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Occupational Factors and Risk for Preterm Birth

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Occupational Factors and Risk for Preterm Birth

By

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Abstract

Introduction: Preterm birth (PTB) is a leading contributor to infant death globally and in the United States. The biological mechanisms and etiologies for PTB are not well understood making prevention challenging. The correlation between increased number of women in the workforce and increased incidence of PTB in the U.S. inspired a thorough review of occupational risk factors that may contribute to shortened gestational length.

Background: The studies reviewed assessed the following occupational factors and their association with PTB: physical job demands, exposure to whole-body vibration and noise, shift work, long working hours, and psychosocial job strain.

Methods: A systematic search using Augsburg University's Lindell Library, PubMed, and ScienceDirect databases was conducted to find peer-reviewed studies that examined maternal occupational factors and birth outcomes.

Discussion: PTB was most associated with physically demanding jobs, long working hours, and prolonged exposure to whole-body vibration. However, more research is needed to further clarify at what exposure level and stage of the pregnancy exposures have the most impact. Additionally, more studies that control for confounding variables and address the role of maternal race and socioeconomic status are needed.

Conclusion: There is not sufficient evidence to support the implementation of workplace policies that limit job duties or working hours for women during pregnancy. However, it may be prudent for clinicians to educate pregnant patients that heavy lifting, prolonged standing and bending at the trunk, working long hours, and having a full-time job with exposure to whole-body vibration has been associated with early parturition.

Introduction

Each year 15 million babies are born into the world too early, too small, and too sick.¹ According to the World Health Organization (WHO) the rate of preterm birth (PTB) across the globe ranges from 5-18% with the highest rates primarily occurring in countries of Africa.² However, the burden of PTB is not only confined to low-income nations. In 2019, one in every 10 infants (10.2%) born in the United States was affected by PTB, a statistic that has been on the rise since the 1950's.^{3,4} The incidence rate for American Indian and Alaska Native women is even greater at 11.7%, and the rate amongst African American women is equivalent to that of many developing countries at 14.4%.³ The proportion of babies born preterm in the United States does not coincide with the size of its healthcare sector or the fact that it leads the world in scientific and medical innovation.⁵ Other industrialized nations like Canada, Australia, United Kingdom, Japan and the Nordic countries report significantly lower PTB rates compared to the U.S., ranging from 5.7-8.6%.^{6,7} In the 2012 Global Action Report on Preterm Birth published by the WHO, former United Nations Secretary General Ban-Ki Moon stated, "What is lacking in this effort is the will, not the techniques, technologies or science."² However, researchers are still working to define risk factors, discern their magnitude, and better understand the pathogenesis of PTB. Having the ability identify at-risk women early in their pregnancy, or perhaps even preconception, would allow for more research on risk-specific interventions that hopefully yield a reduction in PTB and its sequelae.

The widely accepted definition of preterm birth is an infant born between 20-37 weeks gestation.¹ It can be further categorized as late-moderate preterm (32-37 weeks), very preterm (28-32 weeks) or extremely preterm (<28 weeks).¹ Spontaneous PTB accounts for nearly 80% of all preterm births – 30% are related to spontaneous rupture of the membranes and 50% follow

the spontaneous initiation of labor.⁸ The remaining 20% of preterm births are considered interventional or iatrogenic.⁸ That is, an obstetrician deems labor induction or a cesarean section medically necessary due to condition that threatens fetal or maternal health outcomes.⁸ Data indicates that the interventional PTB rate has considerably increased over the years while the spontaneous PTB rate has slightly declined.⁴ This trend is often used to explain the cause of elevated PTB rates in the United States. Particularly, it's proposed that clinicians are less reluctant to intervene at a younger gestational age because of the medical advancement in neonatal care.⁴ However, many experts in the field suggest the issue is likely more complicated than that. In fact, many consider comparing interventional and spontaneous PTB inconsequential because the pathological mechanisms that lead up to both are typically the same.⁴

Prematurity is a challenging and complex condition that continues to be a leading cause of neonatal morbidity and mortality in the United States.⁹ Preterm infants are developmentally unprepared for life outside the womb putting them at high risk for detrimental health conditions such as respiratory distress syndrome, necrotizing enterocolitis, intraventricular hemorrhage, and neurodevelopmental disorders like cerebral palsy.³ The ramifications of PTB can extend well beyond the neonatal period. Babies who are born even just a few weeks preterm (34-36 weeks) are 3 times more likely to die from respiratory problems, infections and sudden infant death syndrome (SIDs) in their first year of life compared to infants born at term.¹⁰ In addition, increased care needs for babies and children born prematurely can be extensive and lifelong, creating exorbitant financial burdens for families and society.¹¹ In 2016, the average medical cost for an infant born prior to 37 weeks gestation was estimated at \$64,000. That cost increases fivefold, to \$344,000, for an infant born prior to 28 weeks gestation.¹¹ Due to the high rate of mortality, risk for serious health sequelae, and significant healthcare costs related to preterm

birth, the Center for Disease Control (CDC) has declared a reduction in its incidence a national public priority.³

