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Heat Stress's Impact on Agricultural Worker's Health, Productivity, and its Effective Prevention Measures: A Review and Meta-Analysis

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ABSTRACT

Growing temperature due to climate change is one of the biggest threats in the current situation for humankind after Covid-19. Heat exposure is challenging for certain occupations like agriculture because of the combined effect of the external thermal environment and heat generated by inner organs due to heavy muscular work. A potential part of the world population is agriculture, commonly affected by heat-related illness and productivity loss due to heat exposure. We use our review as a springboard to expand the negative influence of heat stress on the agricultural workforce's health. We used CrossRef, PubMed, Embase, Google Scholar, Scopus, Science Direct databases, and some other reverent websites to revise various research priorities related to heat stress associated with epidemiology, loss of productivity, and some effective prevention measures. We have properly reviewed selected top 35 scientific priorities associated with heat stress-related epidemiological studies on more than 5 million agricultural workers to elaborate the probability of heat-related illness in the farming sector. We divided the examined data into six categories for the effective analysis of chosen studies: author, topic of study, target population sample condition of study heat exposure recognized health issue, specific study outcome, etc. The result of the survey reveals that heat stress-related disorder among farmers is in increasing order. The increasing order of impact of climate change in the form of heat stress in the agricultural sector tremendously influences the agricultural worker's health, productivity, and livelihood. Most of earlier research priorities concluded that heat stress could effectively reduce by low-cost measures, proper work-rest Schedule, hydration, heat stress awareness, and prevention training but needs adequate implementation. Further comparative assessment of physiological parameters of agricultural workers in heat stress conditions of different geographical locations is essential for future research to develop a Policy for sustainable livelihood in the agricultural sector.

Keywords:
Heat stress; Heat-related illness (HRI); Agricultural worker's health; productivity; prevention measures.

1. Introduction

Rising temperature due to Global climatic change (GCC) is more intense in the form of heat stress for agricultural workers as most agricultural work is associated with the outdoor environment (Pal et al., 2021; S. D. Wästerlund, 2018). Intensifying temperature is the most important consequence of climate change, one of the biggest current threats for humankind after Covid-19 (Pal et al., 2021).

GCC increased the global mean temperature, which led to increasing the difficulty of heat stress for outdoor workers (Lucas et al., 2014; Park et al., 2017). According to the report of world bank data, nearly one billion people are associated with agricultural work, which is about 28% of the total employment population of the world in 2018 (Cassidy & Snyder, 2020). Heat exposure is challenging for certain occupations like agriculture because of the combined effect of the external thermal environment and heat generated by inner organs due to heavy muscular work (Riccò, 2018). According to the International Labour Organization (ILO (International Labour Organization), 2019), agricultural and construction workers will be the hardest hit. In 1995 and 2030, the agricultural sector alone accounted for 83 percent and 60 percent of global working hours lost due to heat stress (ILO (International Labour Organization), 2019).

A potential part of the world population is agriculture, commonly affected by heat-related illness (HRI) and productivity loss due to heat exposure (Morabito et al., 2020). Further, an earlier study revealed that the heat-related fatality rate of agricultural workers is usually twenty times higher than civilian workers. Around sixteen percent of deaths of occupational workers are associated with crop production (Flocks et al., 2013). In the hot environmental condition of agriculture, heat-related illness occurs when core body temperature (CBT) exceeds the body's capacity to sustain equilibrium and cannot dissipate heat (Brotherhood, 2008; Flocks et al., 2013; Hancock & Vasmatzidis, 2003). Apart from agricultural workers usually living in substandard houses and less economic security; therefore, they cannot return to control the climatic environment after working more extended periods in a hot outdoor environment that raises the probability of HRI (Hesketh et al., 2020). Agricultural work is always associated with heavy activities that execute a substantial workload and increase the metabolic rate of individuals, leading to increased heat in the human body.

Considering the above issue in the agricultural sector, we review the earlier heat stress associated with epidemiological scientific study in the agricultural field. Further, we thoroughly analyze the related research priority in heat-related illness (HRI), some essential factors, and work productivity in hot environmental conditions of agricultural workers. We also evaluate some existing scientific safety policies and prevention measures of HRI in the farming sector.

2. Materials and Methods

After a thorough review of the previously announced scientific research priorities, we adopted relevant data and utilized this data to achieve the selected objectives. We use our review as a springboard to expand on the negative influence of heat stress on agricultural workforces health by highlighting the heat-related epidemiology in the farming sector, the loss of productivity of the agricultural workers, and some recommended HRI prevention measures.

To categorize related topics for Systematic Reviews and meta-analysis of previously published priorities, we used the PRISMA statement by Moher et al. (2009). To locate the relevant study, we cited 83 selected publications from 1985 to 2021, including books, full-length research and review articles, websites, and degree theses, after revising various research priorities related to heat stress associated with epidemiology, productivity loss, and some effective prevention measures using CrossRef, PubMed, Embase, Google

Scholar, Scopus, Science Direct, and some other revered websites. Out of 641 recognized publications, we have cited 83 selected publications and properly evaluated thirty-five full-length heat stress-related previous papers (Fig.1). We divided the examined data into six categories for the effective analysis of chosen studies: author, topic of study, target population sample condition of study heat exposure recognized health issue, specific study outcome, etc.

