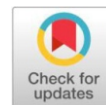


## Review Article

## Open Access

# Ergonomic evaluation of occupational health hazards of farmers involved in sugarcane cultivation



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## ABSTRACT

Sugarcane is a critical cash crop cultivated worldwide, with Brazil being the largest producer, followed by India, China, and Thailand. However, workers in developing countries like India face numerous work-related health issues, including ergonomic problems, occupational hazards, and injuries. Sugarcane farming is labor-intensive, with harvesting identified as the most hazardous activity. The repetitive movements and use of poorly designed tools during harvesting often lead to frequent cuts, injuries, and musculoskeletal disorders. Farmers are also exposed to high levels of toxic pesticides, resulting in respiratory issues such as coughing and chest pain. This study systematically reviewed the ergonomic and occupational health hazards faced by sugarcane farmers, analyzing 33 articles selected from an initial review of 88. Fifty-six articles were excluded for various reasons. The findings emphasize the importance of ergonomic interventions in reducing the physical demands of manual tasks and mitigating musculoskeletal problems. Low-cost ergonomic solutions and awareness training programs were identified as effective measures to improve farmers' working conditions and health outcomes. The study concludes that ergonomic evaluations and targeted interventions are essential to preventing injuries and musculoskeletal issues among sugarcane farmers. Future research should focus on implementing and assessing these interventions to evaluate their long-term impact on farmers' health and productivity. Despite the identification of several ergonomic hazards related to sugarcane farming, the number of studies remains limited. This review provides valuable insights to guide the development of regulations, tools, and strategies aimed at mitigating these risks and improving the overall well-being of sugarcane farmers.

**Keywords:** Chronic kidney disease, Ergonomic Risks, Musculoskeletal disorders, Occupational health hazards, Sugarcane cultivation

## INTRODUCTION

Sugarcane is a vital cash crop cultivated worldwide, covering an area of more than one million hectares. Brazil is the largest producer of sugarcane, followed by India, China, and Thailand. In India, approximately 2.8 lakh farmers cultivate sugarcane across a vast expanse of 4.4 lakh acres, with over 11 crore individuals directly or indirectly reliant on the sugar industry [40]. Notably, about 7.5% of the rural population—encompassing 60 million sugarcane farmers and a substantial number of agricultural laborers—engages in sugarcane cultivation, including harvesting and ancillary activities [49]. Sugarcane farming represents one of the most significant agriculture-based industries, contributing to job creation, revenue generation, and societal development in economically disadvantaged regions of the country [65]. Among the various stages of sugarcane cultivation, harvesting is a critical activity requiring considerable labor and effort [13].

Occupational health and safety have been a major concern worldwide in the agriculture sector. Various undesirable hazards are associated with farming, such as pathogen infection, injuries from exposure, physiological disorders, pesticide

poisoning, respiratory infections, musculoskeletal disorders and injuries from tools and plants. Regarding injuries and work-related illness, The International Labour Organisation (ILO) has ranked agriculture among the top three most hazardous occupational groups [38]. Worldwide, every day around 170,000 sugarcane workers are killed annually around the world due to exposure to hazards [31]. Farmers are at very high risk for fatal and non-fatal injuries; and farming is one of the few industries in which family members (who often share the work and live on the premises) are also at risk for fatal and non-fatal injuries [45].

Occupational hazards have deleterious effects on individual health and safety, as well as organizational effectiveness [8]. Farmers have many health problems during sugarcane cutting because of the lack of proper knowledge about equipment and proper safety uses. Workers in developing countries like India face many work-related health problems. Sugarcane workers have a high level of occupational accidents and they are exposed to high toxicity of pesticides and most of the workers suffer from cough and chest pain [8] in the sugar cane field. Most of them are poor farmers who cannot afford that equipment; therefore, they use local knives and sickles for sugarcane cutting. These local equipment are hazardous contributing to numerous cuts and minor injuries. Again, there are different other conditions on the fields that result in various ergonomic problems [67]. Apart from minor injuries, ergonomic problems like – Musculoskeletal disorders (MSDs), body pain (neck, shoulder, elbow, wrist, mid-back and low back, knee and calf muscles) [26] and other major

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diseases like- CKD (Chronic kidney disease) are common among the sugar cane Farmers [16].

Sugar cane cutters live with modern work methods but in slavery-like conditions, which can affect their health [57]. However, most sugarcane farmers have inadequate policies and infrastructure to meet these health hazards. Hence, workers are exposed to workplace accidents, repetitive strain injury (RSI), and work-related musculoskeletal disorders (MSDs) in the neck, upper back, lower back, and arms due to continuous movements [62]. The different workplace exposures of sugarcane farmers that lead to their occupational health problems are- unsafe working conditions, exposure duration, not using personal protective equipment (PPE), improper job rotation, not providing health & safety training, dissatisfaction with the job, prolonged working hours in a week, safety inspection & employment pattern in an irregular manner [39].

Ergonomics is a multidisciplinary science that activities to make a better fit between the work and the worker to ensure their healthiness and well-being. It is concerned with ensuring a good fit between people and the objects with which they interact [62]. It emphasizes designing and arranging things so that workers can use them easily and safely. Effective ergonomic interventions can reduce the physical demand of manual materials-handling work, thus reducing the chances of musculoskeletal disorders. Such interventions play an important role in improving the company's production without causing injury to workers. Low-cost ergonomic interventions can effectively improve such adverse conditions. Agricultural work is one of the highly physically demanding occupations. Musculoskeletal disorders are common among farmers because farmers handle heavy workloads, often in awkward postures and experiencing some work-related problems [25]. Effective ergonomic interventions can reduce the physical demand of manual materials-handling work, thus reducing the chances of musculoskeletal disorders [62]. Such interventions play an important role in improving production without causing injury to workers.

In the last 10 years, there have been studies that evaluated the working conditions and health effects of sugar cane cutters. During manual cutting, workers are exposed to a number of health hazards [53], such as physical hazards – weather conditions (high temperatures, solar radiation, rain), chemical hazards – gases and particulate matter from burning cane, and pesticide residues; biological hazards – venomous animals;

risks of accidents: traumas and fire; ergonomic risks – repetitive postures and movements, physical overload, and mental risks imposed by the work rhythm, constant attention, concentration, and lack of regular pauses. Despite several studies, there is a lack of systematization of the findings and evidence, as well as of the suggested measures to preserve the health of the workers.