The coronavirus pandemic of 2020 impacted global health in ways that experts never could have anticipated. In the obstetric realm, an unexpected reduction in preterm birth was observed at several U.S. institutions, and others parts of the world, surrounding government mandated lockdowns.¹²⁻¹⁶ In May 2021, the U.S. Department of Health and Human Services (HHS) released their provisional data report on births which confirmed what the institutions had observed.¹⁷ The PTB rate had dropped from 10.23% in 2019 to 10.09% in 2020, the first reduction in PTB in the United States since 2014.¹⁷ The emerging data is not only encouraging but also intriguing given the vast socio-environmental changes that occurred for many women throughout the 2020 year. One of the most notable events of the pandemic was the closing of non-essential businesses and the promotion of social distancing by working remotely. One poll reported that in April 2020 approximately 70% of working Americans were working from the comforts of their own home.¹⁸ The unprecedented and widespread change in work environment and accompanying decline in PTB raises the question as to whether occupational stressors are contributing to early parturition.

This paper is to explore factors that are commonly encountered by women in the workplace and determine how they impact risk for preterm birth. Previously published literature primarily examined factors of physical activity, exposures, working hours, and psychosocial stressors, all of which will be reviewed. A necessary foundation for accomplishing a reduction in PTB in the United States is identifying all mitigatable risk factors, including those in the occupational setting. Comprehensive knowledge of risk-factors will allow for early identification

of women at greatest risk, promotion of active avoidance, and initiation of timely interventions to foster the best possible birth outcomes.

Background: Literature Review

Working During Pregnancy

In 2016, 57% of women participated in the United States workforce, and of those women, 74% reported working full-time.¹⁹ According to the U.S. Census Bureau, nearly 90% of women continue to work up until the last month before their child's birth.²⁰ Financial stability, conservation of paid leave, preservation of insurance, and professional fulfillment are presumably some of the reasons women opt to work throughout the duration of their pregnancy. Some studies have reported that working women are at reduced risk for adverse pregnancy outcomes, including preterm birth, compared to women who are not employed.²¹⁻²³ Researchers believe the association between work and improved outcome may be explained through a variety of indirect pathways such as education level, health status, socioeconomic status, and social support, all which independently influence risk for PTB.^{22,23} While these factors remain important when assessing overall risk for PTB, they are often of low value to clinicians in practice as they are not easily modifiable within the duration of pregnancy.

However, the research has shown gestational length may also be impacted by numerous direct factors related to work. Several studies have examined strenuous physical activities such as heavy lifting, demanding body postures, and prolonged standing/walking. Occupational exposures were also commonly analyzed, but due to already well-understood and highly acknowledged ramifications of chemical, heavy metal, and radiation exposure, this paper only addresses whole body experience exposures including vibration and noise. Shift work, long working hours, and job strain were also common stressors examined in the existing literature.

Identification of activities and exposures associated with PTB will mitigate risk, guide clinicians' recommendations for pregnant workers, and provide supporting data for the development of universal policies that protect women against workplace pregnancy discrimination.

Occupational Physical Activity in Pregnancy

Research has clearly established that exercise during pregnancy offers numerous benefits including promoting healthy gestational weight, reduction in urinary incontinence and constipation, reduction of low back and pelvic discomforts, and it decreases the risk for developing pregnancy complicating conditions like preeclampsia and gestational diabetes.²⁴

Exercise has also been related to improved perinatal outcomes. Particularly, it reduces the risk of fetal macrosomia (>4000g at birth), a condition which can lead to brachial plexus injuries, fractures, and asphyxia during vaginal delivery.²⁵ Currently The American College of Obstetricians and Gynecologists (ACOG) recommends that pregnant women achieve at least 150 minutes of moderate-intensity physical activity each week.²⁶ Power walking, stationary cycling, swimming, and modified yoga are the activities experts agree are safe to engage in throughout pregnancy, unless there is a diagnosed complication in which exercise is contraindicated.²⁶

Needless to say, leisure activities like those mentioned prior differ considerably from the type of physical activity in the work environment. Leisure activities often occur over a short period of time, include dynamic movements, and allow for adequate recovery time.²⁷

Conversely, occupational activities are performed throughout the day and oftentimes recovery time is limited or nonexistent.²⁷ Strenuous physical activity without sufficient time to recover has been linked to reduced uteroplacental blood flow.²⁷ Prolonged placental blood flow compromise results in hypoxemia and fetal stress. There is evidence to suggest that fetal stress may “activate cells in the placenta and fetal membranes to produce corticotropin-releasing hormone (CRH).”²⁸

CRH initiates prostaglandins production which stimulates the uterine muscles to contract promoting preterm labor.²⁸

While physical activity is generally encouraged in pregnancy, the activities imposed on women in the workplace are not comparable to those deemed safe and need to be examined separately. It is important to distinguish what occupational physical activities are positively associated with PTB, at what level does the risk begin to increase, and at what gestational age does activity have the most impact. The most frequently evaluated physical demands encountered by women in the workplace were lifting, body posture, and prolonged standing/walking.