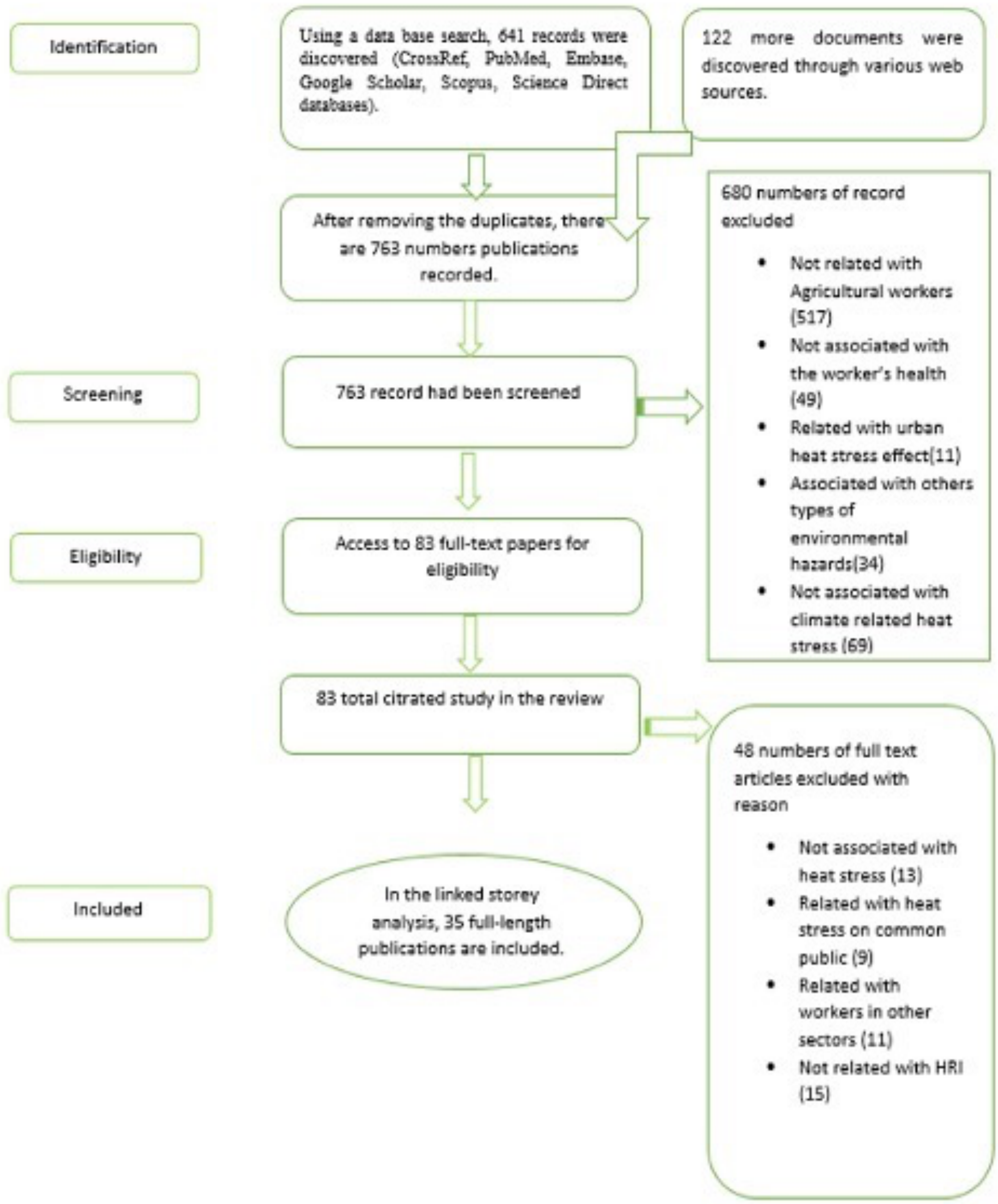

Figure 1. Exhibition of the entire storey of the associated research (Adopted and Modification from (Moda & Minhas, 2019; Moher et al., 2009; Nunfam et al., 2018; Pal et al., 2021).

3. Results and Discussion

The review paper's principal goal is to highlight the previous heat stress-related epidemiology, work productivity, and prevention priority of agricultural workers. We focused on pure heat stress-related scientific study on farming workers and highlighted some significant scientific study findings to address this issue. Eventually, we also elaborate on some existing scientific safety policies and prevention measures of HRI in the farming sector.

3.1 Analysis of designated studies

Table 1 summarises the findings of a comprehensive examination of 35 full-length scholarly articles. Besides that, we cover the United States, India, Nicaragua, Mexico, Iran, Slovenia, Florida, South Korea, Georgia, Oregon, Italy, Carolina, Hispanics, Nigeria, Germany, Nicaragua, and so on.

Table 1. Systematic analysis of previous scientific papers by proper review (Adopted and improve from the study of (Moda & Minhas, 2019; Pal et al., 2021)

Sl. No.	Author	Topic of Study	Target Population Sample	Condition of Study Heat Exposure	Recognized Health Issue	Specific Study Outcome
1	Crowe et al. (2009)	Heat stress evaluation of Costa Rica sugarcane field workers	Field workers of Sugarcane: Costa Rica and Nicaragua (N=17)	Harvesting in Outdoor and Sugarcane processing in the heat of an oven	Dehydration, kidney diseases, and Heatstroke	1. Extreme heat stress due to climatic change. 2. Heat stress causes adverse health effects on sugarcane workers. 3. More specific research on health approaches of ecosystem needs to improve sustainable solutions to heat stress.
2	Jackson & Rosenberg (2010)	Prevention measure of heat associated illness of agricultural workers	Crop workers: US(N=100000)	Standard Agricultural Text in Outdoor condition	Heatstroke, heat rash, heat cramps, heat syncope, heat exhaustion,	1. Fatality rate of crop workers in the U.S. twenty times more than others 2. Out of total heat-related death in the U.S. Between 1992 to 2006, 67% of death associated with Agriculture and its sub-sector 3. Training, Hydration, Proper Work rest schedule, Proper checking of the environmental condition by WBGT meter, modifying agricultural machinery or tools to reduce effort, Avoiding Strenuous jobs, using cooling devices, etc., are preventive measures.
3	Flocks et al. (2013)	Observations heat associated illness and Pregnancy health of female farmworkers	Female farmworkers: Mexican descent &Haitian (N=35)	Agricultural nurseries and ferneries work in the enclosed hot environment	Respiratory problems, dehydration, headaches, excessive sweating, vomiting, etc.	1. Age, pregnancy, body mass index, and chronic disease makes female agricultural workers more susceptible to heat 2. Humidity and temperature both combine effect increase risk levels for outdoor workers.

						3. Proper scheduling for work-rest, drinking water frequently proper training for symptoms of heat illness & sign, workload increase gradually, Prevention measure, etc. are pointed as a preventive measure
4	Heidari et al. (2015)	Estimate of heat stress of North Iran farmers by WBGT index	Farmers: North Iran(N=79)	Agricultural work, animal husbandry jobs & horticulture jobs in outdoor condition	Heat stress, heat strain & severe health risk	1. Evaluation of heat associated stress and strain of subject (0.78 clo) by following ISO 7243 & ISO 9886, respectively 2. WBGT index is more than recommended in humid and hot environments due to high R.H. and generally lies between 24 to 32.6 degrees in summer. 3. WBGT index mainly influenced by humidity and wet bulb temperature; 4. The correlation coefficient between the WBGT index and auditory temperature was determined to be the strongest ($r= 0.84$, $P< 0.001$).
5	McQueen, (2012)	Heat stress assessment of migrant crop production workers	Tomato Workers: US(N=18)	Picking tomato under the hot sunny condition	Increase heart rate and body temperature, physiological strain, weight loss, dehydration, heat stress, sickness, etc	1. Percentage of trained and non-trained (working in hot conditions) are 30 % & 70% respectively. Trained workers can tolerate more heat stress than untrained workers 2. Need proper training about hydration and acclimation of workers to reduce heat disorder.
7	Pogačar et al. (2017)	The conception of climatic change and work associated heat stress impact on	Agricultural advisers and Farmers: Slovenia(N=316)	Agricultural work, Manufacturing, construction, tourism, and transportation work in an open environment	Thirst (81 %), tiredness (59 %), sweating (84 %), confusion (10 %),enhanced stress (25	1. Around 44% farmers and 62% adviser's response about heatwave which very high than other work 2. Advisers shares a moderate experience about the heatwave in Manufacturing (33%) and Construction

