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# Prevalence and Associated Risk Factors of Dehydration Among Construction Workers

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## ABSTRACT

Dehydration poses a significant health risk to construction workers due to heavy physical work and exposure to hot working conditions. This study aimed to determine the prevalence of dehydration and identify associated risk factors among construction workers. A cross-section study was conducted involving 32 construction workers in a construction project for the construction of a wheat flour and soybean mill owned by PT. Agri First which operates at KIM 2 Medan. Data were collected using questionnaires, fingertip pulse oximeters, urine refractometers, and observation sheets. Dehydration is categorized based on the level of urine specific gravity (ultrasound). The data was statistically tested using the Fisher Exact test (α=0.05). The majority of workers (75%) were dehydrated. There was no significant relationship between dehydration and age. However, workers with more than 3 years of experience were more likely to be dehydrated compared to workers with less than 3 years of experience (OR = 8,333, 95% CI: 1,392-49,872). Workers with moderate workloads were also more likely to be dehydrated compared to workers with light workloads (OR = 18,333). There was a significant association between water intake and dehydration (p = 0.000). All workers who did not drink enough water were dehydrated, while only 66.7% of those who drank enough water were dehydrated. Workers with more than 3 years of experience, moderate workload, and inadequate water intake have a higher risk of becoming dehydrated. Interventions to improve hydration among construction workers are urgently needed.

**Keywords:** dehydration, construction workers, water intake, workload

## INTRODUCTION

Most construction workers face hot working environments, exacerbated by global warming in recent years (Alshebani & Wedawatta, 2014). Globally, productivity has decreased by nearly 10% and could surge to 40% if climate change worsens (De Sario et al., 2023). Hot weather and high temperatures in the workplace can negatively impact workers' health, reducing physical and mental functions(Clayton, 2020). Literature reports that excessive heat exposure significantly reduces productivity and endangers worker safety, causing extreme fatigue, decreased concentration, cramps, muscle tension, and heat stroke (International Labour Organization, 2019; Lucas et al., 2014).

Due to physical activity and hot environmental conditions, construction workers have significant fluid intake needs (Bahadır et al., 2017). A study found that most construction workers begin and end each work shift in a state of dehydration. Heat stress exposure in workers, measured using individual workload assessments, often exceeds standards, particularly for outdoor jobs (Al-Bouwarthan et al., 2020a). The literature emphasizes the importance of replenishing water lost through various physiological processes. The WHO recommends adequate water intake of 2.9 liters for men and 2.2 liters for women (WHO, 2005). Piil et al. (2018) found that dehydration, especially under high heat stress conditions, can significantly impair cognitive and motor performance. Maintaining body water balance is crucial to support vital activities, especially for construction workers who need large amounts of fluids due to intense physical activity and environmental conditions (Bahadır et al., 2017).

Various factors are linked to dehydration in workers. A study found that sun exposure and high heat workload are significant predictors of dehydration, with 38% of workers at risk of heat-related illnesses (Montazer et al., 2013). Another study identified demographic characteristics that make workers more vulnerable to extreme weather conditions, including dehydration (Karthick et al., 2023). Workers over 40 are more at risk of dehydration (Miller, 2015). Job tenure and workload are also associated with the incidence of dehydration among workers (Puspita & Widajati, 2020; Soeripto, 2009). Inadequate fluid intake can lead to dehydration, particularly concerning workers performing physical labor or working in hot environments (Orysiak et al., 2022).

PT. Nusa Raya Cipta, Tbk, is a construction company established in 1975, specializing in building construction, civil works, and infrastructure. One of its ongoing projects is the construction of a wheat and soy flour mill for Agri First Indonesia, operating in KIM 2 Medan. The hot temperature and weather conditions at the KIM 2 Medan worksite place workers at risk of dehydration. This study aims to analyze the prevalence and risk factors of dehydration among construction workers at PT. Nusa Raya Cipta. Research on dehydration risk factors in construction workers can provide crucial information for stakeholders in developing policies and interventions to help construction workers prevent dehydration, such as providing easy access to drinking water and increasing education about dehydration.

## METHODS

This study uses a quantitative method with a cross-sectional design to examine the relationship between several factors and the incidence of dehydration. The factors studied as independent variables were age, working age, workload, and drinking water consumption, while the dependent variables were dehydration. The research was carried out in the construction project of a wheat flour and soybean factory owned by PT. Agri First, which operates at KIM 2 Medan. This research was conducted in February – March 2024.

This research involved 32 employees of PT. Nusa Raya Cipta Tbk. was assigned to the construction project of a wheat flour and soybean flour factory owned by PT. Agri First Indonesia. This is because the population is relatively small, so total sampling is used. In collecting data, researchers used observation sheets and urine sampling. Respondents were interviewed to obtain information about their age and length of service. Workers' ages were categorized into two groups: >44 years old and ≤44 years old. Length of service was categorized as long if it was >3 years and as new if it was ≤3 years.

