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Field Study

Heat impacts on health and productivity: the case of two ready-made garment factories in tropical Bangladesh

Farzana Yeasmin[1,2,3] | Aaron J. E. Bach[2,4] | Jean P. Palutikof[2,5] | Fahim Tonmoy[6,7] | Fahmida Tofail[8] | Mahbubur Rahman[3] | Shannon Rutherford[1,2]

[1]School of Medicine and Dentistry, Griffith University, Queensland, Australia
[2]Cities Research Institute, Griffith University, Queensland, Australia
[3]Environmental Health and WASH, Health System and Population Studies Division, International Center for Diarrheal Diseases Research, Bangladesh
[4]School of Health Sciences and Social Work, Griffith University, Queensland, Australia
[5]National Climate Change Adaptation Research Facility, Griffith University, Queensland, Australia
[6]Adjunct Research Fellow, Griffith University, Queensland, Australia
[7]Sustainability & Climate Change, Deloitte
[8]Nutrition Research Division, International Center for Diarrhoeal Diseases Research, Bangladesh

Abstract

Objective: The ready-made garment (RMG) sector is pivotal to Bangladesh's economy, providing export opportunities and employment. To ensure sustained productivity and a thriving workforce, workplace hazards like heat must be acknowledged, assessed and managed. This paper explores heat impacts on health and productivity of production-line workers in two RMG factories of Bangladesh. **Methods:** Focus group discussions and in-depth interviews were conducted with the workers of two RMG factories in Dhaka in 2022 to identify perceived heat-related health and productivity impacts and explore barriers to workers accessing heat-related medical care. Key informant interviews were conducted with factory officials, onsite health professionals, government officials, the RMG peak body, and non-government organisation professionals with expertise in industry and workplace issues. **Results:** Workers and health professionals attributed symptoms like headaches, dizziness, fatigue and nausea to heat. Factory health professionals observed changes in cardiovascular strain (eg, altered blood pressure responses) in workers during summer. Other key informants identified higher absenteeism across summer. Heat was identified as an impediment to overall productivity by workers themselves and others working across the sector. **Conclusion:** This qualitative study identified how heat exposure in indoor work environments of RMG in Bangladesh influences health of workers and how productivity is influenced directly by heat but also indirectly via necessary cooling measures to reduce heat strain that take workers away from the production line. Despite knowledge of access to hydration as an important heat health risk mitigation strategy, quota pressures inherent in these factories restrict the use of this vital measure.

Keywords: extreme heat, heat stress disorders, occupational health, occupational stress, working conditions

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Correspondence
Farzana Yeasmin: School of Medicine and Dentistry, Griffith University, Queensland, Australia
E-mail: farzana.yeasmin@griffithuni.edu.au

Introduction

The health-related impacts of a person's working conditions are complex and depend on internal and external

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interrelated factors[1], including the specific demands of the job itself and the physical environment in which the job occurs. These impacts include occupational illness, injuries, and in extreme cases, death[1]. They relate not only to workers' wellbeing but are also connected to a company's productivity. Among the external factors which can impact employee health and productivity, climatic conditions are significant[2]. The Global South routinely confronts heat stress in the workplace and, due to the scarcity of effective countermeasures, is regarded as highly vulnerable to the impacts of climate change[3].

Workers in high-risk occupations, like construction, mining, firefighting, farming, and manufacturing, particularly in low-middle income countries in tropical regions, face excessive heat strain due to intensive physical labour in hot environments[4,5]. Heat exposure can influence the risk of occupational injuries, which can have an indirect impact on productivity[4,5]. Heat in the workplace can manifest in symptoms, such as fatigue, headache, seizure, fainting, and nausea, even if workers may not be clinically heat-stressed[5]. In the longer term, the identified health effects arising from chronic heat exposure include cardiovascular diseases, mental health problems, digestive diseases, dyslipidaemia, and kidney disease[6]. The lack of a systematic assessment of workplace risks and the reporting of heat-related health issues presents a significant challenge. Predicting heat-related illnesses at work is difficult because the early symptoms of heat stress are often mild, which likely leads to underreporting in occupational settings[5].

The ready-made garment (RMG) industry has been the driving force in Bangladesh's transition to an export-oriented economy[7]. The industry's success is linked to cheap labor costs, dynamic private entrepreneurship, and government policy support[7]. In 2019, the industry generated USD$34.1 billion (contributing 84% of export earnings) to Bangladesh's gross domestic product[8]. However, workers are low-paid[8,9], and poor working conditions in RMG factories are common, including insufficient lighting, poor ventilation, and extreme heat[10]. These impacts are compounded by job insecurity and inadequate compliance with regulations, resulting in significant physical and mental strain for workers, frequently causing a high incidence of illnesses, including those related to heat stress[10].

While poor working conditions remain a challenge, recent improvements have been made in Tier 1 factories (ie, those that receive direct orders from buyers) due to stronger legislation, especially since the 2013 Rana-plaza building collapse in Bangladesh[11]. However, Tier 2 factories ie, those (that sub-contract to these bigger companies) are still lagging behind in addressing many areas of risk.

Under a high greenhouse-gas emissions scenario (RCP 8.5)[12], Dhaka is projected to face an average increase of 3.9°C[13] by the end of the 21st century[13,14], leading to more frequent and more severe heatwaves[13]. During the months of April to June, outdoor maximum temperatures in Dhaka average 32 ± 2°C, with a corresponding relative humidity of 65 ± 14%[15]. The indoor temperature of garment factories in Bangladesh during the months of April to July can reach 38°C to 40°C during peak working hours[16,17]. Identifying present-day exposure to excessive heat among Bangladesh RMG workers is essential for understanding how heat-related risks are likely to evolve in the future.