		agricultural advisers and farmers			%), dizziness (24 %), productivity (68 %) concentration (34 %) loss	(37%) sector, minor in tourism (35%) and transport(28%) sector 3. Less number (<18%) of the participant of survey share negligible heat wave in any sector 4. Farmers facing highest heat stress than other sectors
8	Zamanian et al. (2017)	Assessment of heat stress on biological parameter	Male farmers: Iran(N=387)	Farm work on the hottest day of summer	kidney disease,skin disease ,BP,increase CBT	1. Direct relationships were observed between heat indices and physiological factors (excluding systolic B.P.) 2. Inverse relationship observed among CBT and skin temperature, B.P., pulse rate 3. Important connotation was observed between skin temperature and WBGT (CI: 0.02, 0.61, B = 0.31, P = 0.03) and between skin temperature and Humidex (CI: -0.03, 0.40, B = 0.21, P = 0.02) 4. No important connotation observed supplementary heat stress indices like PHS, UTCI, STI & HIS. 5. Compared to other heat stress indices, Humidex and WBGT, were found more significant and showed a better relationship with the physiological parameter

9	Culp et al. (2011)	Reduce heat associated illness of Hispanic agricultural workers	Farmworker: Hispanic U.S. (N=5000000)	Farm work in a hot and humid environment	Discomfort, thirsty, Sweating, chronic health condition, Heat syncope, Heatstroke, Heat cramps, Heat exhaustion	1. New workers should follow the strategy of heat acclimatization 2. For demanding and heavy work, cooler hours should be considered. 3. Hydration, clothing and personal protection equipment, training proper work-rest Schedule, rest in shade area early risk assessment is a prevention measure 4. Workers with renal or cardiovascular disease should eat fewer liquids, and health screenings should be undertaken before fieldwork.
10	Spector et al. (2016)	Evaluation of the heat contract and risk associated with traumatic injury of agricultural workers	Outdoor Agricultural worker: Washington USA(N=12213)	Outdoor farm work(Cherry harvesting) in the hot open environment	Traumatic injuries	1. Outdoor farmworkers are in higher traumatic injuries due to hot working condition 2. The observed odds ratio of traumatic injury related to < 25 (self-reported period of work) was 1.14, 1.15 & 1.10 (95% confidence interval) for day-to-day peak Humidex of 25 to 29, 30 to 33 & 34, correspondingly. 3. Related to all other work, a strong relationship was found during the harvesting period of cherry in June & July. 4. Combined effect of injury and heat associated illness can increase the risk for agricultural workers in the hot environment
11	Riccò (2018)	Assessment of the relationship between high ambient temperature	Agricultural workers: Northeast Italy (N=20000)	Agricultural work in hot outdoor condition	Occupational Injury	1. Occupational injuries (O.I.s)of agricultural workers in the hot environment were observed 3.4±2.3 events/day, and total damage was found 7325 numbers.

		& occupational injuries in the hot season.				2. The odds ratio identified the danger of occupational injuries 3. Most of O.I.s observed in several hot conditions, especially during heat waves, and odds ratio(OR) was observed 1.09, CI (conference interval 95%) 1.02-1.17(P=0.0165) 4. For higher than 95th percentile day temperature OR = 1.119, 95% CI: 1.008–1.242 and at daily peak temperature O.I.s, OR = 1.144, 95% CI: 1.029–1.272. 5. Need perfect Policy to make advance alert or warning systems for farmworkers in hot environmental conditions.
12	Mutic et al. (2018)	Sorting of heat associated disorder indications among Florida agricultural workers	Farmworkers: Florida(N=198)	Farm work in a hot and humid environment	Headache, heavy sweating, sudden muscle cramps, vomiting or nausea, confusion, dizziness, collapsing while at work,	1. Important, regularly noticed indications were headache (58%), heavy sweating (66%), muscle cramps (30%), dizziness (32%). 2. Female's farmworkers had three times more odd experiments (OR = 2.86, 95% CI 1.18–6.89) in hot and humid working condition 3. Workers may find themselves in a difficult situation due to an unidentified cluster of symptoms. 4. Initial determination heat associated disorder, suitable work-related health strategy, engineering control, on-site care, etc. can reduce the danger of heat
13	Park et al. (2017)	An important factor associated with heat-related disease of heat exposed outdoor workers	Heat exposed agricultural and other outdoor workers: Korea (N=47)	Outdoor working condition	Heat cramp (1 case), heat syncope (2 instances), heat stroke (39 cases), heat exhaustion (5 issues)	1. Heat-associated events arose around 61.7 % when high wet-dry bulb temp, and Heat associated events arose around 95.7% when the temperature was more than the WBGT limit.

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						2. The above finding suggests that the WBGT limit is more responsible for predicting heat disorder than ambient temperature 3. the essential factors of heat-associated illnesses are environmental factors, high metabolic rate during work, heat acclimation, etc.
14	Fleischer et al. (2013)	Reduction of HRI by the help risk factor among migrant agricultural workers	Migrant Farmworker: Georgia (N=405)	Farm work in hot condition	Chronic disease, Fainting, Headache, vomiting or nausea Confusion, Hot dry skin, Sudden muscle cramps	1. Around 75% of those who took part in the study had three or more heat-related sickness symptoms. 2. The research was the show that three or more HRI symptoms prevalence by 7.3 % by increasing admittance to medical care, prevalence by 9.2% by increasing rest in the shade, prevalence by 6 % by increasing admittance to frequent break, and the majority by 6.7 % by plummeting soda intake. 3. Data of the research show that HRI of farmworkers can be prevalent by frequent breaks in the shaded area, proper training on the reduction of HRI
15	D. S. Wästerlund (1998)	A review on the scientific study of stress on forest workers	Forest workers: All over the world (N=not specified)	Forest work in heat stress condition	Dehydration, productivity loss, fatigue, weight loss	1. Dehydration, weight loss, fatigue, and loss of productivity are common problems found in forest worker 2. Protective clothing for heat stress condition, proper work-rest Schedule, study on self-pacing are essential preventive measures for forest workers