The current review has compiled the ergonomic risks and occupational health hazards associated with sugarcane farming which will help the future researchers for developing policies, tools and techniques that can reduce or eliminate these risks in sugarcane farmers.

**MATERIALS AND METHODS**

Bibliographic search in databases: Google Scholar, Science Direct, PubMed and SciELO databases. The inclusion criteria were: articles published in Urdu, Portuguese and English, between January 2014 and October 2024, a period during which a significant number of accessible full-text studies were available. Articles were initially selected based on an analysis of their titles, followed by a review of their abstracts. Those who did not deal with the work impact of cutting burned and unburned sugarcane in the cutter's health were excluded. The keywords utilized for the database search included: sugarcane workers, sugarcane cutters, sugarcane harvesting, occupational health hazard of sugarcane farmers and work-related ergonomic risks of sugarcane farmers.

Out of the 88 articles evaluated, 23 were discarded after the title analysis, 20 after reading the abstract or the full text, and 13 articles because they were not accessible in their entirety, leaving 33 articles included (Figure.1).

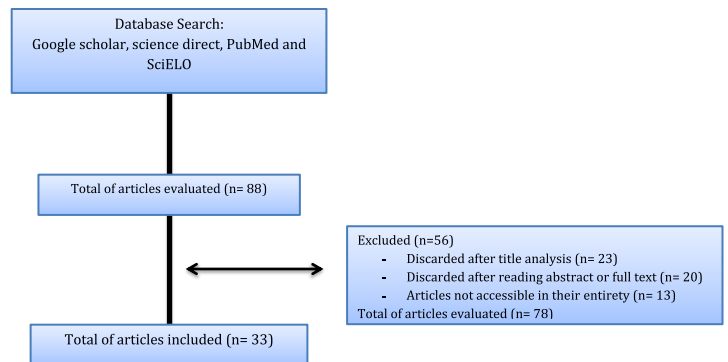


Figure.1 Flow chart of the selection of articles for review

**RESULTS AND DISCUSSION**

*Empirical Reporting of Work-related Ergonomic Risks:*

Author Name (Year)	Study Name	Work related Ergonomic Risks
Nilvarangkul K. et al. 2018 (Cross sectional study)	Development and validation of a work-related low back pain risk assessment tool for sugarcane farmers.	<ul style="list-style-type: none"> <li>Physical labor is the major cause of LBP (Lower back pain) among Thai sugarcane farmers.</li> <li>Work-related low back pain risk assessment tool for sugarcane farmers had high sensitivity (88.35%) due to high prevalence of LBP.</li> <li>Work-related LBP risk assessment tool had appropriate sensitivity, specificity, positive predictive value, negative predict value and accuracy were 82.02%, 30.49%, 62.65%, and 54.40% respectively.</li> </ul>
Biswas G. et al. 2016	A review on the occupational health of sugar cane workers.	<ul style="list-style-type: none"> <li>Sugarcane workers are exposed to workplace accidents and musculoskeletal disorders.</li> <li>High rates of lower back and knee joint pain observed among sugarcane workers in Ahmednagar.</li> <li>The prevalence of work-related musculoskeletal disorders (WMSDs) among sugarcane farmers in the study was high (88.70%).</li> <li>Repetitive motions, awkward postures, forceful exertions were all significantly linked to reporting WMSDs during the previous 12 months.</li> </ul>
Phajan T. et al. 2014 (A cross-sectional analytical Study)	Work-Related Musculoskeletal Disorders Among Sugarcane Farmers in North-Eastern Thailand.	

Thapa B. and Sharma A. 2019 (Descriptive cross sectional Study)	Prevalence of Occupational Health Consequences During Sugarcane Harvesting Among Harvesters of Morang District.	<ul style="list-style-type: none"> <li>Shoulder joint, wrist joint, neck joint and low back pains were the mostly encountered musculoskeletal pain.</li> <li>The prevalence of wrist and hand joint pain is 84.4%. It was as a result of the sugarcane being cut with heavy, local tools.</li> </ul>
Gangwar S. and Kwatra S. 2017	Prevalence of Musculoskeletal Problems among Sugarcane Workers in Uttar Pradesh.	<ul style="list-style-type: none"> <li>Sugarcane workers who sowing and harvesting sugarcane have a high prevalence of physiological discomforts due to long work hours, awkward body postures, repetitive work, and physical load. These activities are linked to musculoskeletal disorders (MSDs).</li> <li>Sugarcane workers suffered from pain and discomforts more in neck, upper arm, and low back.</li> </ul>
Vasave S. Y. and Anap D. B. 2016 (Cross sectional study)	Prevalence of musculoskeletal disorders among sugarcane workers – a cross sectional study	<ul style="list-style-type: none"> <li>Prevalence of Musculoskeletal disorders (MSDs) is high in sugarcane workers. The highest prevalence of MSDs for the last twelve months is on the low back (50%) &amp; knee (29%).</li> </ul>
N. Monjezi 2021 (Descriptive-analytical approach)	Ergonomic Evaluation Posture of Sugarcane Workers using REBA Method.	<ul style="list-style-type: none"> <li>Musculoskeletal disorders in workplaces occur due to awkward posture and non-ergonomic design of the workstations for lifting and carrying of materials.</li> </ul>
Prommawai N. et al. 2019 (Cross-sectional analytical study)	Musculoskeletal Disorders and Quality of Life of Sugarcane Farmers in the Northeast of Thailand: A Cross-sectional Analytical Study	<ul style="list-style-type: none"> <li>Up to 75% of sugarcane farmers in northeastern Thailand suffered from MSDs, with shoulders and lower backs accounting for the majority of these cases.</li> <li>More than one-third of these farmers had poor QOL (Quality of Life).</li> </ul>

Evidence reported on Work related Ergonomic Risks was represented in Table 1.

Agriculture is considered to be one of the most hazardous occupations and has a high prevalence of physical disorders, suggesting a significant role for ergonomic risk factors [1]. Manual sugar cane cutting involves rapid forceful movements with the sickle, which puts a lot of physical strain on the cutter. A study [49] reported that the work-related stresses in any work situation to which the human body is subjected to experience over a long-time cause loss of efficiency, musculoskeletal injuries, or disability over a period of time. Work related musculoskeletal problems are group of painful disorders of muscles, tendons and nerves that result from injuries due to risk factors prevalent in the workplace.