There are still no comprehensive statistics that clearly articulate the extent of the heat hazard for RMG workers in Bangladesh. Further, there is limited publicly available data related to what extent workers and sector stakeholders consider heat a problem within the Bangladesh RMG industry. The lack of a systematic assessment of workplace risks and the reporting of heat-related health issues presents a significant challenge to prevention and management of this risk. While there has been some limited research in other sectors, there remains insufficient knowledge of health and productivity impacts of heat in Bangladesh's RMG sector. The aims of this research are to better define and understand the effects of heat on the health, wellbeing and productivity of RMG workers in Dhaka from diverse stakeholder perspectives.

Materials and methods

We conducted focus group discussions (FGDs), in-depth-interviews (IDIs) with the factory workers, and key informant (KI) interviews with sector stakeholders.

The qualitative researchers obtained written informed consent from all participants. Permission was granted to conduct the study activities from the management of the garment factories. We conducted the study during Dhaka's summer: May to July 2022. The FGDs and IDIs with factory floor workers were carried out at two factories in Dhaka (see Table 1) that were recruited following approval of management. The factories studied represent typical factories that have multiple stories (5–12 floors) with different activities spread across different floors.

Details of FGD participants are provided in Table 2. Data was collected via four FGDs. They were separated by gender to ensure that female FGD participants could respond freely. Table 3 provides example questions asked. The semi-structured FGD questionnaire did not always follow the same order, and additional questions were guided by the participants' answers.

To enhance the credibility and validity of the findings from FGDs, we conducted IDIs for verification and to obtain deeper insights (see Table 2). Factory managers assisted with recruitment of the pool of potential FGD and IDI participants and we engaged representative workers in common jobs, such as cutting, sewing, and ironing. FGD and IDI participants were different, and their questions were pre-tested with 'mock' interviews. We

Table 1. Characteristics of participating RMG factories

	Factory 1	Factory 2
Relevant factory characteristics	• Cooling methods: ceiling fans, exhaust fans, evaporative cooling fans • Onsite canteen • Onsite health clinic	• Cooling method: ceiling fans • No onsite canteen for workers • Onsite health clinic
Worker selection	• Cutting, sewing, and ironing • Participants were selected from the fourth and fifth floor	• Cutting, sewing, and ironing • Access to the factory was not granted – workers were provided by the factory authority from the sixth and seventh floor
Rest, break and requirements	• Lunch time is the only mandatory break for the workers - morning and afternoon breaks are optional. Workers take the one-hour lunch break sequentially, line by line	• Lunch time is the only break for the workers- there are no morning or afternoon breaks. Workers get a one-hour lunch break at the same time
Hydration	• Drinking water stations are available for workers on every floor	• Drinking water stations are available for workers on every floor
Available on-site health services	• One doctor (up to 12 pm) and one nurse (working hours) • No additional cooling at the clinic (only ceiling fans) • Two beds with curtains for privacy	• One doctor (up to 12 pm) and one nurse (working hours) • No additional cooling at the clinic (only ceiling fans) • Three beds with curtains for privacy

Table 2. Factory worker characteristics

	Focus group discussions		In-depth interviews	
	Factory 1	Factory 2	Factory 1	Factory 2
Sample size	16	16	4	4
Males, n	7	7	2	2
Age, years	25 [23–27]	27 [23–30]	28	24–28
RMG experience, years	3 [2–4]	2 [1–4]	3–5	2
Number of years of schooling	5 [3–8]	7 [5–9]	3–8	5–9
Monthly salary, $US	125 [110–140]	130 [110–150]	120–150	110
Females, n	9	9	2	2
Age, years	28 [22–35]	25 [20–29]	28–35	26–27
RMG experience, years	4.5 [2–7]	2 [1–3]	2	3
Number of years of schooling	7.5 [5–10]	7.5 [5–10]	8	6–7
Monthly salary, $US	113 [110–115]	113 [110–115]	130	120

Where applicable, data reported as median [range]

found that we achieved thematic saturation once we had conducted eight IDs.

Fifteen KIs were chosen for their expertise in industry and workplace issues to provide insights on the effects of excessive heat on workers' health and productivity (see Table 4). KI interviews were conducted with personnel from the original two factories along with personnel from an additional three factories.

Post data collection processing

The methods and goals of data collection are set out in Table 3. Data collection was carried out by two native Bengali speakers with expertise in qualitative research and anthropology backgrounds. Then the audio-recorded Bangla interviews were transcribed into English by the same two qualitative researchers, who are experienced transcribers as well. This translation aimed to ensure that the content of the interviews could be comprehensively understood and analyzed, removing any language barriers and maintaining the nuances and cultural context embedded in local phrases and expressions. Code lists for each of the question groups (ie, FGD, IDI, KI interviews) were prepared by two qualitative researchers separately.

Following individual coding and categorization, the research team worked together to draw inferences from the findings. Each researcher independently coded a subset of the data, and discrepancies were resolved through discussion and consensus. To further ensure reliability,

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Table 3. Data collection methods

Data collection methods	Objective of data collection	Data types and questioning	Example questions included

Focus group discussions (FGD)
• 4 groups
• 2 from each factory
  • 1 male FGD
  • 1 female FGD
• Each FGD 10-12 people
	Understanding of workers' perceptions of heat and its impact on health and productivity	• Workers' perceptions of heat stress
		• Perceived heat-related productivity impacts
		• Factors that influence workers' heat exposure
			• Do you consider that heat affects you in the workplace?
			• Is there a particular time of day, a particular time of year, in a particular job when you feel heat stressed?
			• Do you ever experience symptoms that might be related to heat exposure? Eg, faintness, headache, dizziness, heavy sweating, increased thirst, headaches, vomiting

