Results should be interpreted cautiously due to the rather wide confidence interval of the odds ratio.
Association of the continuous versions of shiftwork with pregnancy loss (Table 2) also showed some significant results. A 25% increase in percent of hours worked on night shift was associated with 87% increased odds of pregnancy loss (OR = 1.87, 95% CI:1.01–3.47, \( p = 0.0475 \), Model 3, Table 2) after adjustment for demographic covariates (age, race/ethnicity, education, marital status, and rank). Further adjustment for lifestyle factors (smoking, and alcohol consumption) did not attenuate the effect of percent of hours in night shift on pregnancy loss (OR = 2.25, 95% CI: 1.10–4.60, \( p = 0.0256 \), Model 4, Table 2).

**Discussion**

In this study, we conducted a preliminary investigation of the association between shiftwork and pregnancy loss among police officers. We found that (1) female police officers who worked the afternoon or night shift during their career had almost a two-fold greater odds of...
ever having a pregnancy loss but was not statistically significant; (2) female police officers who spent less than 70% of their work hours on day shift and those who rotated between shifts had a three-fold greater odds of a pregnancy loss compared to those who spent 70% or more of their work on day shift— but only after adjustment for demographic factors, and (3) each 25% increase of hours worked on night shift was associated with 87% increased odds of lost pregnancy after adjustment for demographic factors. Although statistically significant, the wide confidence intervals indicate variability in the estimates.
The police officers in this study worked fixed 10-h shifts. Several previously published studies have reported results that are consistent to ours regardless of the definition of shiftwork used (i.e. rotating shifts, fixed night shifts, fixed afternoon shifts, etc.). In a meta-analysis, Cai et al. (2019) found that the odds for pregnancy outcomes such as preterm delivery and miscarriage was greater for those women on fixed shifts relative to those on rotating shifts. Their results also showed that working fixed night shifts was associated with a 21% increase in the odds of pre-term delivery and a 23% increase in the odds of miscarriage compared to day shifts. In our study, the odds of pregnancy loss were also higher for fixed night vs day workers. This result suggests that the longer the time continually exposed to night shifts, the greater the odds of pregnancy loss. Even female officers who did rotate to day shifts had higher odds of pregnancy loss if most of their work was on night shifts (<70% on day shifts). A gradient dose-response was seen in the present study as each 25% increase in percent of hours on night shifts resulted in an 87% increased odds of pregnancy loss.

In the present study, women who worked less than 70% on day shifts during their career had higher odds of having a lost pregnancy compared to those who worked day shifts. The threshold (length of time engaged in shiftwork) was much lower in a study by Begtrup et al. (2019) which found that only two nights per week affected pregnancy loss. The Begtrup et al. (2019) study longitudinally study investigated whether working night shifts during pregnancy increased the risk of miscarriage among 22,744 Danish women, most of whom worked in public hospitals. The participants worked one or more nights shifts during pregnancy weeks 3–21. Their results showed that women who worked ≥2 nights during the previous week had an increased risk of miscarriage after pregnancy week 8 compared with women who did not work night shifts. The cumulated number of night shifts during pregnancy weeks 3–21 increased the risk of miscarriages in a dose-dependent pattern. Results from another large longitudinal study found that fixed night shiftwork significantly increased the risk of late pregnancy loss (HR = 1.85; 95% CI = 1.00–3.42) (Zhu et al., 2004). In Zhu’s study, rotating shiftwork was not associated with pregnancy loss. However, Cai et al. (2019) found in a meta-analysis that women who worked rotating shifts compared to fixed day shifts had increased odds for preterm delivery (Odds ratio 1.13, CI = 1–1.28) and several other problems such as gestational age, preeclampsia, and hypertension.

Study limitations and strengths
There are several limitations in the present study. First, the study is cross sectional and does not infer causation. Secondly, the association of shift work and pregnancy loss has not been explored among police and this study is a preliminary assessment. Third, we are limited in that we do not have data regarding when the pregnancy loss occurred preceding the survey (i.e. when it occurred relative to the start of the study enrollment). The participants self-reported if they ever had been pregnant and if they ever had a pregnancy loss. The questions were not about pregnancy during some specific period of time preceding the survey; only that the loss occurred while the participant was a police officer and worked shift work at the time of loss.