16	Hesketh et al. (2020)	Characteristic of heat-related illness (HRI) of Washington workers from 2006 to 2017	Agricultural workers, Public Administration workers including other outdoor workers: Washington (USA)(N=6538)	Work under the hot ambient temperature condition	Kidney failure, dehydration, and other heat-related illnesses	1. Public administration has the highest HRI (131.3 / 100 000 FTE), followed by farming, forestry, fishery, and hunting (102.6 /100 000 FTE). 2. The median maximum daily temperature, which was below the Washington heat regulation, was responsible for almost 45 percent of the claims. 3. Need some adequate additional protections to avoid HRI depending on heat exposure intensity.
17	Spector et al. (2014)	Heat associated disorder in forestry and agricultural sectors of Washington	Agricultural and forestry worker: Washington (N=178,000)	Work in hottest months of the year	Heat cramps, syncope, heat exhaustion, heat edema or weariness, acute renal failure diagnosis, or heat stroke are all symptoms of heat exhaustion.	1. Claims of HRI was most mutual in crop production workers 2. The average Himax (Tmax) was 99°F (95°F) for outdoor heat-related illness claims. 3. HRI in the case of agricultural and forest workers depend on personal, environmental, and work associated risk factors 4. Need a clear relationship between occupational injury and heat exposure.
18	Bethel & Harger (2014)	Heat associated disorder among Oregon agricultural workers	Farmworkers: Oregon(N=100)	Farm work in the hottest month of summer	skin bumps, skin rash, light-headedness, dizziness, fainting, extreme weakness, confusion, nausea, fatigue, etc	1. Around 30% of farmworkers notice facing ≥2 HRI indications. 2. Out of the participated farmworkers who remain at peace was found to have a high heat knowledge, and participators are very concerned about HRI was found less heat knowledge. 3. Conducting proper heat-related training and education changes the farmworker's practice about the cooling measure and adopting the preventing strategy of HRI.

19	Morabito et al. (2020)	Loss of productivity in a hot environment and its effective prevention measure	Farmworkers: Florence(Italy) & Guangzhou (China)(N=36)	The experiment did under Sun and shade	Productivity loss	1. By working in the shade and adjusting work hours, the output loss per hour and associated financial costs might be reduced (p <0.05). 2. Proper heat-associated reduction strategy effectively reduces the heat in the job place.
20	Messeri et al. (2019)	Perception of heat stress of agricultural and construction workers of Italian industries	Workers of agricultural and construction sector(Native and Migrant): Italy(N=330)	Work in an open outdoor environment in the summer session	Heat stress and Productivity loss	1. Based on the acknowledged physical exertion and perceived, native workers have a better threshold level (WBGT ≥ 29.3 ◦C) than migrant workers (WBGT ≥ 27.9 ◦C). 2. Migrant workers reported that in hot environments, work required more effort.
21	Stoklosa et al. (2020)	Heat Tiredness and Pesticide Exposure in migrant agricultural workers	Agricultural workers:US (N=10,000 to 20,000)	Work in hot Sun	Heat Tiredness	1. Heat associated illness is four times expected in the agricultural sector than in other sectors 2. In the case of Central and South America or Mexico, it was observed that around 71%death is associated with agricultural workers
22	Sahu et al. (2013)	Determination of relationship of heat contract with productivity and cardiovascular stress of Indian rice harvesters	Male rice harvesting worker: West Bengal, India (N=124)	Harvesting in hot and humid condition	Pain, heat exhaustion, heat strain, productivity loss	1. At low heat, the heart rate of rice harvesting workers recovered quickly, but it recovers slowly in high heat. 2. Greater than 26°C WBGT temperature, the collection of rice bundles per hour was considerably decreased (5% /°C increment of WBGT) 3. Exposure to hot and humid working conditions for a long time, heat strain occurs, and productivity is also lost.

24	Spector et al. (2015)	Assessment of heat associate illness casing risk factor of crop workers of Washington	Crop worker: Washington, USA(N=97)	Crop related work in summer session	heavy sweating, light-headedness, dizziness	1. Value of odds ratio of heat-related illness is decreased with age(OR = 0.92; 95% confidence interval [CI] = 0.87–0.98) 2. Modifiable workplace characteristics should be taken into account when attempting to discourage HRI.
25	Mirabelli et al. (2010)	Indications of heat-related illness of North Carolina agricultural workers	Farmworker: North Carolina(N=300)	Working in heat stress condition	Dehydration, heat-related disorder	1. Around 94% of the worker was reported working in extreme heat. 2. Around 40% of workers reported HRI symptoms. 3. It was observed that increase of H-2A migrant workers in changing activities and work hours during hot conditions, probability of heat illness is lower than non-H-2A worker 4. Proper understanding of working conditions and helping strategies decrease heat exposure probability

26	Sadiq et al. (2019)	Effect of heat on maize farmer's health and productivity in a tropical climatic condition	Maize farmers: Nigeria(N=396)	Work associated with maize cultivation in tropical hot climatic condition	Heat rash, heavy sweating, dizziness, tiredness, headache, Unconsciousness, difficulty in breathing, rapid pulse, and elevated body temperature	1. Maize farmers are experience tiredness (48.5%), headache (40.4%), Heavy sweating (93.2%), dizziness (34.1%) daily in tropical climatic conditions. 2. The productivity of farmers is substantially different in 3 time periods of the workday. 3. The productivity of farmers is substantially higher in between 6–9 am ($p < 0.001$) and 12–3 pm ($p < 0.001$) than 9 -12 am. 4. The factor significantly influence the farmers productivity were age ($p = 0.033$), gender ($p < 0.001$), BMI ($p = 0.008$). 5. In tropical climatic conditions, farmers were regularly facing heat exhaustion which reduced their productivity.
28	Ioannou et al. (2017)	Assessing the effect of environmental heat contact on work time loss on labor in the agricultural sector	Grape picking workers: Germany(N=7)	Grape harvesting in hot ecological conditions	Productivity loss	1. WBGT, air temperature, solar radiation, universal thermal climate index are responsible for changing the mean skin temperature(TMS)of workers ($p < 0.05$). 2. Hourly work time break(WTB) increase for every ^{o}C increase in temperature, UTCI, WBGT, and TMS were 0.8%,0.6%, 0.8 %, and 2.1%, respectively. 3. 64.0% of the seasonal changes in work time loss (WTL) ($P= 0.017$) are explained by Seasonal changes in UTCI, and 36.6% of the variance in WTL ($p < 0.001$) describe by productivity change. 4. Heat lead to considerable labor loss

29	Chatterjee et al. (2016)	Evaluation of physiological strain of male rice farmers due to Contact to Heat and work	Paddy cultivators: India(N=31)	Paddy transplanting in a hot and humid environment	physiological strain	Working in strenuous environmental condition over the threshold level produce physiological strain in paddy cultivator
30	Arcury et al. (2015)	North Carolina Latino Farmworkers heat associate illness	Farmworker: North Carolina Latino (N=235)	Farm work in hot outdoor and indoor condition	Vomiting or nausea, sudden muscle cramps, fainting or dizziness, hot and dry skin; confusion	1. While working outside and inside hot environments, farmworkers experience heat illness around 35.6% and 13.9%, respectively. 2. While working outside, the farmworkers' heat-associated illness experience due to the spending after work extremely hothouse, harvesting and topping tobacco and working by wearing wet shoes and clothes. 3. High-quality research and Policy need to reduce heat-associated illness.
31	Culp & Tonelli (2019)	Midwestern Hispanic Farmworkers heat associated illness	Farmworkers: Midwestern Hispanic (N=168)	Picking of melons and manual detasseling of corn in hottest months of the year	Muscle cramps, extreme thirst, stomach cramps, skin rash	1. Out of all participate farmworkers, 5.4% experience dizzy or light-headedness, 19.6% experience extreme thirst, 7.4% experience muscle cramps, 8.6% experience stomach cramps, and 4.4% experience distressing skin rash. 2. The uncomfortable (physiological intensity score > 4.0) category of the participant had a higher body temperature (100.05°F) than moderate(> 2.5-4) and mild P.I. score (⩽ 2.5). 3. The uncomfortable category's participants had a higher average breathing rate and heart rate than moderate and mild categories.