A total of 8 articles included in this review (Table 1) address work-related ergonomic risk factors among sugarcane farmers. The findings indicate a high prevalence of ergonomic risks due to awkward body postures, repetitive work patterns, and the use of locally made hand tools, all of which contribute to musculoskeletal disorders (MSDs).

Prolonged and repetitive cane-cutting activities during the harvest season significantly increase the risk of MSDs, with shoulder pain being particularly common due to the use of handmade sickles. According to [44] findings work-related low back pain risk assessment tool for sugarcane farmers appropriate sensitivity, specificity, positive predictive value, negative predict value and accuracy were 82.02%, 30.49%, 62.65%, and 54.40% respectively. Physical labor is a major cause of lower back pain, affecting 88.35% of sugarcane farmers, particularly in Thailand. It takes several months to grow sugar cane and it is necessary to hire large numbers of workers, primarily for manual harvesting. The worker work for twelve or more hours a day and get poor returns. Sugar cane cutting is the most laborious farm work where the farmers have to bend for hours. The sugarcane bundle is manually lifted and transferred to the vehicle after harvesting. Because this is a continuous process, a lot of workers experience physical pain from their awkward lifting posture, which causes MSDs [41].

#### Empirical Reporting of Occupational Health Hazards:

Author Name (Year)	Study Name	Occupational Health Hazards
Kiatkitroj K. et al. 2022 (Cross-sectional study)	Risk factors associated with heat-related illness among sugarcane farmers in Thailand.	<ul style="list-style-type: none"> <li>The prevalence of heat-related illness symptoms was 48%, symptoms included heavy sweating, weakness/fatigue, dizziness, muscle cramps, headache, and vertigo.</li> <li>Sugarcane farmers wearing two-layer shirts had a higher risk of heat-related illness.</li> </ul>
Biswas G. et al. 2016	A review on the occupational health of sugar cane workers.	<ul style="list-style-type: none"> <li>Sugarcane workers in Nicaragua experience kidney diseases due to occupational heat stress.</li> <li>Sugarcane cutters in El Salvador suffer from chronic kidney disease (CKD).</li> </ul>
Raza H.A et al. 2019	Residual impact of pesticides on environment and health of sugarcane farmers in Punjab with special reference to integrated pest management.	<ul style="list-style-type: none"> <li>Sugarcane workers who use pesticides cause number of health issues, including skin burning, skin infections, nausea, chest pain, diarrhea, respiratory issues, hypertension, convulsions, bleeding, cramping, nausea, asthma, fever, dizziness, and vomiting.</li> </ul>
Dally M. et al. 2020	The impact of heat and impaired kidney function on productivity of Guatemalan sugarcane workers.	<ul style="list-style-type: none"> <li>A 4% increase in risk for every degree that the daily average wet bulb globe temperature (WBGT) rises above 30°C and 3% increase in recorded injury risk for every degree that the WBGT rises above 30°C.</li> <li>Agricultural workers at increased risk of occupational injury in humid and hot environments.</li> </ul>
Santos U.P. et al. 2015	Burnt sugarcane harvesting is associated with acute renal dysfunction	<ul style="list-style-type: none"> <li>Burnt sugarcane harvesting caused acute renal dysfunction in previously healthy workers, associated with dehydration, systemic inflammation, oxidative stress, and Rhabdomyolysis.</li> </ul>

More K.D <i>et al.</i> 2021 (Observational Study)	Prevalence of Ophthalmological and Dermatological Problems Related to Pesticide Exposure among Sugarcane Farm Workers in Western Maharashtra.	<ul style="list-style-type: none"> <li>Pesticide-exposed sugarcane farmers reported a high rate of ophthalmological problems (21.6%) including burning sensations, itching, and irritation of the eyes and dermatological problems (37.2%) including dry skin and itching.</li> </ul>
Leite M.R <i>et al.</i> 2018	Sugarcane cutting work, risks, and health effects: a literature review	<ul style="list-style-type: none"> <li>Work in the manual cutting of sugarcane, especially when the cane is burned, exposes workers to several risks responsible for health problems – respiratory, renal, cardiovascular, osteomuscular, ocular, and dermatological.</li> </ul>
Hansson E. <i>et al.</i> 2020	Pathophysiological Mechanisms by which Heat Stress Potentially Induces Kidney Inflammation and Chronic Kidney Disease in Sugarcane Workers.	<ul style="list-style-type: none"> <li>Inflammation, hyperuricemia, and rehydration with sugary liquids and NSAID (non-steroidal anti-inflammatory drugs) intake are associated with an increased risk of kidney injury.</li> <li>Reduced kidney function in populations at risk of CKDnt (Chronic Kidney Disease of non-traditional origin) often coincides with signs and/or symptoms of inflammation such as fever, elevated CRP (C-reactive protein), leukocytosis, or leukocyturia.</li> </ul>
Bodin T. <i>et al.</i> 2016	Intervention to reduce heat stress and improve efficiency among sugarcane workers in El Salvador: Phase 1	<ul style="list-style-type: none"> <li>The impact of heat stress conditions on the sugarcane workforce can be minimized with the implementation of the WRS (Water. Rest. Shade) intervention. Following the intervention, symptoms of dehydration and heat stress generally decreased.</li> </ul>
Bhalerao V. <i>et al.</i> 2023 (Comparative study)	A Comparative Study of Sugarcane Harvesting and Its Impact on Health Conditions of Labor from Thailand and India.	<ul style="list-style-type: none"> <li>There is a significant difference in sugarcane harvesting practices and labor health conditions between Thailand and India.</li> <li>While manual harvesting in India disproportionately affects women and poses safety concerns, mechanized harvesting in Thailand can reduce the physical strain on female labor.</li> <li>Female sugarcane cutters in India face a number of health care issues as a result of the demanding nature of sugarcane cutting, insufficient safety precautions, and restricted access to healthcare.</li> </ul>
Laws R. L <i>et al.</i> 2014 (Longitudinal Studies)	Changes in kidney function among Nicaraguan sugarcane workers.	<ul style="list-style-type: none"> <li>The study found evidence that one or more risk factors for chronic kidney disease (CKD) are occupational, as indicated by the decline in kidney function during the harvest and the differences in kidney function by job category and employment duration.</li> <li>The study suggests that the kidney disease observed is primarily tubuleinterstitial, rather than glomerular, in nature, based on the observed decline in kidney function and the rarity of albuminuria.</li> </ul>
Priuli R. M. A <i>et al.</i> 2014 (Longitudinal study)	The impact of stress on the health of sugar cane cutters.	<ul style="list-style-type: none"> <li>The work process of the sugarcane cutter can cause stress, symptoms of burn out, exhaustion, physical and psychological symptoms after the harvest period.</li> </ul>
Mohanaselvan T. <i>et al.</i> 2024 (Direct interviews with a pre-structured interview schedule)	Mechanization Level and Occupational Health Hazards in Sugarcane Cultivation in India.	<ul style="list-style-type: none"> <li>Lack of penetration of developed technologies in villages due to low awareness levels among farmers, leading to most operations being done manually despite the availability of power sources.</li> <li>Sugarcane leaves are a common cause of injuries, with simple safety interventions like face shields, hand gloves, and footwear being cost-effective preventive measures for injuries sustained in sugarcane cultivation.</li> </ul>
Silveira H.C <i>et al.</i> 2013	Emissions generated by sugarcane burning promote genotoxicity in rural workers: a case study in Barretos, Brazil.	<ul style="list-style-type: none"> <li>Results indicate that sugarcane cutters exhibited increased MN (micronucleus) frequencies compared to a control group, possibly due to exposure to emissions derived from sugarcane burning.</li> </ul>
Crowe J. <i>et al.</i> 2013	Heat Exposure in Sugarcane Harvesters in Costa Rica	<ul style="list-style-type: none"> <li>Sugarcane harvesters are at risk for heat stress for the majority of the work shift.</li> <li>Sugarcane harvesters carried out labor-intensive work with a metabolic load of 261 W/m<sup>2</sup> (6.8 kcal/min), corresponding to a limit value of 26° WBGT which was reached by 7:30 am on most days.</li> <li>After 9:15 am, OSHA recommendations would require that workers only work 25% of each hour to avoid health risks from heat.</li> </ul>
Boonruksa p. <i>et al.</i> 2020	Heat Stress, Physiological Response, and Heat-Related Symptoms among Thai Sugarcane Workers.	<ul style="list-style-type: none"> <li>Dehydration was observed among sugarcane cutters.</li> <li>The common heat-related symptoms (&gt;50%) reported by cutters were weakness/fatigue (91.1%), heavy sweating (83.3%), headache (57.8%), rash (52.2%), and muscle cramp (52.2%). Factory workers commonly reported weakness/fatigue (64.5%) and heavy sweating (52.7%).</li> <li>A comparison between cutters and factory workers, for heat-related symptoms “ever” experienced found cutters had significantly more symptoms of weakness/fatigue, heavy sweating, headache, skin rash, muscle cramps, dry mouth, dizziness, dry/cracking skin, swelling of hands/feet, skin blisters, and fainting.</li> </ul>

