



Research article

Prediction of pregnancy disorders in female workers in the industrial sector

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ABSTRACT

Context: As female workers face a higher risk of exposure to workplace hazards than women in general, it is imperative that measures be put in place in the workplace to ensure safe and healthy pregnancies.

Objectives: This study aimed to analyze the effects of occupational hazards in the workplace environment on the potential for pregnancy disorders experienced by female workers.

Methods: This was an analytical, observational study with a case-control design. The participants were female workers who worked in industrial environments in both formal and nonformal industries. The inclusion criteria used in this study were female workers who had been or were pregnant at the time of the study, had worked in the industrial sector for at least one year, and did not smoke or consume alcohol. The samples were collected from 144 female workers. Midwives assisted in collecting data and conducting examinations of female workers. This study was conducted in Surabaya and Sidoarjo between June and December 2020. Data were analyzed descriptively, and a multivariable logistic regression test was performed. The study was conducted in accordance with the health protocols and prevention of COVID-19.

Results: The results showed that occupational hazards in the workplace environment that affect pregnancy disorders include workload ($p = 0.004$, OR = 28.676 (2.979–276.076)); hot working environment ($p = 0.014$, OR = 3.077 (1.254–7.552)); strong odors ($p = 0.017$, OR = 7.640 (1.436–40.656)); shift work ($p = 0.023$, OR = 8.063 (1.337–48.623)); irregular shift work ($p = 0.018$, OR = 7.371 (1.409–38.557)); and night shift work ($p = 0.015$, OR = 11.780 (1.605–86.450)).

Conclusions: Companies are expected to pay special attention to female workers regarding various workplace controls to prevent potential pregnancy-related disorders.

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1. Introduction

As female workers face a higher risk of exposure to workplace hazards than women in general, it is imperative that measures be put in place in the workplace to ensure safe and healthy pregnancies [1]. This is because various risk factors in the workplace can lead to pregnancy disorders, menstrual disorders, and even the death of mothers and babies. Women who work are more vulnerable to various factors that exist in the workplace compared to men [2,3] (see Fig. 1).

Substances or agents that can affect reproductive health are referred to as reproductive hazards. Reproductive hazards can cause one or more health effects depending on when female workers are exposed to these hazards [4]. Exposure in the first trimester of pregnancy can cause birth defects or miscarriage. Exposure in the second and third trimesters of pregnancy can cause deceleration of fetal growth, brain development, and spontaneous abortion. Reproductive hazards may not affect all female workers or every pregnancy in female workers ([5–7]; Sejbaek et al., [8]).

2020). Occupational hazards include exposure to substances in the workplace that have the potential to cause health problems. These hazards can be physical, chemical, biological, or psychosocial [9–11]. Workplace occupational hazards are risks associated with working in specific occupations that can cause injury or illness to employees. These hazards can be categorized into several types, including: Safety Hazards, Chemical Hazards, Biological Hazards, Physical Hazards, Ergonomic Hazards, Work Organization Hazards. The Author select the variable based on previous research (Safety, 2024).

Efforts to protect female workers have been undertaken worldwide. The protections include granting permission to leave when the pregnancy enters the 30th week, prohibiting night shifts for pregnant female workers, and providing the opportunity for mothers to breastfeed for the first six months of the baby's life [12–14].

With protection from the government and various global organizations, the incidence of pregnancy disorders, miscarriages, and menstrual disorders among female workers can be reduced. However, various preliminary studies have reported that 31.7 % of female workers in the industrial areas of Sidoarjo experienced pregnancy and menstrual disorders. Fourteen respondents stated that they had experienced a miscarriage. The East Java Statistic Indonesia data stated that the number of female workers in Sidoarjo was 43.77 % of the total. This study used data on whether the disorders were caused by the workplace environment, family environment, health service factors, or others [13,14]. This study used the triangular approach to the Epidemiology of Host, Agent, and Environment. The 'Host' aspect would be evaluated through assessments of nutritional status, which include measurements of mid-upper arm circumference (MUAC) and blood pressure. The 'Agent' aspect involved occupational hazards, while the 'Environment' aspect pertained to shift work.

This study aimed to analyze the effects of occupational hazards in the workplace environment on the potential for pregnancy disorders.