Workload information was obtained by measuring pulse rates using a fingertip pulse oximeter. Measurements were taken at two times: 1) Before work started (07:30) to obtain the resting pulse rate, and 2) During work hours (08:00 - 12:00) with three measurements taken to obtain the working pulse rate. Workload was then calculated using the CVL (Cardiovascular Load) method. CVL is a calculation used to determine workload classification based on the increased working pulse rate compared to the maximum pulse rate (Purba & Rambe, 2014). Measurement results were categorized as: 1) Light (%CVL < 30%), no fatigue; 2) Moderate (%CVL 30%-60%), work improvement needed but not urgent; 3) Fairly heavy (%CVL 60%-

80%), short-term work allowed; 4) Heavy (%CVL 80%-100%), immediate improvement needed; and 5) Very heavy (%CVL > 100%), no activity allowed (Tarwaka, 2015).

To measure drinking water consumption, researchers used observation sheets to collect data on workers' water intake. The guidelines used in this study refer to regulations from The National Institute for Occupational Safety and Health (NIOSH), stating that workers in hot environments should drink 150-200 ml of water every 15-20 minutes (NIOSH, 2011). During observation, 240 ml cups of drinking water were provided to the workers, who were allowed to take water freely during work hours. The recommended water intake was 1800-2400 ml during work hours, from 08:00 to 12:00. Water consumption was categorized as insufficient if respondents drank less than 150-200 ml every 15-20 minutes (or less than 1800-2400 ml during work hours). Workers who consumed 150-200 ml every 15-20 minutes (or 1800-2400 ml during work hours) were considered sufficient.

To determine workers' dehydration levels, an indicator of fatigue, urine samples were taken after 4 hours of work, and their specific gravity was measured using a refractometer. Urine samples were examined at the Gatot Subroto Medan Laboratory at Jalan Jend Gatot Subroto No 86/42, Medan City. Workers were categorized as dehydrated if their urine specific gravity (USG) was 1.016 - ≥1.030 and as usual if USG was ≤1.015.

Univariate data analysis was conducted to determine the frequency distribution of each variable. The dependent variable was dehydration, while the independent variables were age, length of service, workload, and water consumption. The results were then presented in frequency distribution tables. Bivariate analysis in this study used the Fisher Exact test to analyze the relationships between age, length of service, workload, and water consumption with the incidence of dehydration in workers (α=0.05). Data were statistically analyzed using SPSS 26.

## RESULTS

This study involved as many as 32 construction workers working on the wheat flour and soybean mills construction project. All workers are willing to be involved in data collection until the research is completed. In Table 1, it can be seen that most workers are over ≤44 years old (62.5%). Most workers have worked for over 3 years (71.9%). The workload of respondents was dominated by the medium category (78.1%).

Table 1. Respondent characteristic

| Characteristic | n | % |
|---|---|---|
| Age | | |
| >44 years | 12 | 37,5 |
| ≤44 years | 20 | 62,5 |
| Working Period | | |
| >3 Years | 23 | 71,9 |
| ≤3 Years | 9 | 28,1 |
| Workload | | |
| Keep | 25 | 78,1 |
| Light | 7 | 21,9 |
| Drinking Water Consumption | | |
| Less | 20 | 62,5 |
| Enough | 12 | 37,5 |

The results of observations on the amount of drinking water consumption showed that the majority of respondents (20 people) consumed drinking water in 15-20 minutes (see Table 2). 6 respondents did not consume drinking water at all. A total of 6 respondents consumed 1 glass of drinking water, 7 respondents consumed 2 glasses, 5 respondents consumed 3 glasses, and 6 respondents consumed 4 glasses of drinking water. The number shown on the drinking water consumption cell indicates the number of cups workers consume, a sign (−) that no drinking water is consumed. From the results of urine examinations, it can be seen that the majority of workers (75%) are dehydrated (1,016 - ≥1,030). Only 8 workers had urine-specific gravity in the normal category. Regarding drinking habits, respondents showed that 20 workers consumed less water.