Blond J. <i>et al.</i> 2017	Particulate matter produced during commercial sugarcane harvesting and processing: A respiratory health hazard	<ul style="list-style-type: none"> <li>Particulate matter (PM) exposure levels associated with pre-harvest agricultural burning of sugarcane and with sugar processing in the factory pose a potential hazard to human health, particularly chronic exposures in occupational scenarios.</li> <li>Sugarcane processing and the associated activities create Particulate matter (PM) that should be considered both an acute and chronic respiratory hazard.</li> </ul>
Gascon M. <i>et al.</i> 2012 (Longitudinal study)	Respiratory, allergy and eye problems in bagasse-exposed sugar cane workers in Costa Rica.	<ul style="list-style-type: none"> <li>Workers in this study, in particular during the harvesting season, are more likely caused by an irritating action of inhalable dust (bagasse or other compounds) than microbiological agents.</li> </ul>
Dawson J. B. <i>et al.</i> 2018	Risk Factors for Declines in Kidney Function in Sugarcane Workers in Guatemala.	<ul style="list-style-type: none"> <li>Kidney function on average, slightly increased during the 6-month harvest, a notable one-third of the workers worsened.</li> <li>Occupational and behavioral factors play significant roles in declines in kidney function.</li> </ul>
Thapa B. and Sharma A. 2019 (Descriptive cross sectional Study)	Prevalence of Occupational Health Consequences During Sugarcane Harvesting Among Harvesters of Morang District.	<ul style="list-style-type: none"> <li>86 per cent of harvester had nasal congestion, 67.7% had minor cuts whereas approximately 4.2% of them had major cuts.</li> </ul>
Radir A. F. <i>et al.</i> 2017	The Impact of Heat on Health and Productivity Among Sugarcane Workers In Kampong Cham, Cambodia.	<ul style="list-style-type: none"> <li>There was a significant difference in physiological changes during working and resting periods of workers.</li> <li>Core body temperature of males (0.037) and heart rate of females (0.043) during working period were correlated with environmental heat exposure with a weak negative correlation. Most of the workers reported heat exhaustion (87.2%), tiredness, (86.4%), headache (61.8%) and muscle cramps (60.0%).</li> <li>High environmental heat exposure could reduce productivity of Cambodian sugarcane workers, but it had no effects to their physiological changes.</li> </ul>
Durai G. <i>et al.</i> 2019	Occupational Health Hazards Of Sugar Cane Industry Workers – A Review	<ul style="list-style-type: none"> <li>The main causes of injuries- not providing safety enclosures to the rotating machine parts, excessive noise and vibration.</li> <li>Adverse effects on workers' health are caused by poor ventilation and lighting during working hours.</li> <li>Lack of safety measures, improper training and education program causes injuries to workers. The workers have poor knowledge about hazards regarding occupational health and insufficient self-reported practices.</li> </ul>
Cabrera L. <i>et al.</i> 2022	Lung Cancer in the French West Indies: Role of Sugarcane Work and Other Occupational Exposures.	<ul style="list-style-type: none"> <li>Occupational risk factors contributed to the occurrence of lung cancer in the French West Indies and confirmed the role of specific exposures related to sugarcane work in lung cancer risk.</li> </ul>
Ruths J.C <i>et al.</i> 2021 (Qualitative study)	Rural work in the sugarcane sector and its influences on health: scoping review.	<ul style="list-style-type: none"> <li>Sugarcane work environments can impact workers' health and disease processes. The primary health issues observed were respiratory, circulatory, renal, and musculoskeletal problems, genotoxic agents, and work-related accidents.</li> </ul>
Glaser J. <i>et al.</i> 2020	Preventing kidney injury among sugarcane workers: promising evidence from enhanced workplace interventions.	<ul style="list-style-type: none"> <li>Prevent kidney injury among sugarcane workers, and other heat-stressed workers, by improving access to water, rest and shade.</li> </ul>

Evidence reported on Occupational Health Hazards was represented in Table 2.