Lifting

Heavy lifting is an essential component of many jobs, especially for those who work construction, retail, delivery service, or health care. According to the CDC, pregnant women who lift heavy loads are at increased risk for musculoskeletal injuries due to changes in body habitus, altered posture and balance, and greater ligament laxity.²⁹ However, the impact of lifting on pregnancy outcomes, including PTB, has not been equally as clear. The proposed mechanism by which lifting may lead to preterm birth parallels the pathway discussed previously. During heavy lifting blood flow is preferentially directed toward the working skeletal muscles rather than the uterus and placenta facilitating preterm labor.²⁷ Lifting is also known to cause increased intraabdominal pressure, which has also been linked to increased uterine contractility.³⁰

Five studies were reviewed that examined occupational lifting and birth outcomes. Of those studies, 4 identified a positive association with PTB.^{27,30-32} Across the studies lifting was quantified as either weight lifted per time or total weight lifted per day. When weight lifted per time was evaluated there was little agreement between the studies regarding what weight is

attributable to an increased risk for PTB. A 2013 study that utilized the Danish National Birth Cohort reported that women who lifted more than 20 kg more than 10 times per day were at increased risk for PTB.³⁰ A more recent meta-analysis that examined 51 studies found that women who lifted more than 10 kg more than 10 times per day were at increased risk for PTB.³² Another meta-analysis suggested the association may exist at even lower load weights. Van Beukering and colleagues,³¹ reported that women who engaged in repetitive lifting or carrying of more than 5 kg were at increased risk for PTB compared to those in the less than 5 kg group. However, unlike the previously mentioned studies this meta-analysis did not report a lifting frequency at which the risk increase.³¹ Additionally, there was notable variation amongst how exposure was classified in studies analyzed by Van Beukering et al.³¹ For instance, some defined exposure as lifting a specified weight a certain number of times per day, while others referred to exposure as lifting more than a particular number of hours per day or days per week.³¹

According to a study that examined total daily lifting weight, a fourfold increased risk for preterm delivery was recognized in women who lifted more than 1000 kg per day.³⁰ Another study by Cai et al.²⁷ had similar results, revealing 31% increased odds for PTB for women that lifted 100 kg or more per day. In principle, the results from Cai et al.²⁷ support previously discussed findings of an increased risk for PTB when more than 10 kg was lifted more than 10 times per day.³² However, when researchers assessed weight lifted per time, there was no significant difference in incidence of PTB among women who lifted more than 11 kg per time compared to women who lifted less.²⁷

Demanding Body Posture

In addition to lifting, prolonged demanding body posture may be another physical activity factor experienced in the workplace that contributes to risk for preterm birth. Four

studies that examined maternal body posture were reviewed and 3 reported a statically significant increase in PTB.³³⁻³⁵ There was some variation among the studies in how ‘demanding posture’ was defined. Two studies focused in on prolonged bending, which was described as forward flexion at the waist that occurred for 1 or more hour(s) per day.^{27, 35} The other two studies included various working position in their definition. For instance, Corteau et. al³⁴ considered demanding posture to be bending, squatting, or arms raised above shoulder level for 3 or more hours per day. Lee et. al³³ assessed a composite ‘occupational physical activity’ variable which included 9 factors – 5 fatiguing body postures (bending, twisting of the body, kneeling, crouching, and stooping) and 4 other physically strenuous workplace activities (moving objects, walking, running, and a maintaining or regaining balance).

Lee et al.³³ identified a significant increased risk for PTB among women who worked jobs in the highest quartile of occupational physical activity, compared to women who worked jobs in the lowest quartile. When researchers analyzed activities individually, the strongest factor associated with PTB was prolonged bending or twisting of the body during the first trimester.³³ Women who reported working a job in the highest quartile of bending or twisting in the first trimester were 44% more likely to deliver preterm than women who worked jobs in the lowest quartile.³³ These findings parallel those from another study which reports a threefold increased risk for PTB in women whose work required them to bend forward at the trunk for more than 1 hour per day.³³⁻³⁵ However, in contrast to Lee et al.³³ this study identified heightened risk to be most associated when prolonged bending occurred in the third trimester as opposed to the first.³³⁻
³⁵ For this reason it remains unclear at what stage during the pregnancy does prolonged bending make the most impact on birth outcome.

Uncertainty also remains regarding the duration at which a demanding posture must be sustained to impact risk for PTB. A study by Cai et. al²⁷ found no association between bending and PTB when the position was endured for more than 1 hour per day. However, Croteau and colleagues³⁴ reported an increased risk for PTB in women who engaged in demanding work postures (bending, squatting, or arms raised above shoulder level) for more than 3 hours per day. Croteau et. al³⁴ also reported the risk was greatest when the condition was present at the beginning of pregnancy and persisted throughout the full duration of pregnancy and lower amongst women who were able to eliminate the condition at an early gestational age. This finding is important clinically as it suggests if the risk is identified, and preventative measures are implemented early in the pregnancy, the risk for PTB may be mitigated.

In the population examined by Lee and colleagues,³³ 42% of women who engaged the greatest amounts of bending and twisting reported jobs in 2 major roles: food preparation or serving and health care practitioners/technicians. Other jobs presumed to involve high amounts of trunk bending are jobs that include working with small children (nannies and teachers), cleaning, and shop work.³⁵ The classification of jobs most associated with strenuous work postures is valuable to the practicing clinician as they strive toward identify all potential health hazards that may impact birth outcome.