2. Material and methods

This was an analytical, observational study with a case-control design. The participants of this study were female workers who worked in industrial environments in both formal and nonformal industries. Because this regency has various industrial spots, Surabaya and Sidoarjo were chosen. The inclusion criteria used in this study were female workers who had been or were pregnant at the time of the study, had worked in the industrial sector for at least one year, and did not smoke or consume alcohol. The sample consisted

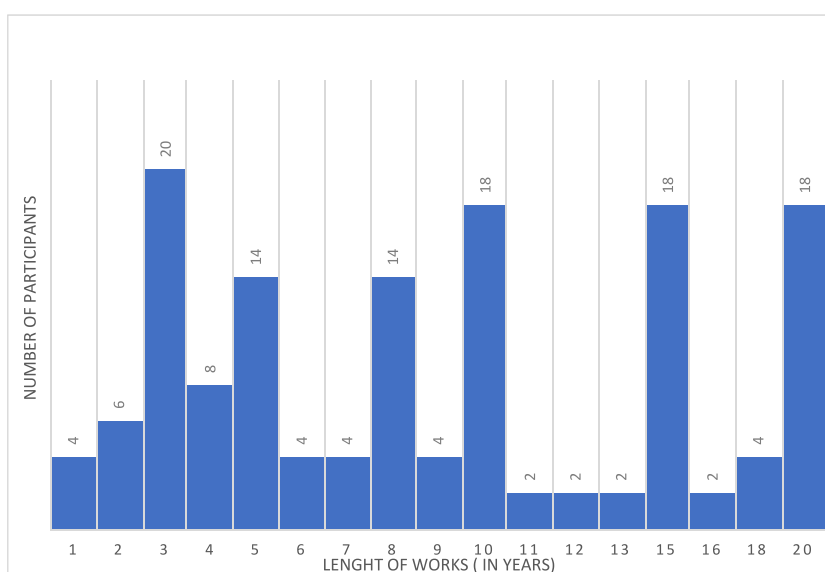


Fig. 1. Working period of female respondents in the industrial sector.

of 144 female workers, 72 in the case group and 72 in the control group. The case group consisted of female workers who experienced pregnancy disorders at least once during their last pregnancy. The control group comprised female workers who were pregnant at the time of the study and did not experience pregnancy disorders.

The sample was collected from female worker in each industry, we collect the data, we calculate the sample and choose the sample using stratified random sampling.

The dependent variable was pregnancy disorders, whereas the independent variables included workload, heat, cold, exposure to dust, strong odors, noise, stuffiness, shift work, irregular shift work, and night shifts. The characteristics of the respondents in the form of MUAC, blood pressure, education, and length of work are presented descriptively. Midwives assisted in collecting data and conducting examinations of female workers. This study was conducted in Surabaya and Sidoarjo between June and December 2020. The are main beneficial industry that still allowed to operate in pandemic period. The government allow it with Covid19 Protocol.

Data analysis was performed descriptively, and multivariable logistic regression was performed. The study was conducted in accordance with the health protocols and prevention of COVID-19. The ethical test was conducted by the Health Research Ethical Clearance Commission of Universitas Airlangga (Decree number 382/HRECC.FODM/VIII/2020).

3. Results (and discussion)

3.1. Characteristics of respondents

This study was conducted among female workers in the industrial sector. From all of the 144 participants, 59.7 % stated that they had experienced pregnancy disorders, such as preeclampsia, breech pregnancy, preterm birth, anemia, preterm rupture of membranes, and bleeding, at least once in the last pregnancy. Concerning the nutrition of pregnant women, 13.9 % of the respondents experienced Chronic Energy Deficiency, as measured by the MUAC. The blood pressure of most respondents was normal (58.3 %). The most recent educational level of most respondents was senior high school (54.2 %). The results further revealed that 4.2 % of the respondents had experienced miscarriages, 45.8 % had experienced health problems during pregnancy, and 43 % worked with the shift work system in the company. [Table 1](#).

The working period of female workers varied from 1 to 20 years. The most common working period was three years (20 respondents, 13.9 %), followed by 10, 15, and 20 years (18 respondents each, 12.5 %).