### Occupational Health Hazards in Sugarcane Cultivation:

Occupational health deals with all aspects of health and safety in the workplace and has a strong focus on the primary prevention of hazards [71]. According to The International Labour Organization and World Health Organization [31] the occupational health of workers refers to free of physical, physiological, and mental illness during work. It is defined as the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations-“total health of all at work”. India is the fourth major sugar-producing country in the world, the first three being Russia, Brazil and Cuba. About 4.5 crore farmers are engaged in sugarcane cultivation in India [8]. Workers in developing countries like India and other countries face as many occupational health problems. Sugar cane workers have a high level of occupational accidents and they are exposed to high toxicity of pesticides. They may also have an increased risk of lung cancer, possibly bagassosis. This may be related to the practice of burning foliage at the time of cane cutting.

A number of individual farmers work on small-scale sugarcane farms for income. The majority of these small-scale farms sell sugarcane directly to consumers in the local market for chewing and juice. Because of this, the majority of farmers harvest sugarcane by hand without wearing personal protective equipment. A Sugarcane harvester is a person who is engaged in cutting, tie up & loading of sugar cane in vehicle [67]. The majority of farmers frequently sustain minor cuts, bruises, and wounds during harvesting; occasionally, they sustain severe cuts or lose fingers. Sugar cane harvesting demands a lot of physical labor. Farmers have many health problems during sugarcane cutting because of the lack of proper knowledge about equipment's and proper safety use. According to [67] (Table 2), studies revealed that 67.7% of sugarcane harvesters experienced minor cuts, while only 4.2% reported major cuts.

### Respiratory Problem of Sugarcane farmers

Allergic disorders in the agriculture sector are very common among farm workers, causing many occupational diseases every

year [5]. The inhalation of particulate matter released during the cutting of burned cane can affect the upper and lower airways, causing symptoms and respiratory diseases, as well as lung function impairment in the workers [52]. So far few studies have examined in particular during the harvesting and pre-harvest season, are more likely caused by an irritating action of inhalable dust cause of respiratory Problems sometimes it become chronic in farmers [27][37][38] due to their harsh working environment condition.

During the harvesting season, dust levels were relatively high in some departments, while endotoxin and mold levels were around background levels. Workers' ventilatory lung function differed between departments before, but not during the harvesting season or between seasons. During the harvesting season, the prevalence of wheeze and eye problems almost doubled in workers exposed to bagasse and other types of dust, whereas shortness of breath and rhinitis increased only in bagasse-exposed workers. Reporting wheezing and shortness of breath was positively associated with the number of years working at the refinery, suggesting a long-term health effect.

### Heat stress, Dehydration and kidney function

One of the leading preventable causes of morbidity in the world is heat illness. Employees who are exposed to extreme heat may lose the ability to use compensation systems, endangering their health. Heat stress also directly affects output by impairing task performance and raising the risk of occupational illnesses and injuries [17]. In many indoor and outdoor work settings, heat is a frequent and significant physical health risk to employees. Body heat produced by metabolic processes (related to workload) and heat exposure from the work environment (from weather and man-made heat) can combine to cause heat gain [72]. Between roughly 6 am and 3 pm, workers are subjected to intense heat and sunlight during the sugarcane harvest season. Each sugarcane worker experienced heat-related issues, such as weakness or exhaustion, excessive perspiration, headache, skin rash, muscle cramps, dry mouth, lightheadedness, dry or cracked skin, hand or foot swelling, blisters, fainting [11] and long term dehydration is associated with CKD (Chronic Kidney Disease) [73] were observed in all sugarcane workers due to their extended workschedules.

Despite the agricultural sector's current economic prosperity, harsh working conditions during burnt sugarcane harvesting still exist, including exposure to air pollutants from the dust and exhausting labor in hot weather because of the economical yield that is correlated with worker productivity [6] [52]. While pre-harvest burning is a common practice in many countries, including Brazil, Guatemala, Mexico, and Costa Rica, the practice of burning sugarcane residues varies throughout the world. In the United States and the Philippines, sugarcane fields are burned either before or after harvest, but in India, most of the sugarcane residues are usually burned in the field only after harvest due to lack of proper composting techniques [23].

The major sugarcane-producing areas of the world have recently adopted the practice of mechanical harvesting [14] [68]. In this system, dry leaves, tips and green leaves are cut off and thrown on the soil surface forming a straw that acts as mulch over soil surface [48][3]. For the past several years South Gujarat, India farmers are burning sugarcane straw at the time of harvesting the crop [65]. Normally, the sugarcane crop is harvested manually and chaff is used for feed of animals as well as biomass. But to save time, money and labor farmers are going to adopt chaff burn practices before harvesting the sugarcane crop.

The sugarcane straw and residue are burnt in the fields for their easy harvesting and cleaning the field. According to [61], studies have linked sugarcane harvesting to an epidemic of chronic kidney disease in Central America, primarily affecting previously healthy young workers. Burnt sugarcane harvesting, in particular, has been found to cause acute renal dysfunction in these workers, attributed to a combination of dehydration, systemic inflammation, oxidative stress, and rhabdomyolysis. The majority of studies listed in Table 2 are highly relevant in highlighting the occupational health issues reported by sugarcane workers.

### CONCLUSION

Sugarcane farmers face various occupational health hazards and ergonomic risks during cultivation, primarily due to the lack of safety measures, knowledge, education, training, and the use of non-ergonomically designed handmade tools. These factors contribute to a range of injuries and health problems. The demanding working conditions result in ergonomic issues such as musculoskeletal disorders and work-related strain caused by repetitive movements, awkward postures, and prolonged working hours. Farmers often work in adverse environmental conditions, which can lead to dehydration, heat strokes, exhaustion, chronic kidney disease (CKD), muscle cramps, and fatigue. This review highlights the urgent need for ergonomic evaluations to mitigate injuries and musculoskeletal issues. Additionally, it emphasizes the importance of implementing strong awareness and education training programs for farmers to minimize health risks and improve their overall well-being.