Prolonged Standing and Walking

According to the research pregnant women who work on their feet for extended periods of time may be at increased risk for preterm delivery. Four studies were reviewed that evaluated prolonged standing and walking on birth outcomes.^{23,27,31,35} Three studies reported a statistically significant increased risk for PTB,^{23,27,31} while one suggested minimal association.³⁵ A 2014 meta-analysis that analyzed 12 studies found a higher rate of preterm birth in women who

reported walking or standing more than 3 hours per day.³¹ The studies evaluated by the meta-analysis, primarily assessed exposure that occurred during the first trimester.³¹ Two other recent studies also recognized a positive association between prolonged standing/walking at work and shortened gestational length. Vrijkotte et al.²³ found that women who were on their feet for more than 30 hours per week at work were at increased risk for PTB. However, researchers of this study determined that the increased risk was only significant among interventional PTB and not spontaneous PTB.²³ A dose-response analysis conducted by Cai et al.²⁷ identified that women who spent more than 3 hours per day walking or standing at work were 10% more likely to deliver preterm.

The biological mechanism by which prolonged standing and walking contribute to preterm birth is not entirely understood. One proposed theory is that prolonged standing leads to pooling of blood the lower extremities which results in less venous return to the heart, reduced plasma volume, and ultimately reduced cardiac output.²⁷ Reduced cardiac output impacts blood flow to the placenta affecting fetal growth and promoting labor.²⁷ The suggested pathway by which excessive walking may contribute to PTB differs from that of standing, as it is thought to be catecholamine mediated.³³ Put simply, prolonged walking can lead to elevated norepinephrine levels, a stress hormone that has been linked to increased uterine contractile.³³

Exposure to Vibration and Noise

There is a great emphasis put on counseling women to avoid chemical, heavy metal, and radiation exposures during pregnancy. The accentuation is certainly justified given these types of exposures are well-known to have the potential to cause miscarriage, birth defects, and developmental issues.³⁶⁻³⁸ However, there are other physical exposures, such as vibration and sound, that may be mistakenly perceived as benign because of their frequent presence in our

daily experiences, both inside and outside of the workplace. The effect of vibration and noise exposure on pregnancy outcomes deserves similar scrutiny as other occupational exposures so appropriate exposure parameters can be implemented and risk can be mitigated.

Whole-Body Vibration

Vibrations that are transmitted through the entire body from sitting, standing, or lying on a vibrating surface are referred to as whole-body vibration (WBV).³⁹ Exposure to WBV is most common in work industries that utilize heavy machinery and vehicles such as construction, agriculture, forestry, and transportation.³⁹ Research has linked exposure to WBV to an increased risk for back pain which prompted the European Union-Occupational Safety and Health Administration (OSHA) to implement a 1.5m/s^2 daily exposure limit for workers and a 0.5m/s^2 employer 'action value,' the level at which an employer is legally required to act to reduce employee exposure.^{39,40} Undoubtedly, vibrations of this caliber are transmitted to a fetus in utero, however, few studies have examined the effect of WBV on birth outcomes.

In an extensive literature search only 2 studies were found that examined the impact of WBV on risk for preterm birth. An early study by Croteau and colleagues³⁴ assessed several occupational environmental factors including exposure to WBV. Researchers reported that women who were exposed to WBV throughout the entirety of their pregnancy were at increased risk for PTB.³⁴ However, it is important to note that exposure was evaluated by means of a single, dichotomous (yes/no) self-report survey question.³⁴ Therefore, researchers were unable to draw any conclusions regarding at what vibration magnitude, frequency, or duration of exposure the risk increases.

In 2020, Skröder et al.³⁹ further examined exposure to occupational WBV during pregnancy. Researchers conducted a retrospective nationwide cohort study, which included data

from nearly all births that occurred in Sweden between 1994-2014. Results mirrored that of Corteau et al.,³⁴ revealing an increased risk for PTB among women who were exposed to WBV compared to women who were not exposed.³⁹ The greatest risk existed among full-time employees with low number of absence days from work (<45 days).³⁹ Notably the association was present with exposures well below the current EU-OSHA exposure limit value (1.5m/s²). Researchers suggest that the increased risk of PTB may exist with exposure levels as low as 0.3m/s².³⁹ Therefore, the current daily exposure limit and the level at which employers are required to act to reduce exposure (0.5m/s²) in the EU may not be useful in protecting pregnant women against adverse birth outcomes. Unlike the EU, the United States currently has no legal standards that limit exposure to vibration for any worker. However, if future studies continue to observe similar results it may be necessary to implement workplace regulations that limit WBV exposure for full-time pregnant workers. According to results from Skröder et al.³⁹ that limit should be 0.5m/s², or less.