In-depth interviews (IDI)
• 8 total IDIs
• 4 from each factory
  • 2 male IDI
  • 2 female IDI
	Explore in-depth the impact of heat on worker health status and productivity
	Explore in-depth the benefits and barriers to workers accessing medical care for extreme heat
		• Loss of production, not achieving work targets, loss of workdays/work hours due to fatigue/exhaustion, sickness/ hospitalization
		• Enablers and barriers to workers seeking to access medical care for extreme heat
			• If you experience heat-related health issues, does it affect your ability to do your job? How?
			• Do you face any challenges in achieving your expected quotas due to heat stress? How?
			• What medical care is available for you at work?
			• Is any health information provided in the workplace? E.g., information signs about dehydration, symptoms of heat illness

Key-informant (KI) interviews • Factory officials: 1 owner, 2 supervisors, 3 managers • Workplace health professionals: 2 doctors, 2 nurses • Government: 2 high-level national officials • Industry peak body: 1 representative • Nongovernmental organizations: 2 high-level professionals	Explore management/policymaker-perceptions of factory conditions and workers' welfare and productivity related to the hot season Explore management/policymaker perceptions of heat stress as an issue for the overall sector	• Effect of heat on RMG workers' health • Effect of heat on RMG workers' productivity • Enablers and barriers to workers seeking access to medical care for extreme heat	• From your observations/ knowledge of the industry/ experience, do RMG workers ever experience symptoms of heat-illness? • Do workers always achieve their work targets? Is heat a problem in using the labor force effectively to achieve hourly/ daily targets?

Table 4. Key informant interview participant characteristics

Position	Gender	Industry experience, years
Government official	Male	2
Government official	Male	2
Industry peak body representative	Male	30
Non-governmental organization	Male	31
Non-governmental organization	Male	4
Doctor (factory 1)	Female	2
Doctor (factory 3)	Male	7
Nurse (factory 1)	Female	3
Nurse (factory 3)	Female	6
Line supervisor (factory 1)	Male	4
Line supervisor (factory 1)	Male	7
Factory manager (factory 1)	Male	23
Factory manager (factory 2)	Male	13
Factory manager (factory 4)	Male	9
Factory Owner (factory 5)	Male	12

intercoder reliability checks were conducted, where a random sample of the coded data was reviewed by all coders to confirm consistency. The field notes used to capture informal discussions and observations were annotated for the tone and attitudes of the respondents. All data were analyzed considering the content and context, followed by comparison and triangulation.

The analysis approach adopted was thematic analysis. Themes were developed by grouping related codes by the study team, and these themes were then examined in relation to the study objectives. The process included constant comparison and triangulation, comparing findings across different data sources and respondent groups to validate the results and ensure comprehensive coverage of the research questions.

To reach data saturation, the research team monitored the emergence of new themes during the coding process. Data saturation was considered reached when no new themes or significant insights were identified in the later stages of coding, indicating that the data collection had captured the full range of perspectives relevant to the study. This thorough and systematic approach to data analysis aimed to ensure the reliability and trustworthiness of the findings, providing a robust basis for the study's conclusions.

Results

Four aspects of workplace heat and its reported impacts are explored based on the emergent themes developed from the collected data: these include impacts on worker health and access to within-factory health services, interrelationships between heat, health and productivity and barriers to the implementation of strategies to reduce heat-related impacts.

Heat and RMG worker health

Heat was reported by all workers to be worst in the afternoon, especially between 13:00–16:00 during the April to June summer season.

Sources of heat-related discomfort for workers were stated by supervisors, managers, industry peak body, and workers in RMG factories to include proximity to, and working with, machines that are substantial heat sources, such as irons; jobs requiring exertion, such as packing and ironing; working in locations where mechanical cooling, such as fans, are absent; and wearing of traditional women's clothing, such as the hijab or burka, which may be many-layered, close-fitting, and/or made of heavy non-breathable fabrics.

Sweating was a commonly reported heat response, and many of the workers reported experiencing headaches, fatigue, and dizziness on hot days. Some indicated they felt nauseous, suffered from gastro-intestinal discomfort or diarrhea, while others indicated frequent thirst, dry throat, or loss of appetite. Some female workers reported symptoms indicative of a urinary tract infection (UTI). Symptoms of all reported illnesses were also identified as being worse in summer by the factory health professionals, suggesting heat as a contributing factor. A few workers indicated that, following blood pressure checks at the factory health clinic, the factory health professional attributed their blood pressure abnormalities directly to the heat experienced in the factory. One factory doctor stated:

> *"Headache, neck ache, are very common heat-related illness to the workers and they cannot stand; their hands and legs are shaking. We understand by observing their appearance that they become dehydrated due to excessive sweating. We measure blood pressure and find it very low."* KI 7

The workers expressed their understanding of the negative impacts of heat on their well-being and productivity. Almost all of the KIs (n = 15) recognized that heat is a risk for workers' health. One non-governmental organization (NGO) KI confirmed the ongoing issue of heat-health risks for the RMG sector. However, this understanding may not be industry wide, as stated by a peak body representative:

> *"Once some workers in a garment factory got sick but they could not feel that it was due to the heat. Some workers fainted however they didn't understand that it was due to hot weather."* KI 3

Despite these identified problems, improvement in conditions was recognized by a government informant who indicated:

> *"In the last 20–30 years it* [overall management] *has improved a lot and it was possible because of all NGOs and others working together. Now it has a good standard."* KI 1

And in contrast to heat risk in other sectors, one government KI expressed the opinion that excess heat in the RMG was not a widespread issue:

> *"If I compare with other sectors, RMG factories have reasonable temperatures. I don't think it is high, it is healthy, I think. Because we have sufficient windows as I visited garment factories in the last couple of years, working conditions have improved a lot. In that case, heat I don't think is currently a big concern.* KI 2

Further, when government KIs were asked about heat-related illnesses in garment factories, they expressed that they had not heard about this issue from factory management.