3.2. The effect of risk factors on pregnancy-related disorders in female workers

The results showed that occupational hazards in the workplace environment that affect pregnancy disorders include workload ($p = 0.004$, OR = 28.676 [2.979–276.076]); hot working environment ($p = 0.014$, OR = 3.077 [1.254–7.552]); strong odors ($p = 0.017$, OR = 7.640 [1.436–40.656]); shift work ($p = 0.023$, OR = 8.063 [1.337–48.623]); irregular shift work ($p = 0.018$, OR = 7.371 [1.409–38.557]); and night shift work ($p = 0.015$, OR = 11.780 [1.605–86.450]). Female workers who are exposed to heat and strong odors are at a greater risk of developing pregnancy disorders. Female workers with irregular shift work systems and night shifts are also at a greater risk of developing pregnancy disorders. The magnitudes of the risk factors are listed in [Table 2](#). Female workers with heavy workloads had a 28,676 greater risk of miscarriages. Meanwhile, female workers exposed to heat, strong odors, irregular shift work, and night shifts were at a greater risk of developing pregnancy disorders, the magnitudes of which are presented in [Table 2](#).

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40.656]); shift work ($p = 0.023$, OR = 8.063 [1.337–48.623]); irregular shift work ($p = 0.018$, OR = 7.371 [1.409–38.557]); and

Table 1
Characteristics of female respondents in the industrial sector.

| No | Variable | Category | Amount | Percentage (%) |
|----|-----------------------------|--------------------|--------|----------------|
| 1 | Pregnancy disorders | No | 58 | 40.3 |
| | | Yes | 86 | 59.7 |
| 2 | Mid-upper arm circumference | Normal | 124 | 86.1 |
| | | Chronic Energy | 20 | 13.9 |
| 3 | Blood pressure | Normal | 84 | 58.3 |
| | | Abnormal | 60 | 41.7 |
| 4 | Education | Elementary School | 4 | 2.8 |
| | | unior High School | 54 | 37.5 |
| | | Senior High School | 78 | 54.2 |
| | | University | 8 | 5.6 |
| 5 | Miscarriage | No | 138 | 95.8 |
| | | Yes | 6 | 4.2 |
| 6 | Health Problems | No | 78 | 54.2 |
| | | Yes | 66 | 45.8 |
| 7 | Shift work | Yes | 62 | 43.1 |
| | | No | 82 | 56.9 |

Table 2
Effects of occupational hazards on pregnancy disorders among female workers.

| No | Variables | Pregnancy Disorders Yes(%) | Pregnancy Disorders No(%) | B coefficient | P-value | OR (95 % CI) |
|----|--------------------------------|----------------------------|---------------------------|---------------|---------|------------------------|
| 1 | Workload | | | | | |
| | Heavy | 57 (79.2 %) | 7 (9.7 %) | 3.356 | 0.004 | 28,676 (2,979–276,076) |
| | Light | 15(20.8 %) | 65(90.3 %) | | | |
| 2 | Heat (Hot working environment) | | | 3.563 | 0.014 | 3,077 (1,254–7,552) |
| | Yes | 20(27.8 %) | 8(11.1 %) | | | |
| | No | 52(72.2 %) | 64(88.9 %) | | | |
| 3 | Cold | | | −0.403 | 0.373 | 0.668(0.275–1.622) |
| | Yes | 10(13.9 %) | 14(19.4 %) | | | |
| | No | 62(86.1 %) | 58(80.6 %) | | | |
| 4 | Dust | | | 0.000 | 1 | 1(0.240–4.162) |
| | Yes | 4(5.6 %) | 4(5.6 %) | | | |
| | No | 68(94.4 %) | 68(94.4 %) | | | |
| 5 | Strongodors | | | 2,033 | 0.017 | 7,640 |
| | Yes | 61 (84.7 %) | 25 (34.7 %) | | | |
| | | | (1,436–0,656) | | | |
| | No | 11(15.3 %) | 47(65.3 %) | | | |
| 6 | Noise | | | 2.061 | 0.064 | 7,856 (0.890–69,356) |
| | Yes | 1(1.4 %) | 1(1.4 %) | | | |
| | No | 71(98.6 %) | 71(98.6 %) | | | |
| 7 | Stuffiness | | | | | |
| | Yes | 45(62.5 %) | 15(20.8 %) | | | |
| | No | 27(37.5 %) | 57(79.2 %) | | | |
| 8 | Shiftwork | | | 2,087 | 0.023 | 8,063 (1,337–48,623) |
| | Yes | 60 (83.3 %) | 12 (16.7 %) | | | |
| | No | 12(16.7 %) | 60(83.3 %) | | | |
| 9 | Irregular shift work | | | 1998 | 0.018 | 7,371 (1,409–38,557) |
| | Yes | 53 (73.6 %) | 10 (13.9 %) | | | |
| | No | 19(26.4 %) | 62(86.1 %) | | | |
| 10 | Nightshif | | | 2.466 | 0.015 | 11,780 (1,605–86,450) |
| | Yes | 63 (87.5 %) | 7 (9.7 %) | | | |
| | No | 9 (12.5 %) | 65 (90.3 %) | | | |