Researchers have yet to discern the exact mechanism by which WBV may contribute to early parturition. A study conducted in pregnant rats revealed exposure to WBV resulted decreased progesterone levels, a hormone highly involved in the maintenance of pregnancy.^{39,41} Researchers also noted reduced uterine blood flow, increased prostaglandin and corticosterone levels in rats exposed to WBV, pathways that have all been linked to the early onset of labor and preterm delivery.^{39,41} It is important to point out that the rat subjects were exposed to significantly greater vibration rate than any pregnant woman in Skröder et al.³⁹ The rats endured vibrations of 10m/s², which is more than 6 times the rate of the limit set by EU-OSHA (1.5m/s² exposure).^{39,41}

Noise Exposure

Loud noise is a common exposure to experience in the work environment however, little known about how impacts birth outcomes. “Noise is a stressor that activates the sympathetic and endocrine system through the hypothalamic-pituitary-adrenal (HPA) axis leading to excessive release CRH from both mother and fetus.”^{42,43} As discussed previously, elevated CRH has been linked to the initiation of preterm labor.^{28,43} Limited number of studies were found that assessed the association between maternal noise exposure and the outcome of interest, preterm birth.

A nationwide cohort study utilizing 3 of Sweden’s population registers, directly examined maternal occupational exposure to loud noise in pregnancy and its effects on birth outcomes.⁴² Researchers categorized women in to 3 noise intensity groups depending on their reported job and a calculated annual average of daily noise exposure level – less than 75 A-weighted decibels (dBA), 75-84 dBA, and 85 dBA or greater.⁴² PTB was more common among women in the intermediate noise level group (75-84 dBA), however the association did not exist in the highest exposure group (85dBA or greater). Therefore, no clear association between exposure to noise exposure and gestational length was birth was confirmed. Their results mirrored that of an earlier study which also reported no significant increase in PTB among women exposed to occupational noise of at least 79dBA.⁴⁴ However, 2 studies that assessed the effect of specific noise exposures on pregnancy outcomes, such as aircraft noise and loud road traffic noise, indicated a possible association with preterm birth.^{45,46} These results may be important to consider for pregnant women who work for airlines, near airports, women who work construction, or other jobs near major roadways. Due to lack of consistent and high-quality results more research is still needed to clarify whether an association exists and at what level does the risk present.

Working Hours in Pregnancy

Shift Work

Rhythmic variations in ambient light impacts several underlying biological processes and human behaviors such as patterns of sleep, feeding, and times of fasting. Shift work commonly disrupts these normal cycles as it involves working outside normal daylight hours.⁴⁷ Shift workers may work in the evening, overnight, or extra-long workdays.⁴⁷ Their schedules may be permanent non-traditional working hours, or their schedule may rotate. Some jobs that commonly involve shift work are emergency responders, healthcare providers, air traffic controllers, security guards, restaurant employees, and hospitality personnel.

Research has connected occupational shift work, particularly overnight work, to adverse health outcomes including metabolic dysregulation, cardiovascular disease, and mental health conditions.^{48–50} The notion that shift work may also negatively impact pregnancy outcomes is based on presumed disruption of normal melatonin levels, due to prolonged exposure to illumination, as one would be working through the night.⁵¹ Melatonin is a hormone that is primarily secreted by the pineal gland in the presence of darkness and it contributes to wake-sleep cycle regulation.⁵¹ However, it is also thought to play a role in the maintenance of pregnancy through stimulating the production of progesterone, a hormone that prevents uterine contractility.^{51,52} In addition, reduced melatonin has been associated with a pathway that results in the release of prostaglandins, nitric oxide, and pro-inflammatory cytokines which can promote preterm labor.⁵³

Four studies were reviewed that evaluated the association between maternal shift work and preterm birth.^{51,53–55} One of the studies specifically examined women who worked in the health care setting,⁵⁵ while the remaining 3 studies assessed workers in various job sectors.^{51,53,54}

The results were mixed. Two of the 4 studies identified an increased risk for PTB in women who worked night shift or rotating shifts,^{53,55} while the remaining 2 reported no statistical difference compared to women who worked regularly scheduled day hours.^{51,54} Kader et al.⁵⁵ found that women who worked more than 25 night shifts during the first trimester were 1.62 times more likely to give birth preterm than women who only worked day shift.⁵⁵ Researchers also reported that women who worked 3 or more consecutive night shifts in the first trimester were 43% more likely to experience PTB.⁵⁵ Additionally, a threefold increased risk was identified in women who worked 3 or more consecutive night shifts more than 8 times in the first trimester or were repeatedly exposed to short intervals between night shifts (less than 28 hours).⁵⁵ Cai and colleagues⁵³ reported similar results identifying a 13% increased risk for PTB in women who worked rotating shifts and a 21% increased risk in women who worked fixed night shift compared to workers that consistently worked daytime hours.

In contrast to the studies discussed previously, Specht et al.⁵¹ and Zhu et al.⁵⁴ found no elevated risk for PTB in women who worked night shift compared to day shift workers. Specht et al.⁵¹ reported no association between the number of night shifts worked, duration of night shift, consecutive nights worked in a row, or short interval returns to night shifts and PTB. However, researchers did identify weak increased odds for PTB in women who altered their work from working night shifts in the first trimester to fixed day shift in the second trimester compared to women who continued to work night shift in both trimesters.⁵¹ Intriguingly, Zhu and colleagues⁵⁴ suggest that night work may actually prolong the duration of pregnancy, as they identified an elevated risk of post-term birth among fixed night workers, especially industrial workers. When they limited their analysis to women who worked health care job, specifically nurses and nursing assistants, there was no statistical difference in gestational age outcomes compared to dayshift

workers.⁵⁴ This contradicts the findings of Kader et al.⁵⁵ that identified an increased risk for PTB among health care workers who worked night shift. Zhu et al.⁵⁴ reported that shift work women were more likely to change jobs in pregnancy and more likely to take leave during pregnancy than daytime workers. However, these factors were taken into consideration by researchers and neither appeared to play a significant role in risk estimates.⁵⁴ The conflicting results of the studies that evaluate the impact of shift work on birth outcomes suggests more research is still needed to be able to draw clinically applicable conclusions.