32	Arnold et al. (2020)	Latinx Child Farmworkers heat associated illness	Child farmworkers: Latinx North Carolina(N=165)	Working in hot and humid summer	Dehydration, dizziness	1. Finding shows that heat-associated illness is mutual in child farmworkers. 2. Limited proper workplace shields to stop heat-associated illness
33	Bethel et al., (2017)	Washington and Oregon farmworkers cooling and hydration practices	Farmworkers: Washington and Oregon (N=197)	Outdoor crop work	Dehydration increased core body temperature and HRI	Shade structures, rest stations, shade from trees, wet clothes, a hose, baseball cap, bandana, a sweatshirt hood, etc., are cooling practices followed by Washington and Oregon farmworkers.
34	Delgado Cortez (2009)	Status of Nicaraguan sugarcane farm workers in heat stress condition	Sugarcane workers: Nicaraguan(N= 22)	Working in hot weather conditions	Loss of productivity, loss of body weight, increased heart rate	1. Productivity of farmworkers can increase by drinking water. 2. Awareness of workers increases heat stress prevention.
35	Fleischer et al. (2013)	Migrant Farmworkers status of heat associated illness	Migrant farmworkers: Georgia (N=405)	Work in hot outdoor condition	Sudden muscle cramps, dizziness, Hot and dry skin, Fainting and Confusion, headache	1. The vital reason for the heat-associated illness is lack of anticipation training and less access to frequent breaks, lack of medical attention or shade area. 2. Research shows that the occurrence of 3 or more HRI indications can be reduced by reducing soda intake (6.7%), increasing access to regular breaks (-6.0%), increasing breaks in the shade (9.2%), and increasing access to medical attention (7.3%)

3.2 Analysis of designated studies

We have adequately reviewed selected top 35 scientific priorities associated with heat stress-related epidemiological studies on more than 5 million agricultural workers to elaborate the probability of heat-related illness in the agricultural sector. We have designed the analysis by including the topic of study, target population sample, number of population, condition of the study, heat exposure, recognized health issue, specific study outcome, etc.

3.2.1. Physiology of heat stress

The human body functions well between 36 °C to 38 °C core body temperature (CBT). CBT is defined as the temperature of the inner organ of the body. When CBT rises above 38°C, the body begins to cool the body by increasing heart rate to flow more blood from the internal organ to the external organ and increase the sweating rate called cooling mechanism (Dehghan et al., 2012; Heidari et al., 2015). The cooling mechanisms usually used by the human body are increasing sweating, which rises to heat loss to the surrounding by evaporation, and increasing heart rate, which supply heat and blood from the core body organ to the outer skin (Heidari et al., 2015). In a hot and humid environment, the body cannot quickly give up the heat in the surroundings; as a result, the body is unable to maintain its thermal equilibrium, leading to dehydration and rise CBT above 38 °C. This situation begins with a series of HRI in the form of heat cramps, heat syncope, heat exhaustion, heatstroke, etc. (Dehghan et al., 2012; Heidari et al., 2015; Holmer, 2010).

Tatterson et al. observed that when the ambient temperature is high (32°C), workers' power output is reduced compared to when the temperature is average (23°C). In high temperatures (32 °C), they also notice lower blood lactate ($P<.05$) and higher pH ($P<0.05$) (Tatterson et al., 2000). McQueen also found that increases in body temperature, heart rate, and physiological strain correlated with heat exposure (McQueen, 2012). Heat introduces physiological variation, dehydration which impact strength, comfort, vision, endurance, judgment, concentration, coordination (Hancock & Vasmatzidis, 2003; Jackson & Rosenberg, 2010; Kenefick & Sawka, 2007). Apart from protecting 95 percent of the population, ISO 7933 suggests a maximum permissible water loss via sweating of 5% body weight. This figure was derived from assuming that rehydration accounts for 40% of water loss in 95% of cases (Heidari et al., 2015; ISO (International Organization for Standardization), 2004). When the body's salt and water stores are depleted to dangerously low levels owing to heat exhaustion, a slew of symptoms emerge, including nausea, light-headedness, headaches, renal disease, profuse perspiration, vomiting, extreme weakness, and so on. While the body temperature rises above 40 degrees Celsius (104 degrees Fahrenheit), a life-threatening complication of HRI occurs in the form of heatstroke, which includes convulsions, coma, and delirium (Flocks et al., 2013). Zamanian et al. found important relationship between skin temperature with WBGT ($B = 0.31$, CI: 0.02, 0.61, $P = 0.03$) ,and Humidex ($B = 0.21$, CI: -0.03, 0.40, $P = 0.02$) for outdoor agricultural workers in hot condition (Zamanian et al., 2017).

Moreover, Spector et al. reported that agricultural workers quickly come across traumatic injuries in hot environmental conditions. In agriculture, the incidence rate ratio of injury claims per 1°C increase in maximum daily temperature was 1.005. (95 percent confidence interval 0.993 to 1.016) (Spector et al., 2016). The highest number of work-related incidents happened on days with extreme heat, especially during heat waves (incidence rate ratio = 1.09, 95 percent confidence interval (CI): 1.02–1.17, p =

0.0165) was observed by Matteo Riccò (Riccò, 2018). According to Spector et al. found maximum heat illness claim at 95°F for agricultural workers (Spector et al., 2014). A five percentage productivity decrease of farmers per degree centigrade was noticed by Sahu et al. They observed that the peak and resting heart rates are significantly higher in the air temperature ranges of 31–33.5°C. They also reported when the temperature is low, such as 28–30°C, the heart rate recovers quickly; however, when the temperature is greater, the heart rate recovers more slowly (Sahu et al., 2013)

3.2.2. Factors of heat stress and Heat-related illness (HRI) in agricultural sector

Due to the nature of work, agricultural workers are easily exposed to heat stress conditions. Factors like execution strenuous or prolonged work, wearing PPE or heavy cloth, performing work under direct sunlight also push the farmers into heat stress situations (Heidari et al., 2015). Some principle factors that significantly influence heat stress are humidity, ambient temperature, clothing, wind, physical activity, shade heat, and considerably depending on the individual workers, occupation, and environment (Acharya et al., 2018). In the environmental condition of agriculture, heat-related illness occurs when CBT is more than the body's capacity to sustain equilibrium and cannot dissipate heat 84 (Brotherhood, 2008; Flocks et al., 2013; Hancock & Vasmatzidis, 2003). Work-related factors are associated with heat exposure, metabolic heat ascending from work concentration, clothing is worn while working, and PPE. A preexisting health condition such as metabolic disorders, cardiac arrhythmias, kidney difficulties; physical factors such as cardiorespiratory fitness; medicines; and genetic factors are all individual risk factors. Age, alcohol and medication use, and nutritional status (Cheuvront et al., 2004; Flocks et al., 2013; Glazer, 2005; Rao, 2007; Selkirk & McLellan, 2001).