### FUTURE SCOPE OF THE STUDY

The future scope of these studies holds significant potential for improving both the physical well-being of farmers and the efficiency of agricultural practices. As research, technology, and awareness continue to evolve, several avenues will expand to address ergonomic risks and promote sustainable, healthy farming.

**Conflict of interest:** NA

**Acknowledgment:** NA

### REFERENCE

1. Ahmad N., Haq Z. U., Islam, M. A., Haidree, S. R., & Mehmood, T. (2020). Ergonomic and safety prospects of farm machinery-a review. *International Journal of Biosciences (IJB)*, June, vol. 16 (6) 11-26.
2. Alves F. Por que morrem os cortadores de cana Saude Soc. 2006;15 (3):90-8.
3. Aquino, GS, Medina, CC, Tronchini, ER, Pasini, A., Menezes Junior, AO, Hoshino, AT, Oliveira, EC, Brito, OR. 2016. Root system and yield of sugarcane cultivated under different amounts of straw in southern Brazil. *Afr. J. Agric. Res.* 11(7): -571.
4. Arbex MA, Martins LC, Oliveira RC, Pereira LAA, Arbex FF, Caçado JED, et al. Air pollution from biomass burning and asthma hospital admissions in a sugar cane plantation area in Brazil. *J Epidemiol Community Health.* 2007;61(5):395-400.

5. Arcangeli, G., Traversini, V., Tomasini, E., Baldassarre, A., Lecca, L. I., Galea, R. P., & Mucci, N. (2020). Allergic anaphylactic risk in farming activities: A systematic review. *International Journal of Environmental Research and Public Health*, 17(14), 1–20.
6. Barbosa CM, Terra-Filho M, de Albuquerque AL et al. Burnt sugarcane harvesting- cardiovascular effects on a group of healthy workers, Brazil. *PLoS One* 2012; 7: e46142.
7. Bhalerao, V., Shinde, G., Mane, S., Shah, F., & Scholar, G. (2023). *A Comparative Study of Sugarcane Harvesting and Its Impact on Health Conditions of Labor from Thailand and India*.
8. Bisht, R., & Kumari, R. (2019). Occupational Health Hazards among Sugarcane Factory Employees. *International Journal of Advances in Nursing Management*, 7(4), 311.
9. Biswas G., Bhattacharya A. & Rina Bhattacharya R. (2016). A review on the occupational health of sugar cane workers. *International Journal of Biomedical Research*, 7(8): 568-570.
10. Bodin, T., García-Trabanino, R., Weiss, I., Jarquín, E., Glaser, J., Jakobsson, K., Lucas, R. A. I., Wesseling, C., Hogstedt, C., Wegman, D. H., Abrahamson, M., Apelqvist, J., Aragón, A., Arias, E., Ekström, U., Faber, D., Peraza, S. A., & Rojas, M. (2016). Intervention to reduce heat stress and improve efficiency among sugarcane workers in El Salvador: Phase 1. *Occupational and Environmental Medicine*, 73(6), 409–416.
11. Boonruksa, P., Maturachon, T., Kongtip, P., & Woskie, S. (2020). Heat stress, physiological response, and heat related symptoms among Thai sugarcane workers. *International Journal of Environmental Research and Public Health*, 17(17), 1–15.
12. Butler-Dawson, J., Krisher, L., Asensio, C., Cruz, A., Tenney, L., Weitzenkamp, D., Dally, M., Asturias, E. J., & Newman, L. S. (2018). Risk Factors for Declines in Kidney Function in Sugarcane Workers in Guatemala. *Journal of Occupational and Environmental Medicine*, 60(6), 548–558.
13. Cabrera, L., Auguste, A., Michineau, L., Joachim, C., Deloumeaux, J., & Luce, D. (2022). Health impact of occupational pesticide exposure: a review of epidemiological studies in greenspace workers: Role of Sugarcane Work and Other Occupational Exposures. *International Journal of Environmental Research and Public Health*, 19(20), 13444.
14. Cardoso, T.F., Cavalett, O., Chagas, M.F., Morais, E.R., Carvalho, J.L.N., Franco, H.C.J., Galdos, M.V., Scarpore, F.V., Braunbeck, O.A., Cortez, L.A.B., Bonomi, A. 2013. Technical and economic assessment of trash recovery in the sugarcane bioenergy production system. *Sci. Agric*, 70 (5):353–360.
15. Chaudhari, M., & Jaggi, R. (2020). *Documenting Migrant Lives of Sugarcane Harvesting Labourers in Maharashtra – Autoethnographic Reflections*. 12(5), 1–7.
16. Correa-Rotter R, Wesseling C, Johnson RJ. CKD of unknown origin in Central America: the case for a Mesoamerican nephropathy. *Am J Kidney Dis*. 2014;63(3):506-20.
17. Cortez, O. D. (2009). Heat stress assessment among workers in a Nicaraguan sugarcane farm. *Global Health Action*, 2(1).
18. Crowe, J., Wesseling, C., Solano, B. R., Umaña, M. P., Ramírez, A. R., Kjellstrom, T., Morales, D., & Nilsson, M. (2013). Heat exposure in sugarcane harvesters in Costa Rica. *American Journal of Industrial Medicine*, 56(10), 1157–1164.
19. Dally, M., Butler-Dawson, J., Sorensen, C. J., Van Dyke, M., James, K. A., Krisher, L., Jaramillo, D., & Newman, L. S. (2020). Wet bulb globe temperature and recorded occupational injury rates among sugarcane harvesters in southwest guatemala. *International Journal of Environmental Research and Public Health*, 17(21), 1–13.
20. Dias EC. A organização da atenção à saúde do trabalhador. In: Ferreira Filho M, organizador. Saúde no trabalho. São Paulo: Rocca; 2000. p.1-23.
21. Drahansky, M., Paridah, M. ., Moradbak, A., Mohamed, A. ., Owolabi, F. abdulwahab taiwo, Asniza, M., & Abdul Khalid, S. H. . (2016). We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists , for scientists TOP 1 % . *Intech, i(tourism)*, 13.
22. Ekiti, M. E., Zambo, J. B., Assah, F. K., Agbor, V. N., Kekay, K., & Ashuntantang, G. (2018). Chronic kidney disease in sugarcane workers in Cameroon: A cross-sectional study. *BMC Nephrology*, 19(1), 1–8.
23. Franca, D. A., Longo, K. M., Neto, T.G. S., Santos, J. C., Freitas, S.R., Rudorff, B.F. T., Cortez, E.V., Anselmo, E. and Carvalho Jr, J.A.2012. Pre-Harvest Sugarcane Burning: Determination of Emission Factors through Laboratory Measurements. *Atmosphere*, 3:164-180.
24. G. Durai, R. Ramsenthil & E. Krishnaprabhakaran (2019). Occupational Health Hazards of Sugarcane Industry Workers-A Review. *Think Indian Journal*, Vol. 22.
25. G. Kumudini and T. Hasegawa, Workload and awkward posture problems among small-scale strawberry farmers in Japan, *J Hum Ergol* 38(2) (2019 Dec), 81–88.
26. Gangwar, S., & Kwatra, S. (2017). Prevalence of Musculoskeletal Problems among Sugarcane Workers in Uttar Pradesh. *International Journal of Advanced Engineering Research and Science*, 4(7), 25–28.
27. Gascon, M., Kromhout, H., Heederik, D., Eduard, W., & Van Wendel De Joode, B. (2012). Respiratory, allergy and eye problems in bagasse-exposed sugar cane workers in Costa Rica. *Occupational and Environmental Medicine*, 69(5), 331–338.