Long Working Hours

According to the Organisation for Economic Co-operation and Development, the United States works more hours per year than any other comparable industrialized country.⁵⁶ This leads to the question of whether long working hours may be contributing to high rates of preterm birth in the United States. Research has suggested that long working hours are linked to elevated circulating catecholamine levels which may lead to increased uterine contractility and promote preterm birth.⁵³ Four of the studies reviewed examined the association between long work weeks and gestational age at birth, all of which revealed an increased risk for PTB.^{23,34,53,55}

Kader and colleagues⁵⁵ assessed Swedish health care workers and found that women who worked 10 or more hours per day, more than 20 times during the first trimester were at significantly increased risk for PTB. Additionally, researchers identified a twofold increased risk for women who worked more than 40 hours per week any week in the third trimester.⁵⁵ In a dose response analysis conducted by Cai et al.,⁵³ women who worked more than 55.5 hours per week had a 10% increased risk for preterm birth compared to women who worked 40 hours per week. An earlier study conducted by Croteau et al.³⁴ reported an increased risk for very preterm delivery (<32 weeks gestation) in women who worked more than 5 days consecutively.

However, researchers did not report a significant association between PTB and hours worked per week.³⁴

Vrijotte et al.²³ evaluated several occupational factors and how they each may contribute to spontaneous versus interventional preterm birth. Researchers found no link between weekly working hours and either type of PTB when evaluated independently.²³ However, when long working hours (32 or more hours per week) occurred in combination with heavy physical workload, a significantly increased risk for PTB was apparent.²³ In further evaluation of the combined variables, researchers identified that the increased risk only pertained to interventional preterm delivery.²³ No association was reported with spontaneous preterm delivery.²³

While it is evident that an association between PTB and long working hours exists, the information may be challenging to apply. Imposing workplace policies that limit number of working hours during pregnancy may be unethical as it could put women at an economic or career advancement disadvantage. Comprehensive patient education on risk for PTB is important, however clinicians should always be certain the benefits outweigh the risks before making a recommendation to reduce working hours.

Psychosocial Stress in the Workplace

A growing body of research in obstetrics has been examining the role of psychosocial stress in pregnancy outcomes. Psychosocial stress is defined as, mental strain that occurs due to perceived threat of one's social status, self-efficacy, or acceptance within a group.⁵⁷ Job strain is a type of psychosocial stress that occurs in the occupational setting. It commonly occurs with situations of excessive workload, low job autonomy, exclusion from decision-making processes, highly competitive work environment, or experiences of discrimination or harassment in the workplace.³³ Job strain has not only been associated with poor psychological health but also poor

physical health. Recent studies have shown increased risk for hypertension, coronary artery disease, and cerebral vascular accidents in workers who endure chronic job strain.⁵⁸⁻⁶⁰ However, research that examines the effect of job strain on birth outcomes, including preterm birth, remain limited.

In 1979, Karasek,⁶¹ a U.S. sociologist, developed a job strain model which states, “the greatest health risks occur in workers who experience high psychological workload demands combined with low control or decision-making latitude in meeting those demands.” Karasek’s⁶¹ ‘demand-control’ model is utilized by all the studies reviewed which examine job strain and risk for preterm birth. Researchers quantified level of ‘demand’ by surveying women on their perceptions of working pace, effort, and number of tasks. Level of ‘control’ was commonly evaluated by assessing perception of autonomy, decision-making authority, and ability to influence tasks and working conditions.

Five studies were reviewed that evaluated the impact of psychosocial job strain on gestational age at birth. Results from the studies were mixed. Two reported significant findings,^{34,62} while the remaining 3 concluded no significant relationship.^{33,63,64} While majority of the studies assessed job strain independently, one study conducted by Sejkaek and colleagues,⁶⁴ examined the interaction between psychosocial stress and heavy lifting. Researchers were interested to examine whether job strain in combination with an occupational factor already identified as associated with PTB would additionally increase the risk.⁶⁴ However, no significant impact was identified in the population of women studied.⁶⁴ The results must be interpreted with caution as numerous other studies have identified an increased risk for PTB in women who engage in frequent lifting. Results from Sejbaek et al.⁶⁴ only suggest that high job strain is not likely to increase risk further. None of the 3 psychosocial stress categories (‘interpersonal

stressors,' 'automated work,' and 'job responsibility') analyzed by Lee et al.³³ were associated with increased odds for PTB. However, when individual factors from the categories were analyzed, dealing with physically aggressive people was positively associated with PTB.³³

It is important to preface that the 2 studies reviewed which indicated a positive relationship between job strain and preterm birth are dated, having been published in 1997 and 2007.^{34,62} Brett et al.⁶² described a modestly increased risk for PTB in women with full-time high-demand, low-control jobs. No increased risk was apparent in the group of women who reported working less than 30 hours per week in a high strain job.⁶² Additionally, researchers identified that job strain was more consistently related to PTB in Black women compared to white women.⁶² This finding conceivably suggests that Black women may have increased job strain due to working jobs with higher demands or lower control, or that Black women may have an enhanced stress response.