night shift work ($p = 0.015$, $OR = 11.780$ [1.605–86.450]). Female workers who are exposed to heat and strong odors are at a greater risk of developing pregnancy disorders. Female workers with irregular shift work systems and night shifts are also at a greater risk of developing pregnancy disorders. The magnitudes of the risk factors are listed in Table 2. Female workers with heavy workloads had a 28,676 greater risk of miscarriages. Meanwhile, female workers exposed to heat, strong odors, irregular shift work, and night shifts were at a greater risk of developing pregnancy disorders, the magnitudes of which are presented in Table 2.

After the analysis we created an index represented as the equation:

$$Y = -4.607 + 28.676 (\text{heavy workload}) + 3.077 (\text{hot working environment}) + 7.640 (\text{strong odors}) + 8,068 (\text{shift work}) + 0.018 (\text{irregular shift work}) + 11.78 (\text{night shift}).$$

4. Discussion

4.1. Workload of female workers

Female workers with heavy workloads have a high risk of developing pregnancy disorders. Female workers with heavy workloads are also at risk of experiencing menstrual and psychological disorders and even problems during pregnancy. Heavy workloads can interfere with normal functioning of the ovaries [15]. Besides, heavy workloads are also associated with energy deficiency which can be caused by a lack of nutrient consumption by female workers. This is caused by the interrelationship between working time, workload, and workers' habits, who tend to forget to eat because of stress and heavy workload (Cai et al., 2020 [16]).

A workload that exceeds reasonable limits causes various health problems. The results of this study are supported by the results of Chai's [5] study, which states that lifting weights of >11 kg continuously every day in pregnant female workers has the potential to cause miscarriage and preeclampsia [17,18]. Pregnant female workers who work while standing for >3 h in one day have the potential to experience preterm delivery. Even if a female worker works by lifting weights of >100 kg in a day and standing for more than 4 h, she will be at an increased risk of preterm delivery by up to 31 % [19,20].

4.2. Occupational hazards for female workers in industrial environments – exposure to heat and strong odors

4.2.1. Heat exposure

Heat exposure in pregnant women can lead to dehydration and fetal stress. Heat exposure in pregnant women can also cause premature birth and

miscarriage. A temperature between 33 and 43°C is a risk that causes preterm birth [21]. Furthermore, heat exposure that occurs in the third trimester is also a risk that causes premature births. Various studies have provided significant evidence that temperatures in the workplace that exceed normal limits can cause various problems during pregnancy. Thus, companies are advised to rotate their employees' positions and provide special protection to female workers, particularly those who are pregnant [22].

4.2.2. Strong odors

Strong odors in the workplace can cause nausea, vomiting, and dizziness among female workers [3,23]. During pregnancy, female workers become more sensitive to smell (olfactory); therefore, a slight change in the workplace environment caused by chemicals or other conditions in the workplace environment may cause nausea and vomiting in pregnant women [24,25].

4.2.3. Shift work

Shift work is the second most common risk factor with the potential to cause pregnancy problems among female workers in the industrial sector. Shift work that has the potential to cause pregnancy disorders are irregular shift and night shift work [26]. Irregular shift work will have the potential to cause pregnancy disorders. Shift work can cause psychological, health, and safety problems in female workers at the workplace. It can change circadian rhythms and cause shiftwork disorders. Shift work for female workers can also affect the hormonal system, abortion, low birth weight, menstrual disorders, and the ability of mothers to exclusively breastfeed their babies. Furthermore, shift work in female workers can also cause leading to stress and an increase in free radicals in the ovaries, which has the potential to cause polycystic ovaries, luteal phase defects, endometriosis, and impaired embryonic development [27].