28. Glaser, J., Hansson, E., Weiss, I., Wesseling, C., Jakobsson, K., Ekström, U., Apelqvist, J., Lucas, R., Arias Monge, E., Peraza, S., Hogstedt, C., Wegman, D. H., & Hansson, E. (2020). Preventing kidney injury among sugarcane workers: Promising evidence from enhanced workplace interventions. *Occupational and Environmental Medicine*, 77(8), 527–534.
29. Hansson, E., Glaser, J., Jakobsson, K., Weiss, I., Wesseling, C., Lucas, R. A. I., Wei, J. L. K., Ekström, U., Wijkström, J., Bodin, T., Johnson, R. J., & Wegman, D. H. (2020). Pathophysiological mechanisms by which heat stress potentially induces kidney inflammation and chronic kidney disease in sugarcane workers. *Nutrients*, 12(6).
30. Haq, Z. U., Islam, M. A., Asam, H. M., & Mehmood, T. (2020). *Occupational Health, Safety and Ergonomic Issues of Sugar Industry-A Review Occupational Health, Safety and Ergonomic Issues of Sugar Industry- A Review Faculty of Agricultural Engineering and Technology, PMAS-Arid Agriculture University, April.*
31. ILO, Safety and Health at Work. ILO Cataloguing in Publication Data, 2014; pp: 1-48.
32. ILO. 2000. Safety and Health in Agriculture. Report VI (1), International Labor Conference, 88th Session, 30 May - 15 June. International Labour Ofce, Geneva (accessed August 3, 2023).
33. Kiatkitroj, K., Arphorn, S., Tangtong, C., Maruo, S. J., & Ishimaru, T. (2022). Risk factors associated with heat-related illness among sugarcane farmers in Thailand. *Industrial Health*, 60(5), 447–458.
34. Kumar, A., & Tiwari, O. K. (2021). SHORT COMMUNICATION Socio-Economic symptoms of sugarcane growers in Meerut District of western U. P. India. 10(July), 218–221.
35. Kupferman, J., Ramírez-Rubio, O., Amador, J. J., López-Pilarte, D., Wilker, E. H., Laws, R. L., Sennett, C., Robles, N. V., Lau, J. L., Salinas, A. J., Kaufman, J. S., Weiner, D. E., Scammell, M. K., McClean, M. D., Brooks, D. R., & Friedman, D. J. (2018). Acute Kidney Injury in Sugarcane Workers at Risk for Mesoamerican Nephropathy. *American Journal of Kidney Diseases*, 72(4), 475–482.
36. Laws, R. L., Brooks, D. R., Amador, J. J., Weiner, D. E., Kaufman, J. S., Ramírez-Rubio, O., Riefkohl, A., Scammell, M. K., López-Pilarte, D., Sánchez, J. M., Parikh, C. R., & McClean, M. D. (2015). Changes in kidney function among Nicaraguan sugarcane workers. *International Journal of Occupational and Environmental Health*, 21(3), 241–250.
37. Le Blond, J. S., Woskie, S., Horwell, C. J., & Williamson, B. J. (2017). Particulate matter produced during commercial sugarcane harvesting and processing: A respiratory health hazard? *Atmospheric Environment*, 149, 34–46.
38. Leite, M. R., Zanetta, D. M. T., Antonangelo, L., Marçal, L. J., Ramos, D., Almeida Burdmann, E., & Paula Santos, U. (2018). Burnt sugarcane harvesting work: effects on pulmonary and systemic inflammatory markers. *Inhalation Toxicology*, 30(6), 205–212.
39. Mbonigaba, E. (2015). To assess the prevalence of occupational health related risks and use of safety measures among employees in Bralirwa processing industries in Rwanda. *Occupational Medicine & Health Affairs*, 03(05), 1–6.
40. Mohanaselvan, T., Singh, S. P., Kumar, A., Kushwaha, H. L., Sarkar, S. K., & Joshi, P. (2024). Mechanization Level and Occupational Health Hazards in Sugarcane Cultivation in India. *Sugar Tech*, 26(2), 432–445.
41. Monjezi, N. (2021). Ergonomic Evaluation Posture of Sugarcane Workers using REBA Method. *Journal of Agricultural Machinery*, 11(2), 477–489.
42. More, K. D., Mane, A. R., & Shinde, S. B. (2021). Prevalence of Ophthalmological and Dermatological Problems Related to Pesticide Exposure among Sugarcane Farm Workers in Western Maharashtra. *Journal of Evolution of Medical and Dental Sciences*, 10(32), 2565–2569.
43. Natarajamurthy, P., N. Prasanna, and A. Bharatharathna. 2019. Analysis of cultivational cost of sugarcane in Tamil Nadu. *Indian Journal of Economics and Business* 18 (1): 241–244.
44. Nilvarangkul, K., Phajan, T., Laohasiriwong, W., Smith, J. F., & Settheetham, D. (2018). Development and validation of a work-related low back pain risk-assessment tool for sugarcane farmers. *Industrial Health*, 56(4), 320–326.
45. NIOSH 2013. Agricultural Safety. Official Home Page of Centre for Disease Control and Prevention. From (Retrieved on 15 July 2013).
46. Niu S. 2010. Ergonomics and occupational safety and health: An ILO perspective. *Applied Ergonomics*, 41(6), 744–753.
47. Nunes, D. M. P., da Silva, M. S., & Cordeiro, R. de L. M. (2016). A experiência de trabalho e dos riscos entre os trabalhadores-migrantes nordestinos nos canaviais paulistas. *Saude e Sociedade*, 25(4), 1122–1135.
48. Oliveira, M.W., Trivelin, P.C.O., Kingston, G., Barbosa, M.H.P., Vitti, A.C.2002. Decomposition and release of nutrients from sugarcane trash in two agricultural environments in Brazil. *Proceedings of the Conference of Australian Society of Sugar Cane Technologists*, 24: 1-10.
49. Ostgaard, H. C., & Andersson, G. B. J. (1992). Postpartum Low-Back Pain. *Spine*, 17(1), 53–55.
50. Phajan, T., Nilvarangkul, K., Settheetham, D., & Laohasiriwong, W. (2014). Work-related musculoskeletal disorders among sugarcane farmers in North-Eastern Thailand. *Asia-Pacific Journal of Public Health*, 26(3), 320–327.
51. Phoolchund, H.N. 1991. Aspects of occupational health in the sugar cane industry. *Journal of the Society Occupational Medicine* 41: 133–136.