Environmental factors are associated with climate conditions, such as low airflow, ambient air temperature, and high humidity (Binkley et al., 2002; Flocks et al., 2013; Havenith et al., 2011; Miller & Bates, 2007; Yoopat et al., 2002).

As the temperature and humidity rise, more people in the agricultural sector are exposed to excessive heat, increasing the risk of heat-related illness (HRI) or bad health effects, which can lead to death in severe cases (Crowe et al., 2009; Flocks et al., 2013; Jackson & Rosenberg, 2010). Heat more than tolerance level directly affects physical performance and cognitive. Heat persuade physiological variations, and dehydration affects strength, comfort, coordination, endurance, vision, injuries, judgment, and concentration. Further knowledge about the mentioned heat-associated impact can reduce the HRI in the agricultural sector (Jackson & Rosenberg, 2010). Due to climate change, the earth's surface temperature gradually rises with more frequent longer and hotter heatwaves and increasing numbers of warms nights and hot days (Kjellstrom, 2009; McInnes et al., 2017; Riccò, 2018). The increasing frequency and magnitude of an extreme event due to climate change causes excessive mobility and respiratory and cardiovascular illness mortality.

Some other factors that also influence the impact of heat stress:

3.2.2.1. Gender and cultural difference

A previous study found that gender and cultural differences are important factors that influence the degree of heat stress impact on farm workers' health. According to Jackson & Rosenberg, the mainstream of heat-related victims in California were 84 percent of men who worked outside, and 68 percent of those Spanish was their first language (Jackson & Rosenberg, 2010).

In a study of agricultural workers, Pogacar et al. discovered that women had a higher incidence of headache (64 percent) than men (47 percent), a higher frequency of exhaustion (69 ten percent), and episodes of nausea or vomiting (19 percent) (Pogačar et al., 2017). Mutic et al. found that in Florida farmworkers, females had three times the odds of experiencing three or more symptoms (OR = 2.86, 95% CI 1.18–6.89) than males (Mutic et al., 2018; Spector et al., 2016). In the agricultural sector, males injure more (78%) than females (Fleischer et al., 2013). Although agricultural workers are at an increased risk of heat-related illnesses (HRI), pregnant farmworkers exposed to excessive heat have extra health hazards, including poor pregnancy health and delivery outcomes, according to Flocks et al. (2013).

3.2.2.2. Skill and lack of training

Proper education, skill, training, etc., of agricultural workers also play an essential factor in influencing the grade of heat stress-related illness by improving the recognition of heat threats. According to Jackson and Rosenberg, many of the agricultural labourers who died in the United States were foreign-born workers with little English skills who were often unaccustomed to exertion in hot weather while starting seasonal occupations (Jackson & Rosenberg, 2010). In their study, Bethel and Harger (2014) found that 84% of migrant agricultural laborers frequently subjected to HRI have less than a high school degree (Bethel & Harger, 2014). Migrant farmworkers encountered difficulties in preventing HRI at work due to the absence of proper training (77 percent), reported by Fleischer et al. (2013).

3.2.2.3. Factor of age

Age is another important factor that highly influences the impact of heat stress on workers' health. Heat-related illness signs were more common in older participants than in younger ones. While youngsters are generally aware of the dangers of working in hot weather, work organization frequently prohibits them from adopting appropriate safeguards (Arnold et al., 2020). Heidari et al. reported that other illnesses such as diabetes, hypertension, and cardiovascular inadequacies in agricultural workers are frequently associated with ageing, impacting heat tolerance and thermoregulation (Heidari et al., 2015; Kenefick & Sawka, 2007; Kenney & Munce, 2003). Hesketh et al. found that younger age groups of farmers also had a higher proportion of HRI cases. The 18 to 24 age group accounted for 23 percent of accepted HRI claims, compared to 18 percent of all S.F. claims (P=.002; 95 percent CI= 0.020.08) (Hesketh et al., 2020).

3.2.3. Measures used to identify heat stress

The principal environmental factor, i.e., humidity, ambient temperature, radiation of hot objects, and wind velocity, often affects the heat balance of the human body, leading to physiological changes—workload, health status, clothing, etc. (Parker & Pierce, 1984). ISO 7933 or ISO 7243 suggested that above 38oC core body temperature measures are essential to direct work output and productivity and reduce heat exposure (Holmer, 2010). Numerous heat stress indices are invented to recognize the conditions when workers cannot cope with the situation, and preventive measures become essential (Crowe et al., 2009; Holmer, 2010; Parker & Pierce, 1984). Wet Bulb Globe Temperature and Wet Globe Temperature (WGT) indices associated with humidity, ambient temperature, radiation of hot objects, and wind velocity are commonly used to measure heat stress in hot and humid working environments. The WBGT is possibly the most well-known and used worldwide and adopted as an international standard. WBGT works as a matric that generally follows ISO 7243 standard for measuring the ergonomic effects of hot climates. The Industrial Hygienists and the American Conference of Governmental Industrial Hygienists both extensively employed a heat index to identify heat stress threshold limits values (TLVs) (ACGIH (American Conference of Governmental Industrial Hygienists), 2015).

Further WBGT measures heat stress very quickly with the help of climatic or environmental factors and deliver required work-rest time ratio standards in the hot environment (Holmer, 2010). Thermal Work Limit (TWL) is also an important index used in work-related settings. Apart from skin temperature and core body temperature is more important than other metrics of heat. Other popular indices of Canada and the U.S. are Humidex and National Weather Service (NWS), which generally identify environmental hotness by merging the effects of humidity and heat (Acharya et al., 2018).