Croteau et al.³⁴ examined psychosocial factors utilizing the demand-control model as well as other organizational factors that could contribute to job strain like absence of breaks, piecework, and assembly line work. Researchers reported that women who scored high on job strain and also described receiving low to moderate social support from coworkers or supervisors were at increased risk for preterm and very preterm delivery.³⁴ However, the increased risk was not identified in women with high job strain who reported high colleague social support.³⁴ This result may indicate some degree of protection against PTB if a high strain job is paired with a positive work culture, a topic worthy of future investigation. Croteau et al.³⁴ found no association between absence of breaks, piecework or assembly line work and preterm birth.

The mechanism by which job strain may be associated to PTB is not entirely clear, however Brett et al.⁶² proposed one possible pathway. High-demand, low-control jobs are

believed to heighten catecholamine production and levels can remain increased even after leaving work.⁶² Elevated catecholamine levels have been linked to hypertension and stimulation of uterine contractility, which may promote preterm delivery.⁶² Additionally, hypertension itself appears to increase risk for PTB.⁶² Brett and colleagues,⁶² also bring forward the notion that high levels of job strain may lead to an increase in unhealthy behaviors, such as cigarette smoking. Workers who report high job strain are more likely to smoke and have more difficulty quitting smoking than low-strain workers.⁶² Tobacco use during pregnancy is a well-established risk factor for pregnancy complications and poor birth outcomes including preterm birth.^{62,65}

The impact of job strain on gestational age at birth is unclear due to mixed study results and lack of recent studies that demonstrate significant associations. However, it remains important for clinicians to screen pregnant patients for sources of psychosocial stress in the workplace and other aspects of life. This is primarily due to a significant association between psychosocial stress, mental health, and adverse health behaviors that may impact the pregnancy.^{62,66} Future research should not only be focused on understanding the impact of job strain on birth outcomes independently but how it may interact with other occupational factors such as high physical demands, shift work, and long working hours.

Methods

A search was conducted utilizing Augsburg University's Lindell Library, PubMed and ScienceDirect databases. The search terms for the purposes of this review included: "Occupational Factors AND Preterm Birth," "Maternal Work AND Preterm Birth," "Employment AND Preterm Birth." Synonymous terms for preterm birth were also searched, such as "Gestational Age at Birth," "Prematurity," "Preterm Delivery," and "Birth Outcome." The search was initially limited to articles published within the last 10 years, however due to

limited number of results that matched outcome of interest some articles prior to 2011 were utilized. Only peer-reviewed articles from scientific journals were used as primary literature review sources. Other articles from reputable webpages, such as WHO, CDC, and ACOG were also utilized to provide supporting information for the review. It was initially intended to only include studies that were conducted in the United States given the considerable differences in medical technologies and prenatal care around the world. However, search results yielded several recent and high-quality studies conducted in Denmark and Sweden. These countries possess meticulous birth and health record keeping in national databases which allows researchers to conduct nationwide cohort studies where hundreds of thousands of mother-child pairs can easily analyzed. For this reason, it was critical that these studies were included. The studies reviewed were exclusively observational studies, which was expected given the ethical concerns of conducting clinical trials on pregnant women where birth outcome may be impacted. Both prospective and retrospective studies were included.

Discussion

Preterm birth continues to be a leading cause of newborn death in the United States. Advances in medical technology have allowed for drastically improved survival odds however, survivors can be left facing a multitude of health challenges for years to come. Reducing the incidence of preterm birth has been deemed a national priority due to its significant contribution to infant morbidity and mortality, the economic burden of care expenditures for families and society, and its impact on emotionally. However, the complex nature of the condition and lack of understanding about the etiologies makes prevention difficult. Researchers are in agreement that the problem is likely multifactorial and has influences from many biological and environmental factors. While all potential risk factors are important and deserve to be investigated, it is

especially important to assess environmental factors rigorously as risk may be easily mitigatable with early maternal education and active avoidance.

The correlation between the sudden transformation of workplace environment that occurred for many women due to the COVID-19 pandemic and reduced 2020 PTB rate prompted a review of existing literature on the relationship between occupational factors and PTB. The literature affirms long working hours and prolonged strenuous physical activities has the ability to increase risk for PTB. Despite limited studies that examined whole-body vibration, both concluded that frequent and extended exposure was positively associated with shortened gestational length. Due to mixed results from the studies that evaluated noise exposure, shift work, and psychosocial strain, more research is still needed to clarify whether an association exists.