We found a clear contrast between the perceptions of heat-related risks by factory floor workers and those of government representatives (ie, policymakers). Workers expressed that heat is an issue, with the potential to affect their health and productivity. However, a few policymakers indicated that heat in this sector is not concerning.

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Access to health services

We found in our study factories, on-site factory health services have an important role to play, both in educating the workforce about heat-related risks, and in addressing heat-stress-related symptoms. The extent of health services available in RMG factories is highly dependent on factory size, with smaller units generally lacking full-time doctors while the factories in this study had on-site doctors for at least half of the working day (Table 1). Conversations with workers and a majority of KIs revealed that factory doctors undertook both prevention and treatment activities, addressing issues like preventing excessive heat impacts through health promotion meetings, where they emphasize the importance of adequate hydration, and encourage breaks when feeling exhausted, while also providing health care training to new recruits. Government informants indicated that there is room for improvement in factory-provided worker healthcare, with one suggesting a need to increase the number of beds in the medical centers of many factories.

Heat and productivity

Factory KIs (managers, owner, supervisors) explained productivity measures and influencing factors in their factories. One factory owner described what productivity looks like for their RMG factory:

> *"Productivity is determined by balancing the production line, considering machine placement, estimating output, and analysing operations to calculate overall efficiency."* KI 15

The owner went on to explain the impact of worker absence:

> *"To mitigate the impact of worker absences on the production line, our factory uses a line balancing system with 14 operators and two extras for each line, maintaining operational stability; however, simultaneous absences can still affect production."* KI 15

All KIs were clear that productivity could be affected by the physical and mental conditions of the workers.

Factory management acknowledges the adverse effects of heat on workers, highlighting increased fatigue and more rest breaks, impacting production negatively. Furthermore, they indicated that higher sickness rates and absenteeism during summer can hinder meeting production targets. This awareness is reflected throughout the factory, in the factory floor workforce and in the medical support staff.

The industry representative highlighted that worker absence is a significant factor contributing to negative productivity:

> *"Heat-related problems disrupt workflow on the factory floor. Trying to replace the same expert hands in the operational line is difficult when a worker from that line becomes sick."* KI 3

Workers overall indicated that heat impacted their ability to work to the expected standard. A factory worker reported:

> *"Due to heat stress, we feel headache, neck ache which negatively affect our mental condition and make our work slower."* Worker 9

The medical staff shared the view that heat affects workers' well-being with knock-on effects on productivity. Medical staff also reported some indirect health impacts of heat, including an uptick in workplace injuries, particularly needle injuries, and incidents like falling, during hotter months.

Barriers to implementing heat adaptation strategies in RMG sector

Less than half of the male workers from the FGDs of Factory 1 and Factory 2 said that they alleviate heat-related discomfort primarily through hydration, supported by adequate water provision infrastructure on each floor in both studied factories. Many workers indicated that during the summer season they frequently felt thirsty. Many ascribed their thirst to the excessive heat on the factory floor, especially between June and August. Most were aware of the health impact of drinking too little water and acknowledged that they drink too little during their shift.

One potential barrier to accessing and drinking sufficient water to maintain hydration is the pressure to fulfill production quotas. At Factory 1, there were apparently no managerial restrictions on water intake; however, as one factory doctor stated:

> *"If they drank enough [water], they would not be weak. We encourage them [to drink water], but they cannot do it due to work pressure."* KI 7

From the FGD most of the workers of Factory 2 said that they feel constrained by quota pressures and often sacrifice frequent water breaks when they need to refill their water bottles. They also mentioned that authorities' reluctance to encourage hydration breaks so as to maintain production levels, coupled with some supervisors scolding workers for taking breaks, leads to instances where workers choose to skip drinking water. They face pressures to stay at their workstations from both supervisors and co-workers striving to meet quotas.

In the FGDs, some female workers from Factory 1 and Factory 2 mentioned that clothing was also a barrier to heat adaptation, as social norms require women to wear multiple layers. Another barrier identified by workers of Factory 2 was that they were not allowed to operate the cooling devices themselves and must wait for the designated operator to do so. They also mentioned the lack of technical capacity to address issues when the cooling devices became inactive. Another barrier they face is the delay in repairing the cooling devices.

Discussion

Three key findings have emerged from this qualitative study exploring the relationships between heat, health, and productivity in Bangladesh's RMG sector. First, the health impact of day-to-day heat exposure on RMG workers during the summer season is acknowledged by both workers and factory management, but not adequately recognized by government officials, posing a concern for strengthening the industry's resilience to global warming. Second, heat is widely acknowledged to detrimentally affect productivity in RMG factories through various pathways, including heat-related illnesses, workplace injuries, diminished work capacity, and absenteeism. Third, there is widespread awareness among workers, management, and medical staff of strategies to reduce heat-related risks, but barriers exist to their consistent use, suggesting the need for more formal and enforced heat management protocols.

Detecting early adverse health impacts from heat exposure is challenging due to diverse symptoms, such as headache, fatigue, dizziness, nausea, and loss of appetite, reported in our study. However, on-site health professionals noted serious markers, like abnormal blood pressures and UTIs, in heat-affected workers. These risks may overlap with those in other labor-intensive industries; however, the RMG industry presents unique challenges due to prolonged hours in confined spaces with inadequate ventilation, high machine-generated heat, and limited breaks. The findings suggest that the working conditions in the RMG industry exacerbate heat-related health risks in ways consistent with that of other indoor piecemeal workers working in hot climates and/or hot conditions[18]. Workers from the RMG factories in other countries, like Vietnam and India, commonly reported excessive sweating as a heat response, along with other symptoms, such as headaches, fatigue, dizziness, and frequent thirst[19,20]. Additionally, symptoms such as headaches, physical discomfort, fatigue, declining psychomotor performance, loss of concentration, and reduced alertness can lead to work-related injuries and accidents[21]. Emerging evidence suggests that occupational heat stress has a significant association with other types of injuries as an indirect effect of heat exposure[22].