3.2.4. Severity of heat stress impact on agricultural workers

We found a potential percentage of farmworkers who claim heat-related illness by reviewing heat stress-related studies on more than 5 million agricultural workers (HRI). Jackson and Rosenberg reported that out of total heat-related deaths in the U.S. between 1992 to 2006, 67% of deaths were associated with agriculture and its sub-sector (Jackson & Rosenberg, 2010). Days with temperatures above the 95th percentile, calculated as a daily average, both on current experimental days (95 percent confidence interval (CI): 1.008–1.242; Odd Ratio = 1.119) and in 17.0 ±3.6°C (95 percent CI: 1.013–1.249; Odd Ratio = 1.125), as well as daily maximum temperatures, were associated with the most significant risk of work-related injuries in agriculture, according to Matteo Ricc, (2017) (Matteo Ricc, 2017) [6]. From earlier research, crop labourers in the United States have a twenty-fold higher fatality rate than other jobs (Pogačar et al., 2017). Spector et al. observed that Claims of HRI were more mutual in crop production workers than other sector workers (Spector et al., 2014). Further, Stoklosa et al. also reported that heat-associated illness is four times common in the agricultural sector than in other sectors (Stoklosa et al., 2020). Based on the acknowledged physical exertion and perceived, it was observed native workers have a better threshold level (WBGT ≥ 29.3 ◦C) than migrant workers (WBGT ≥ 27.9 ◦C) (Messeri et al., 2019). It was found that from a previous study, due to heat stress, the productivity of farmers is substantially higher in between 6–9 am ($p < 0.001$) and 12–3 pm ($p < 0.001$) than 9 -12 am. Working in heat stress conditions, a common symptom in agricultural workers is difficulty breathing, rapid pulse, and elevated body temperature (Sadiq et al., 2019). While working outside and inside hot environments, outdoor farmworkers experience higher heat illness (35.6%) than indoor farm workers (13.9%) (Arcury et al., 2015). Spector et al. reported that outdoor farmworkers have higher traumatic injuries due to hot working conditions (Spector et al., 2016). Mutic et al. said that female farmworkers had three times more odd experiments (OR = 2.86, 95% CI 1.18–6.89) in hot and humid working conditions than males (Mutic et al., 2018).

Wesseling et al. found Sugarcane cutters in hot outdoor conditions have higher heat stress, more dehydration, and lower renal function than construction workers (Wesseling et al., 2016). ACGIH set the cut point for the WBGT index at 27.6 based on a heavy workload and 75 percent work plus 25 percent rest each hour (Heidari et al., 2015).

Blank found that the maximum H.I. ranged from 82°F to 93°F. Piece rate workers were more likely than hourly workers to put in more effort at work (adjusted OR= 4.08; 95 percent CI: 1.20, 13.80), and piece-rate workers were less likely to drink water infrequently (adjusted OR= 0.31; 95 percent CI: 0.12, 0.79). They also observed that piece-rate workers had a higher likelihood of self-reported HRI symptoms when compared to hourly workers (Blank, 2014).

3.3. Prevention Measures:

After reviewing the literature on heat stress on agricultural workers, some effective prevention measures and policies of earlier research priority are highlighted. Here we categorize some effective results and techniques of prevention strategies recommended by previous studies to reduce the severity of HRI in the agricultural sector.

3.3.1. Effective Work-rest Schedule

Work-rest scheduling is crucial for lowering the risk of injury in heat stress conditions among physically demanding workers. An accurate assessment of changes in physical stressors throughout work and recovery is essential to identify (Ning, 2011). Compensatory rest should be taken as soon as feasible, if not immediately after working, to counterbalance the consequences of working during a rest time. Suppose this is not practicable due to unusual circumstances (objective reasons). In that case, the employer must remember to provide the worker with whatever protection necessary to protect their health and safety (Richarson, 2017).

Agricultural labourers are likewise subject to California law's rest intervals. When employees work between 3.5 and 6 hours, they are entitled to a ten-minute break, and when they work between six and ten hours, they are entitled to two ten-minute breaks. A minimum of three ten-minute intervals is required for agricultural workers who work between 10 and 14 hours (Robertson, 2017).

An adequate Work-rest period reduces the probability of HRI in the agricultural sector. As a means of coping with the heightened heat stress, work-rest cycle changes that extend the time for physiological recovery are necessary.

Heidari et al. recommended work-rest for agricultural workers on average, 75% work and 25% rest per hour) (Heidari et al., 2015). Work–rest schedule based on body part discomfort ratings for agricultural worker mentioned by Tiwari et al. for three Schedule was 90 min work and 15 min rest, 75 min work 15 min rest and 60 min work and 15 min rest respectively (Tiwari & Gite, 2006). They determined that the duration of work bouts during rototilling operations by power tiller should not exceed 75 minutes, or the operators may experience physiological tiredness, which could lead to accidents and injury, based on the study's physiological and psychophysical findings. They observed that 10-minute rest periods are insufficient for recovering from weariness produced during the previous work session. They suggested that rest periods be kept to a minimum of 15 minutes to avoid significant postural pain. The lunch break should last longer than 45 minutes and should be planned between 13:00 and 14:00 hr when the ambient temperature is highest (Tiwari & Gite, 2006).

A survey of 100 farm labourers was undertaken by Singh and Mehta in 2013 to look into traditional agricultural methods and work-rest cycles in southern Rajasthan. According to the study, agricultural laborers prefer to work in the early and evening hours and avoid working during (Singh, 2013).

- 28 ◦C WBGT: Work for 60 minutes, then take a 15-minute rest.
- 29 ◦C WBGT: Work for 55 minutes, then take a 10-minute rest.
- 30 ◦C WBGT: Work for 45 minutes, then take a 22-minute rest.
- 31 ◦C WBGT: Work for 35 minutes, then take a 25-minute rest.

- 32 ◦C WBGT: Work for 30 minutes, then take a 30-minute rest.

Seasonal changes in the agriculture sector might result in shifts in work patterns. An employer must take a daily rest period of 11 hours of uninterrupted rest every 24 hours, according to Regulations (Northern Ireland) 2016 (WTR) (Robertson, 2017). Frimpong et al. stated in their study that the work-rest ratio for an average acclimatised agricultural worker dressed in light clothing for light work, medium work, heavy work, and heavy work ranging from WBGT 27 to 37 degrees Celsius was 0% rest/hour, 25% rest/hour, 50% rest/hour, 50% rest/hour, 75% rest/hour, and 100% rest/hour, respectively (Frimpong et al., 2017; Parker & Pierce, 1984). Zamanian et al. mention that half-time and half-time work-rest are needed in hot conditions for the IOEL, Iran group (Zamanian et al., 2017). Sahu et al. mentioned minor breaks (3–6 minutes) in their study on agricultural workers in the typical work time management. Five hours of work excludes rest breaks for replenishment, but small breaks (3–6 minutes) were included in the typical work time management (Sahu et al., 2013).

3.3.2. Acclimatization

Acclimatization is one of the most critical steps in avoiding heat-related illness at work by increasing the heat tolerance ability of workers' bodies in heat stress conditions. Acclimatization permits people to resist heat stress while avoiding the morbidity of heat-related disorders. Physical training to increase cardiac performance is the initial step in this process, which entails several physiological and biochemical changes. This allows for significant increases in epidermal blood flow without compromising oxygen supply to other vital tissues. Second, the circulatory system's plasma volume increases, renal blood flow is enhanced, and blood is diverted away from noncritical circulation beds like the splanchnic circulation system (McQueen, 2012). This lessens the damage to the kidneys that would otherwise occur due to mild to moderate degrees of exertional rhabdomyolysis (Charkoudian, 2003; McQueen, 2012). Finally, acclimatization increases the activation of the renin-angiotensin-aldosterone pathway, which allows the kidneys and sweat glands to retain sufficient salt and avoid volume depletion (McQueen, 2012; Sawka et al., 2003). A body generally can take up to two weeks to adapt to activity in hot weather.