Table 2. Amount of Drinking Water Consumption and Specific Types of Urine

| Respondent Code | Drinking Water Consumption ( (15-20 minutes) | | | | | | | | | | | | Weight Gravity of Urine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| 1 | − | − | 1 | − | − | − | 1 | − | − | − | − | 1 | 1.030 |
| 2 | 1 | − | − | − | 1 | − | 1 | − | − | − | 1 | 1 | 1.030 |
| 3 | 1 | 1 | − | − | − | − | 2 | − | − | − | 1 | 1 | 1.030 |
| 4 | − | − | 1 | − | − | 1 | − | 1 | 1 | 1 | 1 | − | 1.020 |
| 5 | − | 1 | 1 | 1 | − | 2 | − | 1 | 1 | 1 | 1 | 1 | 1.010 |
| 6 | − | − | 1 | − | − | − | 1 | − | − | − | − | − | 1.030 |
| 7 | 1 | − | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | − | 1.020 |
| 8 | − | − | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | − | 1.025 |
| 9 | − | 1 | 1 | 1 | 1 | 1 | 1 | − | − | − | 1 | − | 1.025 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | − | 1 | 1 | − | − | 1.015 |
| 11 | 1 | 1 | 1 | − | − | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.020 |
| 12 | − | − | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | − | 1 | 1.005 |
| 13 | − | 1 | 1 | 1 | 1 | 1 | − | 1 | 1 | 1 | 1 | 1 | 1.005 |
| 14 | 1 | 1 | − | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | − | 1.005 |
| 15 | − | − | − | − | − | 1 | − | − | − | − | − | 1 | 1.025 |
| 16 | 1 | − | 3 | − | 1 | 1 | − | 2 | − | 1 | 1 | 1 | 1.005 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | − | 1 | − | 1.005 |
| 18 | − | 1 | − | − | − | 1 | 1 | 1 | − | − | − | 1 | 1.030 |
| 19 | 1 | − | − | − | 1 | 1 | − | − | 1 | 1 | − | 1 | 1.030 |
| 20 | − | − | 1 | − | − | − | − | − | 1 | 1 | − | − | 1.030 |
| 21 | 1 | − | − | 1 | − | 1 | − | − | − | 1 | 1 | 1 | 1.025 |
| 22 | 1 | 1 | − | − | − | 1 | − | − | − | − | − | 1 | 1.025 |
| 23 | 1 | − | 1 | − | − | 1 | 1 | 1 | 1 | 1 | 1 | − | 1.015 |
| 24 | − | − | 1 | − | − | − | − | 1 | − | − | − | − | 1.030 |
| 25 | − | − | 1 | − | − | 1 | 1 | − | 1 | − | 1 | − | 1.025 |
| 26 | 1 | − | − | − | 1 | − | 1 | 1 | − | 1 | − | 1 | 1.025 |
| 27 | − | − | − | − | − | 1 | − | − | 1 | − | − | − | 1.030 |
| 28 | 1 | − | 1 | − | 1 | 1 | 1 | 1 | 1 | − | − | 1 | 1.025 |
| 29 | 1 | − | − | − | 1 | 1 | − | − | − | 1 | 1 | − | 1.025 |
| 30 | 1 | − | − | − | − | − | 1 | − | − | − | − | − | 1.030 |
| 31 | − | 1 | − | 1 | − | − | 1 | − | − | − | 1 | − | 1.025 |
| 32 | − | − | − | 1 | 1 | 1 | − | − | − | − | − | − | 1.025 |

The statistical test results (see Table 3) showed no statistically significant relationship between age and dehydration in construction workers (p = 0.676). However, workers over the age of 44 are at risk of becoming dehydrated 2,143 times compared to workers aged 44 or younger. Meanwhile, construction workers with a working period of more than 3 years have a risk of dehydration as many as 8,333 times compared to workers who have worked for 3 years or less. This is shown by a p-value of 0.023, which is smaller than 0.05, and an OR value (95% CI) of 8.333 (1.392-49.872), which shows a significant relationship between working life and dehydration.

Table 3. Relationship between Age, Working Period, Workload, and Working Period with the Dehydrated Status of Construction Workers

| Predictor | Dehydration Status | | | | p | OR (95%CI) |
|---|---|---|---|---|---|---|
| | Dehydrated | | Normal | | | |
| | n | % | n | % | | |
| Age | | | | | | |
| > 44 years | 10 | 83,3 | 2 | 16,7 | 0,676 | 2,143 (0,356-12,890) |
| ≤ 44 years | 14 | 70,0 | 6 | 30,0 | | |
| Working Period | | | | | | |
| >3 years | 20 | 87,0 | 3 | 13,0 | 0,023 | 8,333 (1,392-49,872) |
| ≤3 years | 4 | 44,4 | 5 | 55,6 | | |
| Working Load | | | | | | |
| Moderate | 22 | 88,0 | 3 | 12,0 | 0,005 | 18,333 (2,394-140,391) |
| Light | 2 | 28,6 | 5 | 71,4 | | |
| Drinking Water Consumption | | | | | | |
| Less | 20 | 100,0 | 0 | 0,0 | 0,000 | 3,000 (1,348-6,678) |
| Adequate | 4 | 33,3 | 8 | 66,7 | | |

Statistical test results indicate that workload significantly predicts dehydration among construction workers (p = 0.005). Workers with moderate workloads have an 18.333 times greater risk of experiencing dehydration compared to those with light workloads. A significant relationship was found between water consumption and dehydration among construction workers (p = 0.000). This means that construction workers who drink insufficient water have a 3 times greater risk of experiencing dehydration compared to those who drink adequate water. Of the 20 workers who drank insufficient water, all (100%) experienced dehydration. In contrast, of the 12 workers who drank sufficient water, only 8 (66.7%) experienced dehydration.