Female workers who only work in the morning shift and never work in the night shift are proven to have no pregnancy problems [23]. Female workers who work in the morning shift or in the administration section at the company have also been proven to have no menstrual cycle disorders and no experience with moderate or severe pregnancy disorders. Meanwhile, female workers working night shifts and shift work exceeding 8 h in one day have been shown to experience pregnancy disorders, menstrual disorders, preeclampsia, preterm delivery, and even babies born with low birth weight.

The health services provided by industries in Indonesia related to female workers include: Health insurance, maternity protection, Nutrition education, Factory health service and canteen, Maternal and newborn health, Covid- 19 protection. Health insurance is provided by certain sectors to female workers, guaranteeing their ability to obtain safe, high-quality, and reasonably priced healthcare services. Maternity protection: Industries are urged to offer maternity protection and assistance to female employees, encompassing provisions for pregnancy and childbirth, together with measures safeguarding against employment termination resulting from pregnancy [28]. Health and well-being training programs. Workplace-based nutrition education has the potential to enhance the understanding of female workers regarding the significance of preventing and managing anemia, with a specific emphasis on consuming foods that are rich in iron. Enhancing factory canteen facilities to offer healthy meals can help make up for food shortages in families and enhance nutrition in general. Factory health services: Reducing health risks for female workers can be achieved by improving factory health services to shift from a curative strategy to a health promotion and preventative approach [29]. By guaranteeing that female employees have access to sufficient, suitable, and reasonably priced healthcare services, these programs hope to improve their general health and wellbeing.

The availability of rest breaks and accommodations for pregnant workers can play a significant role in reducing the risk of pregnancy complications. Adequate rest and breaks can help mitigate the physical and psychological demands on pregnant women, potentially lowering the risks associated with pregnancy disorders. Employers are encouraged to minimize reproductive hazards in the workplace and protect pregnant women by providing necessary accommodations and ensuring a safe working environment. Some effects of providing rest periods in industries on pregnancy disorders such as providing rest periods in industries on pregnancy disorders, Prevention of Musculoskeletal Disorders, Improved Blood Circulation, Lowered Stress Levels, Enhanced Maternal Health Monitoring, Promotion of Work-Life Balance, Compliance with Legal Regulations. Providing adequate rest periods for pregnant workers in industries can contribute to improved maternal health, reduced risk of pregnancy complications, and overall better pregnancy outcomes. It also demonstrates a commitment to the well-being of employees and compliance with legal obligations regarding maternity protection in the workplace ([30] [31]).

Limitation of The study: The study was undertaken during the pandemic era, which imposed numerous limitations. In addition, not all industries grant researchers access to their factories. This research pertains specifically to female workers, rather than women in general. The presence of confounding factors may differ in other locations, making replication difficult. The female worker experiences a more adverse impact compared to regular female workers. We should prioritize their well-being, particularly in the workplace.

5. Conclusion

Occupational hazards that can cause pregnancy disorders include workload, hot working environments, strong odors, shift work, irregular shift work, and night shift work. Companies are expected to pay special attention to female workers regarding various workplace controls to prevent potential pregnancy-related disorders.

Declarations

Ethics statement

Any patients whose data or images are included in our publication had given their approval and concern to publish in Heliyon. The

Ethics Approval also given by Faculty of Dentistry, Universitas Airlangga.

Data availability

The data available on request to corresponding author.

CRediT authorship contribution statement

Tri Martiana: Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Firman Suryadi Rahman:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Santi Martini:** Writing – original draft, Supervision. **Indriati Paskarini:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Data curation, Conceptualization. **Soenarnatalina Melani:** Writing – review & editing, Formal analysis. **Ajeng Kusumawardani:** Writing – review & editing, Writing – original draft, Methodology, Data curation. **Juliana Jalaludin:** Writing – review & editing, Conceptualization. **Khadizah H. Abd Mumin:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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