Exertional HRI can be experienced by workers working in hot and humid environments, depending on their metabolic output and acclimatization level (Adam-Poupart et al., 2013). According to NIOSH, Workers should be acclimatized by progressively increasing their exposure time in hot environments over a 7-14 day period. For new personnel, the acclimatization schedule should include no more than a 20% exposure on day one and a 20% rise on each subsequent day. For personnel with prior working experience, the acclimatization regimen should be no more than 50% exposure on day 1, 60% exposure on day 2, 80% exposure on day 3, and 100% exposure on day 4 (NIOSH (National Institute for Occupational Safety & Health), 2018) .

Jackson and Rosenberg reported that due to lack of proper physiological acclimatization within the first week of work duration, 14% of workers claim HRI. Heat acclimation improves the body's physiological tolerance to heat. After some time off or a few days without working in the heat, acclimatization can wane. Agricultural labourers can get acclimatized to heat by working in hot weather for at least 2 hours each day for 4–14 days. However, acclimatization reverses in the days following the end of the hot work period (Jackson & Rosenberg, 2010).

Spector et al. reported that approximately 15% of agriculture and forestry HRI claimants had been on the job for less than two weeks when they were injured (Spector et al., 2014). Prudhomme and Neidhardt, conducted a study on California workers, including farmers, that 46% of workers were on their first day on the job, and 80% of incidents occurred within the first four days of employment (Prudhomme & Neidhardt, 2006, 2007).

Marois et al., 2013 conducted a study on 467 hired farmworkers. They observed that Water consumption was low, with an average of 10.7 glasses per day, and knowledge of acclimatization was insufficient, with 44% grossly underestimating the time required to acclimatize (Stoecklin-Marois et al., 2013).

Mix et al. was collected blood and urine samples of agricultural workers have collected over 555 workdays during the summers of 2015 and 2016. They reported that due to improper acclimatization Pre-shift, 53 percent of workers were dehydrated (USG 1.020) and 81 percent were dehydrated afterward; on at least one workday, 33% of subjects suffered acute kidney injury (AKI)/ For every 5 degrees (°F) increase in heat index, the risk of AKI increased by 37% (Mix et al., 2018).

3.3.3. Policy

Currently, only California and Washington of the USA have heat hazard regulations to protect farmworkers from HRI (Pogačar et al., 2017; Sawka et al., 2003). Costa Rica passed laws in 2015 requiring agricultural companies to provide rest breaks, water, shade, and protecting apparel to those who work outside (Acharya et al., 2018; Chavkin, 2015).

For 95 percent of the working population, as a measure of heat strain, ISO 7933 defines a 5% limit for body mass loss. The ACGIH advises a maximum of 1 min. recovery, maintain a heart rate (H.R. of 120 bpm. In contrast, the HSE recommends calculating the workplace H.R. threshold based on the age of individual workers (Acharya et al., 2018).

According to OSHA, 2011 rule, employers should increase protective actions when the heat index rises (OSHA (Occupational Safety and Health Administration), 2011). In a nutshell, OSHA divided the risk into four groups based on the range of heat index values: lower, moderate, high, and very high/extreme are the four difficulty levels.

Water and shade; rest; training; constructing an HRI indication observing system; restrictive physical duties; acclimatization; postponing unnecessary work; adequate work/rest cycles, and so on are proposed recommendations of OSHA (Bethel & Harger, 2014; NIOSH (National Institute for Occupational Safety & Health), 2018). The ACGIH used wet bulb globe temperatures (WBGTs) and workload estimates to develop a system for measuring heat-related disease risk (NIOSH (National Institute for Occupational Safety & Health), 2018; Pogačar et al., 2017).

3.3.4. Other prevention measure

Even though the human body has enough ability to withstand heat stress, in the agricultural sector, heat stress becomes more threatening to workers' productivity and health due to higher workload. Apart from the above mention, effective prevention measures are some other necessary measures such as increased frequency of hydration, heat illness-related awareness and training program and campaign, engineering control, heat stress alert system, and protective clothing that effectively reduce the impact of heat stress on workers' health and productivity.

Blank observed that for every 30 minutes or more," hydration frequencies were compared to all other frequencies, the percent consciousness improved to 56 percent. Proper knowledge and training of workers play an essential role in reducing the workers' heat-related disorders (Blank, 2014). Training and awareness need about the adverse impact of heat stress, nature of heat stress, probable symptoms of heat-related disease, proper protective measures, etc. Workers should teach workers about the heat tolerance that significantly depends on a healthy diet and drinking water frequently (Singh, 2013). Apart from workers should be trained about the symptoms, signs, and first aid of heat disorders, which are associated with faintness, dizziness, palpitations, extreme thirst, breathlessness, etc., so that workers learn the basics of first aid and quickly recognize the sign and symptoms heat disorders.

Moreover, work-time shifting and working in the shade are other necessary effective measures. Morabito et al. observed that hourly productivity loss expressively decreases by shift and working in the shade of agricultural workers. The hourly P.L. and the related economic cost were significantly reduced ($p < 0.05$) by working in the shade and work-time shifting (Morabito et al., 2020). Mutic et al. concluded that farmworkers' HRI could be effectively reduced by on-site care, suitable work-related health strategy, early recognition of HRI, and engineering workplace controls (Mutic et al., 2018). Fleischer et al. was observed that the occurrence of 3 or more HRI indications (n=361, 34.3 percent) of migrants agricultural workers can significantly reduce by increasing access to medical attention (7.3 percent); breaks in the shade (9.2 percent); increasing access to regular intervals (6 percent)or dropping soda consumption (6.7 percent) (Fleischer et al., 2013). In their study, Mirabelli et al., 2010 reveal that sufficient water needs to drink of farmers to perform manual harvesting work to decrease health hazards (Mirabelli et al., 2010).

4. Conclusion

By properly reviewing the scientific priority of previous research, it was clear that heat stress-related disorder among farmers is in increasing order. The increasing demand of the impact of climate change in the form of heat stress conditions in the agricultural sector tremendously influences the agricultural worker's health, productivity, and livelihood. Now it is a big challenge for farmers to increase the production in the agricultural industry to feed the whole world in this rising heat stress condition. Earlier research priorities concluded that heat stress could effectively be reduced by low-cost measures, proper work-rest Schedule, hydration, heat stress awareness, and prevention training but need adequate implementation. Further assessment on the working capacity of agricultural workers in a worldwide hot and humid area, the intervention of more developed prevention measures, determination of participation of hereditary and nonhereditary factors in HRI in agricultural workers, assessment of the impact of heat stress along with other stressors in agricultural workers are required as future research to developed Policy for the sustainable livelihood in the agricultural sector.

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