## DISCUSSION

Dehydration is a significant occupational health hazard in the construction industry, particularly for outdoor workers in hot climates. Dehydration and heat stress can contribute to work-related illnesses and injuries, with musculoskeletal disorders, eye diseases, and skin diseases being most common among construction workers in Iran (Jazari et al., 2018). This study found that 75% of workers experienced dehydration while working on the wheat and soy flour factory infrastructure project. The prevalence of dehydration among construction workers is a significant issue, with research showing high rates of suboptimal hydration. A study in Japan found that 78% of construction workers exceeded at least one heat strain guideline or showed clinically dehydrated USG levels (Ueno et al., 2018). In Iran, 38% of workers exposed to sunlight had USG levels, indicating a higher risk of heat-related illness, while 12.72% were clinically dehydrated (Montazer et al., 2013). Across various European industries, 80% of workers were either suboptimally hydrated at the start of work or dehydrated during their shifts (van den Hazel et al., 2019).

In this study, only workers' age was not a significant predictor of dehydration. Several studies emphasize that age is not the primary factor in determining dehydration risk among construction workers. They highlight environmental conditions as the main trigger for dehydration (Montazer et al., 2013; Ueno et al., 2018). Although age is a significant predictor of kidney function decline, it is not the main factor in determining dehydration risk in construction workers. Other factors, such as environmental conditions and individual hydration habits, significantly impact dehydration status (Chicas et al., 2019; Crowe et al., 2022).

This study's findings show that length of service is related to dehydration among construction workers. More extended service is associated with dehydration due to the cumulative effect of prolonged heat stress exposure. Workers with extended service periods will likely be exposed to heat stress for longer durations. This prolonged exposure can lead to dehydration as the body adapts to the heat, and workers may not be aware of their fluid loss. Workers with extended service may be more accustomed to hot environmental conditions and may not take necessary precautions to stay hydrated, such as drinking enough water and taking breaks in the shade.

The results indicate that workload is associated with dehydration among construction workers. As workload increases, so does the body's metabolism, leading to fatigue and thirst. Construction work often involves heavy physical activity, which can increase the risk of dehydration. Combining physical activity and hot environmental conditions can exacerbate fluid loss and dehydration (Bates & Schneider, 2008). The labor-intensive nature of construction work, combined with high-temperature exposure, especially outdoors, increases the risk of heat stress and dehydration (Amit et al., 2020). Workers often exceed the recommended wet-bulb globe temperature exposure limits, increasing heart rates and cardiovascular strain (Al-Bouwarthan et al., 2020a). Psychosocial work environment factors also contribute to dehydration risk (Ekpenyong, 2019). Although pacing in work can help reduce heat stress, the physically demanding nature of construction tasks still poses a significant dehydration risk (Al-Bouwarthan et al., 2020a).

In this study, water consumption is a significant predictor of dehydration. Despite the researchers providing water stations at the work site, workers underutilized them, preferring to consume beverages sold in the canteen, such as tea, coffee, and other sachet drinks. There is often a lack of awareness among workers about the importance of staying hydrated. Many may not recognize the symptoms of dehydration or may underestimate their fluid needs, especially during strenuous activities. A study concluded that inadequate fluid intake during work could pose health risks such as kidney disease (Al-Bouwarthan et al., 2020b). Construction workers engage in heavy physical activity, leading to significant fluid loss through sweating. This fluid loss cannot be adequately replaced if workers do not drink enough fluids to compensate for their physical activity (Al-Bouwarthan et al., 2020a). Research has shown that dehydrated workers often have significantly lower fluid intake at the end of their shift than those who maintain proper hydration levels. Additionally, limited rest opportunities can prevent workers from drinking enough fluids. If workers are not encouraged or allowed to take breaks to hydrate, they may not consume enough water throughout the day (Orysiak et al., 2023). Effective hydration education and establishing hydration protocols at the workplace are crucial to reducing the risk of dehydration..

## CONCLUSION

The study's findings concluded that construction workers' workload, working period, and drinking water consumption are predictors of dehydration. Most construction workers in this study were dehydrated (75%).75% were dehydrated while working on infrastructure development projects. Construction work involves strenuous physical activity that increases fluid loss and dehydration. Effective hydration education and establishing hydration protocols in the workplace are essential to reduce the risk of dehydration. In addition, the provision of easily accessible drinking water is expected to encourage workers to drink regularly.

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