52. Prado GF, Zanetta DM, Arbex MA et al. Burnt sugarcane harvesting: particulate matter exposure and the effects on lung function, oxidative stress, and urinary 1-hydroxypyrene. *Sci Total Environ* 2012; 437: 200–208.
53. Priuli, R. M. A., De Moraes, M. S., & Chiaravalloti, R. M. (2014). The impact of stress on the health of sugar cane cutters. *Revista de Saude Publica*, 48(2), 225–231.
54. Prommawai, N., Laohasiriwong, W., & Nilvarangkul, K. (2019). Musculoskeletal Disorders and Quality of Life of Sugarcane Farmers in the Northeast of Thailand: A Cross-sectional Analytical Study. *Journal of Clinical and Diagnostic Research*, 11–15.
55. Radir, A. F., Hashim, Z., Phan, K., Sao, V., & Hashim, J. H. (2017). The Impact of Heat on Health and Productivity Among Sugarcane Workers In Kampong Cham , Cambodia. *Asia Pacific Environmental and Occupational Health Journal*, 3(1), 9–19.
56. Raza, H. A., Amir, R. M., Idrees, M. A., Yasin, M., Yar, G., Farah, N., Asim, M. A., Naveed, M. T., & Younus, M. N. (2019). Residual Impact of Pesticides on Environment and Health of Sugarcane Farmers in Punjab With Special Reference To Integrated Pest Management. *Journal of Global Innovations in Agricultural and Social Sciences*, June, 79–84.
57. Ribeiro H, Ficarelli TRA. Queimadas nos canaviais e perspectivas dos cortadores de cana-de-açúcar em Macatuba, São Paulo. *Saude Soc.* 2010;19(1):48-63.
58. Ribeiro H. Queimadas de cana-de-açúcar no Brasil: efeitos à saúde respiratória. *Rev Saude Publica.* 2008;42(2):370-6.
59. Rossi-Rocha F, Palucci Marziale M., and do Carmo Cruz Robazzi M., Poverty as a predisposing factor of illness tendencies in sugarcane workers. *Rev Latino Am.* 2011; 15: 736-41.
60. Ruths, J. C., Shikida, P. F. A., & Fracarolli, I. F. L. (2023). Rural work in the sugarcane sector and its influences on health: scoping review. *Revista Brasileira de Medicina Do Trabalho*, 21(1), 1–12.
61. Santos, U. P., Zanetta, D. M. T., Terra-Filho, M., & Burdmann, E. A. (2015). Burnt sugarcane harvesting is associated with acute renal dysfunction. *Kidney International*, 87(4), 792–799.
62. Sarmistha Mishra, Dr. Nandita Bhattacharyya, Dr. Moonty Baruah. Prevalence of work related health problems & ergonomic risk factors among the workers engaged in silver filigree art of Cuttack, Odisha. *Pharma Innovation* 2023;12(4):150-156.
63. Silva MAM. Trabalho e trabalhadores na região do “Mar de Cana e do Rio de Álcool”. *Agraria.* 2005;(2):2-39.
64. Silveira, H. C. S., Schmidt-Carrijo, M., Seidel, E. H., Scapulatempo-Neto, C., Longatto-Filho, A., Carvalho, A. L., Reis, R. M. V., & Saldiva, P. H. N. (2013). Emissions generated by sugarcane burning promote genotoxicity in rural workers: A case study in Barretos, Brazil. *Environmental Health: A Global Access Science Source*, 12(1), 1–6.
65. Singh, N., Thumar, V. M., Leua, A. K., & Chaudhari, D. J. (2018). Impact of Straw Burning Practices on Economics of Sugarcane in South Gujarat Region. *International Journal of Current Microbiology and Applied Sciences*, 7(09), 234–241.
66. Sorensen, C. J., Krisher, L., Butler-Dawson, J., Dally, M., Dexter, L., Asensio, C., Cruz, A., & Newman, L. S. (2020). Workplace screening identifies clinically significant and potentially reversible kidney injury in heat-exposed sugarcane workers. *International Journal of Environmental Research and Public Health*, 17(22), 1–17.
67. Thapa, B., & Sharma, A. (2019). Prevalence of Occupational Health Consequences During Sugarcane Harvesting Among Harvesters of Morang District. *Journal of College of Medical Sciences-Nepal*, 15(2), 128–131.
68. UNICA 2015. Which the planned expansion for the cultivation of sugarcane in Brazil in the coming years.
69. Vasave, M. S. Y., & Anap, D. D. B. (2016). *Prevalence of musculoskeletal disorders among sugarcane workers.* September, 1–8.
70. Wolfert, S.; Ge, L.; Verdouw, C.; Bogaardt, M.J. Big Data in Smart Farming—A review. *Agric. Syst.* 2017, 153, 69–80.
71. World Health Organization (2015). WHO report on Occupational health and safety, Geneva.
72. Xiang, J.; Bi, P.; Pisaniello, D.; Hansen, A. Health impacts of workplace heat exposure: An epidemiological review. *Ind. Health* 2014, 52, 91–101.
73. Yang, X., Wu, H., & Li, H. (2020). Dehydration-associated chronic kidney disease: A novel case of kidney failure in China. *BMC Nephrology*, 21(1), 1–5.