What we do know is that the all officers were on steady 10-h shifts, the shifts that they worked during their careers, the period of time (years) they worked night or day shifts, and that they did or did not experience a pregnancy loss. This information was based on computerized day-by-day account of work history records of the participants since the time of employment or 1994 (whichever came first) up until time of study enrollment. While the exact synchronization of shifts and pregnancy loss were not known in this sample, there is still the potential that the circadian disruption experienced during shift work affected pregnancy. Little is known of the long-term latent effects of circadian disruption in relation to pregnancy loss despite when it occurs, especially over long periods of time as it does in shift work.
Fishbein et al. (2021) speaks of the lack of longitudinal population studies that directly focus on circadian disorders and differences in circadian rhythms across the lifespan.

Information such as health prior to pregnancy and pregnancy difficulties were not available in the current study and should be considered in future work. Use of larger samples and prospective study designs will enhance the statistical power of the study and allow for causal relationships to be made. The healthy worker effect, which proposes that healthier employees are more likely to be selected into night work before becoming pregnant may introduce a bias (Chowdhury et al., 2017). Prior parity has a huge influence on women of reproductive age being in the workforce or not, and profoundly modifies the healthy worker effect (Johnson et al., 2019). It also impacts later pregnancy outcomes. Even though we have data on prior parity (how many children were born to you?), we do not have information on the timeline of the lost pregnancy (i.e. when it occurred, 1st or 2nd or 3rd, etc. pregnancy). There is also the possibility that pregnancy losses may go unnoticed. According to Wilcox (2010), approximately one-third of all human embryos are lost within six weeks of the last menstrual period and only 10–14% are seen as clinical miscarriages (Begtrup et al., 2019).

There are a multitude of other factors which affect pregnancy beyond the scope of this study. The timing of pregnancy loss depends heavily on individual characteristics, lifestyle, and other work exposures which may influence fetal health. Prior meta-analyses suggests that exposure to physical work activity during pregnancy, such as prolonged standing and lifting may be associated with adverse maternal health and pregnancy outcomes, including musculoskeletal conditions such as miscarriage, and preterm delivery (Croteau, 2020; Liu et al., 2024). Lead and chemical exposures during pregnancy has been associated with preeclampsia, spontaneous abortion, and premature membrane rupture (Gardella, 2001). Firearms training exposes officers not only to lead but to other metals like copper, arsenic and barium, which could lead to harmful health effects (Dans et al., 1988). Higher-than-normal noise levels during the course of police work (traffic, firearms training) may lead to preterm delivery (Nurminen, 1995), miscarriage; Zhang et al., 1992), and intrauterine growth retardation (Nurminen, 1995). In the Nurse’s Health Study, it was found that the risk of spontaneous abortion was elevated among women nurses who were exposed to antineoplastic drugs (odds ratio = 1.94), sterilizing agents (OR = 1.39), and x-ray radiation (OR = 1.22) during the first trimester of pregnancy (Chavarro et al., 2016). Work schedule characteristics such as night work and long work hours were also identified as risk factors for spontaneous abortion among nurses. Women who worked only night shifts had a 60% increased risk of spontaneous abortion during the first trimester (Chavarro et al., 2016). These additional risk factors are beyond the scope of the present study and are suggestions for future research.

A major strength of the study was an objective assessment of shiftwork through day-to-day electronic payroll work history records from 1994 or start of employment through date of study enrollment and the availability and participation of women police officers. The present study is a first cursory look at this issue in police work. Future research studies should strive to increase sample size. Increased participation by women will help identify additional biological and environmental mechanisms involved in pregnancy complications. Further investigation is needed to examine to what extent sleep disruption and fatigue affect the health outcomes of pregnant women and their fetuses. Additionally, assessment of changes in biologic factors involved in shiftwork which affect pregnancy outcomes such as melatonin, prostaglandins, aldosterone, lack of gene expression and others is important in future work (Cai et al., 2019).

References


Further reading


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