Heat has a negative impact on worker productivity, leading to heat stress and related health issues[23]. Management and health professional informants in our study acknowledge its influence on productivity and workers' well-being.

A visualization of heat–well-being–productivity pathways

Using the multiple relationships between heat and productivity explored here we have conceptualized the pathways linking heat, worker well-being and productivity in RMG factories (Figure 1). Workers are exposed to heat strain associated with different factors including ambient temperature, clothing, work intensity and individual characteristics (eg, age, gender, health status, body morphology)[24]. The evidence identified via our qualitative inquiry suggests that heat strain leads to behavioral modifications (such as self-pacing, hydration). These adjustments can affect workers' productivity via two pathways.

Pathway 1: employing certain behavioral adjustments, such as self-pacing, proper hydration and rest breaks, or alternatively, neglecting to make such adjustments, can result in diminished work capacity, slower work speed

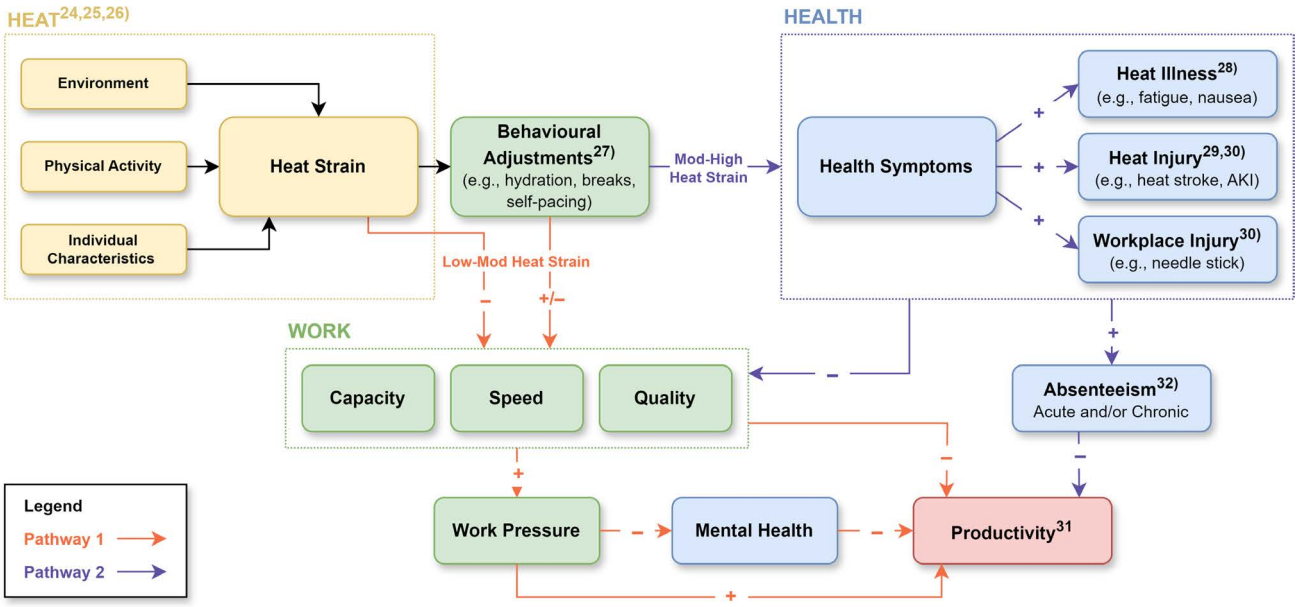

Fig. 1. A pathway model linking heat impacts to health and productivity

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and a higher incidence of errors[25,26]. The interplay of these factors increases work pressure in a production line, potentially compromising mental health and reducing productivity. Alternatively, heat strain can directly lead to reduced performance and therefore contribute to decreased productivity.

Pathway 2: in the absence of adequate health practices, heat strain can lead to several health symptoms, which can be classified as heat illness[27]. These symptoms include exhaustion, fatigue, and nausea, all of which were highlighted in our discussions with workers and management[28,29]. Heat illness can lead to carelessness while operating machinery and workplace injuries (eg, needle injury)[30]. These, in turn, can lead to absenteeism (from hours to days)[31] and reduced productivity[28].

Pressure to meet quotas can exacerbate health risks[32], affecting hydration practices and overall performance. We identified this barrier, which may be consistent with the situation in other industries with similar characteristics. In a recent study, some barriers to the implementation of heat adaptation strategies were explored in workers in Thailand. In this study, researchers found that consistent breaks in an on-site cooling oasis or the use of cooling vests reduced thermal and cardiovascular strain among indoor sawmill workers compared to the control group. However, the cooling interventions introduced also reduced the number of products the workers produced compared to the control group. During extreme heat events, piece-rate workers often face the dilemma of choosing between self-preservation and income stability, a situation exacerbated by workplace deadlines, pressures, and deliverables that may eliminate the option of self-pacing entirely[33]. Ensuring occupational safety and health management is crucial for organizational performance[34], as heat strain directly threatens worker well-being and efficiency[28]. The recent release of Bangladesh's National Guideline (NGO and Government partnership/collaboration) for Heat-Related Illness 2024 outlines the clinical manifestations and general management of heat-related illnesses[35]. It identifies outdoor workers as a vulnerable group for heat; however, it lacks specific guidance on managing heat-related illnesses or reducing heat exposure for indoor (eg, RMG) workers and outdoor workers. This deficit means there is an absence of any publicly available guidance or policy on managing heat-related illnesses for RMG workers in Bangladesh.