Establishing a relationship between modifiable occupational activities and exposures is an important first step in promoting PTB risk mitigation. However, more research is still needed to clarify at what exposure level does the risk increase and at what stage in the pregnancy does it make the most impact. For instance, no consistent evidence exists to support a particular weight, frequency, or duration that lifting corresponds to an increased risk for PTB. Additionally, results of multiple studies suggest an increased risk for PTB with prolonged bending at the trunk, however there was no consensus among what trimester the risk was most elevated. Data which more evidently defines when an occupational factor crosses the threshold from benign to harmful is needed for clinical applicability and the development of universal policies. It may also be important to avoid unnecessary job leave or duty changes that may have harmful implications.

There were many strengths of the studies reviewed including rigorous methodologic standards, large population-based samples of pregnant working women, and many of the studies

were recent providing up-to-date evidence. However, it is important to note the limitations of the studies reviewed. First, there were no randomized control trials available for review. All studies were observational; therefore, researchers were unable to control for confounding factors or confirm a causal relationship between the occupational exposures examined and preterm birth. For instance, the studies that examined occupational physical activity and psychosocial job strain did not consider leisure physical activity level/intensity and non-work-related stressors that may have co-existed. Additionally, few studies evaluated socioeconomic status, a well-established risk factor for adverse pregnancy outcomes including PTB. It is important to consider that some of the occupational factors examined such as strenuous physical labor, shift work, and long working hours may be more prevalent among workers of lower socioeconomic status.

It was also recognized that many studies assessed occupational factors through self-reported measures, which increases the risk for recall-bias. Preterm birth and its sequelae can be distressing for parents, and it's often accompanied by maternal guilt and self-blame. These feelings may have unintentionally led women to over report their occupational activities and exposures increasing their association to PTB. Another limitation worthy of consideration is that the reviewed meta-analyses utilized studies from several countries, including some from developing nations. While this may have helped to provide a large and diverse sample of women, it is important to acknowledge the differences in standard of living, work environments, and prenatal care that likely exists compared to the United States.

It was also recognized that few studies examined maternal race, a factor of significant importance when considering obstetric outcomes in the United States. The incidence rate of preterm birth in the U.S. is markedly higher among Black and African American women. Black women are 50% more likely to give birth preterm than that of white women or Hispanic women.

Several studies reviewed were conducted in Denmark and Sweden using nationwide register databases. While many similarities exist between these countries and the United States, including comparable medical technologies, prenatal care, and standard of living, it is important to note the racial make-up of these nations is not comparable. According to the U.S. Census Bureau, 13.4% of U.S. population is Black or African American.⁶⁷ In contrast, Danish and Swedish populations are less than 6% and less than 3% Black respectively.^{68,69} Therefore, the results of these studies may not be generalizable to the United States.

As discussed earlier, this review of occupational stressors during pregnancy was prompted in response to an observed reduction in preterm births during the state-wide COVID-19 lockdowns which led to 70% of employed Americans to work from home.¹⁸ However, one study reported that the observed decrease in spontaneous PTB was limited white women living in more advantaged neighborhoods.¹⁴ For Black women living in the most disadvantaged neighborhoods the rate of PTB remained the same or increased.¹⁴ This not only suggests that the pandemic response regulations may have disproportionately benefitted white women compared to women of color, but it is also suggesting of inequity among the United States workforce.

While the issue was not examined by any of the studies reviewed, it's plausible that Black women are more likely to hold 'essential' jobs, requiring their physical presence in the workplace, as opposed to working from home, and preventing their avoidance of occupational activities and exposures linked to PTB. More research on the topic of occupational risk factors and PTB that considers maternal race will be useful in identifying a cause and developing a solution for the racial disparities exist in birth outcomes. However, it should be recognized that workforce inequities likely stem from larger societal issues such as education and socioeconomic status, both independent risk factors for PTB. Importantly, strategic investments in research that

targets reducing the PTB rate among Black and African women, to a rate more comparable with white women, will accelerate progress toward achieving a lower national preterm birth rate.

Conclusion

Preterm birth is a complex and multifactorial problem in which maternal occupational factors likely play a role. The studies reviewed expand our knowledge on workplace activities and exposures that are associated with increased risk for PTB. At this time, available evidence does not warrant imposing any mandatory work restrictions however, it may be prudent for clinicians to counsel pregnant women to avoid lifting more than 100 kg total weight per day, working in demanding postures, particularly bending at the trunk more than 3 hours per day, and prolonged standing more than 3 hours per day. Additionally, clinicians should educate women about the association between long working hours, working more than 10 hours per day or 55.5 hours per week, and early parturition.

The research on occupational exposure to whole-body vibration is limited, however both studies reviewed suggest an increased risk for PTB. Therefore, it may be prudent to advise pregnant women to avoid frequent and prolonged exposure. Noise exposure, shift work, and psychosocial job strain are occupational factors that have not consistently been associated with shortened gestational length. Clinicians should however continue to screen their pregnant patients for significant sources of psychosocial stress, as previous studies have linked high psychosocial stress to adverse health behaviors that may impact pregnancy outcomes. Despite the significant findings by the studies reviewed, more research is still needed to clarify the threshold at which the factors convert from benign to harmful. It is also important that clinicians recognize that regardless of medical advice many women must continue to work for financial reasons and elimination of these factors may not be feasible.

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