Many informants noted increased summer absenteeism leading to negative workplace outcomes, including failure to meet production quotas. Proper implementation of workplace health and safety measures is mutually beneficial for workers and organizations, directly enhancing productivity and profit[36]. A warming future, where it may become impossible to fully adjust to rising temperatures, could lead to substantial decrease in labor productivity, potentially causing significant economic repercussions[34]. If the workers continue working in conditions of surpassing heat limits, there is also potential for clinical health repercussions[37]. On the other hand, those workers who adapt by slowing down (ie, pacing) their work may prevent such adverse effects at the cost of decreased productivity[37]. While the physiological reasons behind the decline in human performance and work capacity are widely understood, their integration into assessments of the impacts of climate change has been fragmented until now[34].

Though most KIs, including the NGO and the industry peak body representative, mentioned the severity of heat in RMG factories, our government interviewees argued that many improvements have been made in the RMG sector over the last decade. While this is certainly the case for safety issues, such as fire evacuation protocols[38], environmental factory conditions including heat appear to remain an important workplace health issue[39]. Part of this may be a lack of systematic assessment of workplace risk[40] or reporting of heat-related health issues. Predicting heat-related illness at work is challenging as the early symptoms of heat stress are mild, possibly contributing to the underreporting of such cases in occupational settings[5]. Our study suggests that the absence of centralized reporting contributes to government staff's lack of awareness of the severity of heat-related issues, especially given that these risks will, without action, increase substantially in the future. Industry representatives noted a lack of awareness among workers and management in identifying heat-related illness, citing an incident where workers fainted due to heat exposure, but neither the workers nor the factory managers recognized the cause as heat-related.

Our findings also highlight the valuable role of health service provision in RMG factories, including doctors, nurses, and some dedicated infrastructure (such as clinical space and beds for rest). We found these factory-employed health professionals play both prevention and treatment roles, although their primary focus is on managing acute issues. They were aware of the impacts of heat on worker health and could articulate seasonal patterns of heat-related illness symptoms. Their reports of increased service demand and absenteeism in summer confirm their importance in informal heat surveillance and heat prevention and treatment and assessment of the potential risk. Their observations raise questions about the adequacy of services to cope with seasonal demand (eg, sufficient beds for rest, sufficiently cooled health clinics) and confirm the likelihood of heat influences on productivity. Further, the factory clinics of both factories investigated lack air conditioning, which would offer immediate relief to heat-stressed workers. Without cooling, these clinics have limited capacity to assist workers experiencing heat-related illnesses. Further, while protocols and supports are in place for severe and acute health risks, like needle

injuries, consideration of treatment of heat-related illness or screening for chronic related conditions that can be exacerbated by heat appears non-existent.

Limitations of this study

Primarily due to access constraints, workers from only two factories, and the management, health professionals, and owners from only five factories were included. Instead, this study facilitates the identification of further inquiry questions that could be used to underpin workplace health and safety assessment needs and/or generate training and support guidance for the sector. This research did not specifically examine any of the guiding government policies or industry guidelines related to RMG buildings and design, workplace health and safety, or energy efficiency. Any comments on these are based on the individual perspectives of informants.

Recommendations

On the basis of our study findings in this paper, we recommend:

- Increased industry surveillance of heat as a workplace hazard, including a heat preparedness and warning system that can be used to trigger improved cooling and health service provisions when they are most needed.
- Improved surveillance of heat-related illnesses and associated health conditions to identify worker vulnerability as well as peak times of risk. Additionally, better records of health service demand are crucial for ensuring sufficient infrastructure, including staff, cooling facilities, water, and rest areas, especially during summer months.
- Increased analysis of heat impacts on productivity so that investments can be made in effective heat adaption measures.

Conclusions

Heat is clearly apparent as a workplace hazard in the participating RMG factories. Without sufficient measures, heat-related risks to workers' well-being and productivity will escalate as the climate warms.

Despite awareness of heat-related impacts and available strategies, major barriers exist, such as pressure from supervisors, insufficient cooling systems, and lack of recognition of this risk at the policymaking level. Whereas some barriers can be addressed through information campaigns, introduction of regulation, and willingness to finance improved infrastructure (eg, mechanical cooling in critical areas, such as factory clinics and ironing stations), others will require fundamental shifts in the work culture that appear to prioritize productivity over worker health.

This research highlights the need to build RMG sectoral capacity for surveillance of heat exposure and heat-related health risks to workers, as well as for improvements in government legislation to provide incentives for factory owners and the RMG sector to identify and address heat-related risks.

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Authors' contributions

FY, SR, JP, AB, FT contributed on study conception and the study design. FY collected the data. SR, FY and AB analyzed and interpreted the data for the work. FY drafted the work, JP, AB, FT, FT, MR and SR reviewed it critically and gave final approval of the version to be published.

Conflicts of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Institution and ethics approval and informed consent

We obtained written informed consent from the study participants as well as verbal permission to conduct the study activities from the management of the garment factories. The study protocol was reviewed and approved by the ethical review committee of Griffith University (HREC 2022/419) and review committee of the International Center for Diarrhoeal Diseases Research, Bangladesh.

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Consent to participate

Participants were required to read and provide their informed written consent, before starting data collection.

Availability of data and material

All the primary data are part of results and discussion.

ORCID

Farzana Yeasmin https://orcid.org/0000-0002-3123-7452

Aaron J. E. Bach https://orcid.org/0000-0002-5581-5018

Jean P. Palutikof https://orcid.org/0000-0002-5248-6925

Environmental and Occupational Health Practice

Fahim Tonmoy https://orcid.org/0000-0002-0963-112X
Fahmida Tofail https://orcid.org/0000-0003-2301-9196
Shannon Rutherford https://orcid.org/0000-0002-5851-2987

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Appendix

Questionnaire for KIIs (Owners, Managers, Supervisors, onsite health professionals, BGMEA professionals, NGO professionals, Government officials)

1. Theme 1. Demographics:

101. What is your current Position and how long have you been in the same position?

102. What is your role in your current position?

103. May I know a bit about your previous work experience? Please describe your work experience.

2. **Theme 2. Heat and how heat affects health:**

201. What do you think about heat as a potential concern for Bangladesh?

Probe: What do you think about heat as a potential concern for workers in RMG?

Probe: What do you think about heat as a potential concern for workers in your factory (only for the factory professionals)?

202. From your observations/ knowledge of the industry/experience do the workers of the RMG ever experience symptoms like faintness, headache, dizziness, heavy sweating, increased thirst, headaches, vomiting (Sec 2.1.2 table 1) If yes, when? Is it a time of day, time of year, while doing a particular job (for the factory professionals)?

Probe: If yes do you think these health issue has any relation with heat? How? What do you base this on (for the factory professionals)?

Probe: What do you do when the workers experience these symptoms at your workplace (for the factory professionals)?

203. Do the workers face heat stress in the RMG sector?

204. How often do the workers drink water usually? How much do they drink usually? Do you think it is enough? If not, why not (for the factory professionals)?

205. Are there barriers to drinking and, if so, what are these? Do you think these barriers can be minimized? How (for the factory professionals)?

3. Theme 3- Heat and productivity: We know that the RMG sector in Bangladesh is responsible for 84% of national export earnings (Swazan et al., 2022). The long-term sustainability of the garment industry depends on the productivity of the individual factories. Occupational heat stress within the garment sector presents a direct threat to worker productivity and through declining worker health and wellbeing as well as increasing the likelihood of workplace injury.

301. How do you measure productivity in your factory? What is the minimum required output per hour of the organization and what are the difficulties in meeting productivity targets (for the factory professionals)?

302. What things impact productivity (for the factory professionals)?

303. Do the workers always achieve their work targets? Can you provide some reasons behind missing the work targets? Is heat a problem in using the labour force effectively to achieve hourly/daily targets? If yes, please describe how (for the factory professionals)?

304. Do you believe there is any relationship between heat and productivity? If yes explain this and based on what evidence?

305. Do you think heat-related illnesses or disorders have any impact on your productivity? How?

306. Do you think if any worker face illness, then the whole line face productivity loss? If yes, how do you overcome this loss?

307. Do the workers loss their workdays/work hours due to fatigue/exhaustion, sickness/hospitalisation or heat related illness? Do you think for workers' illness the RMG face productivity loss? If yes how the factory overcome this? Do you think these illnesses can be minimized? If yes how? What strategy will you suggest to minimize this?

308. Do the workers face any injury during their work? Do you think heat exposure has an effect on the risk of occupational injuries? If yes how? Do you think these injuries have an impact on productivity? How? How do you know and based on what evidence?

4. Theme 4- Heat reduction strategies and Barriers to cooling options and medical care: there are many ways we can reduce heat risk in our workplaces

401. Do you feel there is a need for heat intervention strategies in Bangladesh?

Probe- Do you feel there is a need for heat intervention strategies in RMG?

Probe- Do you feel there is a need for heat intervention strategies in your factory (for the factory professionals)?

402. Do you observe any existing intervention strategies going on to mitigate excessive heat? Specifically, what does the RMG industry currently do to reduce heat exposure and cool their factories?

403. Do they do anything more or different when extreme heat events occur? If yes, what are those?

404. Do you have any suggestions to mitigate excessive heat for the workers during hot periods and or extreme heat events?

405. Do the workers use their hydration break? Is the break enough for them? Do you think more hydration break will be helpful? What are the barriers to take more hydration breaks? Is it feasible (for the factory professionals)?

406. Do you use any ventilation to reduce heat/What are the role of ventilation? What are the barriers to provide proper ventilation? Is it feasible?

407. Do you think the clothing has an impact on heat stress? What are your instructions for appropriate clothing to work in this area (probe: for male and female)? What are the barriers? Is it feasible to instruct some appropriate clothing?

408. Do the workers work in the same place for the whole day long? Do you think rescheduling can be helpful to mitigate heat stress? Why or why not? How (for the factory professionals)?

409. Do organisations face barrier to introduce cooling options? If yes, what are the barriers for the factory professionals)?

410. What actions might be taken to overcome these barriers (for the factory professionals)?

411. Do the organisations face barriers to introduce medical care if the worker faces extreme heat? What are the barriers? How do they mitigate these barriers (for the factory professionals)?

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1. Theme 1. Demographics:

101. years of work

2. Theme 2. Heat and how heat affects health:

201. What kind of job do you do here and how long have you been doing this job in this factory? In this sector?

202. What do you think about heat? When do you feel hot during your usual working day? Is there a particular time in the day, a particular time in the year, in a particular job?

203. How often do you drink usually? How much do you drink usually? Do you think it is enough? If not why not?

204. Are there barriers to drinking and, if so, what are these? Do you think these barriers can be minimized? How?

204. Do you ever experience symptoms like faintness, headache, dizziness, heavy sweating, increased thirst, headaches, vomiting (Sec 2.1.2 table 1) If yes, when? Is it a time of day, time of year, while doing a particular job?

205. Do you think these health issues have any relation with heat? How?

206. What do you do when you experience these symptoms at your workplace? Can you share your experiences in detail when you faced one of this/these symptoms at your workplace?

207. Do you face heat stress in your working station? Will you please describe this stress?

208. What strategies do you apply to mitigate these stresses?

3. Heat and productivity:

301. Do you think heat-related illnesses or disorders have any impact on your productivity? How?

302. Do you face any problems to achieve your expected performance due to heat stress? How?

303. Do you always achieve your work targets? What are the reasons behind missing your work targets?

304. Do you lose your workdays/work hours due to fatigue/exhaustion, sickness/hospitalisation or heat related illness?

305. Do you face wage loss during summer due to heat stress? How?

306. Do you face any injury during your work? Do you think heat exposure has an effect on the risk of occupational injuries? If yes how?

307. Do you think these injuries have an impact on productivity? How?

4. Direct impact of heat on productivity:

401. Do you think if any worker face illness, then the whole line face productivity loss? If yes how do you overcome this loss?

402. Do you think for workers' illness the RMG face productivity loss? If yes how the factory overcome this?

403. Do you think these illnesses can be minimized? If yes how?

404. What strategy will you suggest to minimize this?

5. Intervention?

501. Do you feel there is a need for heat intervention strategies?

502. Is there any existing intervention strategies going on to mitigate excessive heat? Specifically, what the industry currently does to reduce heat exposure and cool their factories.

503. Do they do anything more or different when extreme heat events occur? If yes, what are those?

504. Do you have any suggestions to mitigate excessive heat for the workers in summer?

505. Do you have hydration break? Is the break enough for you? Do you think more hydration break will be helpful? What are the advantages or disadvantages to take more hydration breaks?

506. Do you think the clothing has an impact on heat stress? What are your suggestions for appropriate clothing to work in this area (probe: for male and female)? What are the advantages and disadvantages?

507. Do you work in the same place for the whole day long? Do you think rescheduling can be helpful to mitigate heat stress? Why or why not? How?

6. Barriers to cooling options and medical care:

601. What cooling options do you have at your workplace?

602. Do you face any barrier to access these cooling options? If yes, what are the barriers?

603. How do you overcome these?

604. What actions might be taken to overcome these barriers?

605. Do you face any barriers to get medical care if you face extreme heat? What are the barriers? How do you mitigate these barriers?

606. What actions might be taken to overcome these barriers?

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1. Theme 1. Demographics:

101. years of work

2. Theme 2. Heat and how heat affects health:

201. What kind of job do you do here and how long have you been doing this job in this factory? In this sector?

202. What do you think about heat? When do you feel hot during your usual working day? Is there a particular time in the day, a particular time in the year, in a particular job?

203. How often do you drink usually? How much do you drink usually? Do you think it is enough? If not why not?

204. Are there barriers to drinking and, if so, what are these? Do you think these barriers can be minimized? How?

204. Do you ever experience symptoms like faintness, headache, dizziness, heavy sweating, increased thirst, headaches, vomiting (Sec 2.1.2 table 1) If yes, when? Is it a time of day, time of year, while doing a particular job?

205. Do you think these health issue has any relation with heat? How?

206. What do you do when you experience these symptoms at your workplace? Can you share your experiences in detail when you faced one of this/these symptoms at your workplace?

207. Do you face heat stress in your working station? Will you please describe this stress?

208. What strategies do you apply to mitigate these stresses? Are the strategies useful? Do you think any strategy can be added?

3. Heat and productivity:

301. Do you think heat-related illnesses or disorders have any impact on your productivity? How?

302. Do you face any problems to achieve your expected performance due to heat stress? How?

303. Do you always achieve your work targets? What are the reasons behind missing your work targets?

304. Do you loss your workdays/work hours due to fatigue/exhaustion, sickness/hospitalisation or heat related illness?

305. Do you face wage loss during summer due to heat stress? How?

306. Do you face any injury during your work? Do you think heat exposure has an effect on the risk of occupational injuries? If yes how?

307. Do you think these injuries have an impact on productivity? How?

308. Do you think if any worker face illness, then the whole line face productivity loss? If yes how do you overcome this loss?

309. Do you think for workers' illness the RMG face productivity loss? If yes how the factory overcome this?

310. Do you think these illnesses can be minimized? If yes how?

311. What strategy will you suggest to minimize this? Do you think the strategy you suggested are applicable for Bangladesh?

4. Intervention

401. Do you feel there is a need for heat intervention strategies?

402. Is there any existing intervention strategies going on to mitigate excessive heat? Specifically, what the industry currently does to reduce heat exposure and cool their factories.

403. Do they do anything more or different when extreme heat events occur? If yes, what are those? Is that useful for you?

404. Do you have any suggestions to mitigate excessive heat for the workers in summer? What will be the advantages and disadvantages to apply this?

405. Do you have hydration break? Is the break enough for you? Do you think more hydration break will be helpful? What are the advantages or disadvantages to take more hydration breaks?

406. Do you think the clothing has an impact on heat stress? What are your suggestions for appropriate clothing to work in this area (probe: for male and female)? What are the advantages and disadvantages?

407. Do you work in the same place for the whole day long? Do you think rescheduling can be helpful to mitigate heat stress? Why or why not? How? Do you have any option to reschedule your work? If yes, How?

5. Barriers to cooling options and medical care:

501. What cooling options do you have at your workplace? Is it sufficient for you?

502. Do you face any barrier to access these cooling options? If yes, what are the barriers?

503. How do you overcome these?

504. What actions might be taken to overcome these barriers?

505. Do you face any barriers to get medical care if you face extreme heat? What are the barriers? How do you mitigate these barriers?

506. What actions might be taken to overcome these barriers?