The Economic Cost of Heat Stress in Bangladesh's Ready-Made Garment Industry: Evidence on Productivity Loss, Medical Expenditure, and Absenteeism

Shah Md. Al-Emran Sarker

Assistant Professor, Faculty of Business, ASA University Bangladesh, Dhaka, Bangladesh

*Corresponding Email: emran@asaub.edu.bd

ABSTRACT

The ready-made garment (RMG) sector is the second largest sector in the world in terms of employment in Bangladesh, which employs around 4-5 million people and generates more than 84% of the country's export earnings. While the evidence of economic and health effects of increasing temperature on the health and productivity of RMG workers are growing, there is no empirical study to quantify the total economic cost at the sector level due to heat stress. A cross-sectional study surveyed 400 production line workers in 20 factories in Dhaka, Gazipur and Narayanganj between March and September 2024 and assessed wet-bulb globe temperature (WBGT) and productivity loss, absenteeism and self-reported out of pocket (OOP) expenditure on heat-related illnesses. Multivariate ordinary least squares (OLS), Poisson regression and a two-part expenditure model were estimated. 92.3% of pre-monsoon working days in the factories experienced mean WBGT above the ISO 33 C action limit. For every 1 C increase in WBGT, there was a 1.82 percentage-point rise in self-reported productivity loss ($p < .001$) and a 0.54 percentage-point increase in absenteeism ($p < .001$). The mean annual OOP expenditure was estimated to be BDT 2,560 (USD 23.3) per worker related to heat. At the sector level, the total economic costs estimated for the whole year are BDT 31.14 billion (USD 283.1 million) or 9.24% of the wage bill of the sector. This is expected to increase to USD 476.4 million by 2030, under the RCP8.5 business-as-usual climate scenario. These findings highlight the importance of implementing WBGT-based heat standards in the International Accord framework, mandatory cooling infrastructure, and paid heat leave policies.

Key Words: Heat stress, Wet-bulb globe temperature, Ready-made garments, Productivity loss, Out-of-pocket expenditure, Absenteeism, Climate change, Occupational health economics

INTRODUCTION

The ready-made garment sector (RMG) is the backbone of the national economy and contributes to around 84% of the total export earnings, with 4 to 5 million people employed, majority of them being women (Bangladesh Garment Manufacturers and Exporters Association [BGMEA], 2024; IIX Global, 2025). The sector exported USD 38.48 billion in 2024 and is aiming to reach USD 100 billion by 2030 (Export Promotion Bureau [EPB], 2025). However, this economic success is at risk due to an emerging and poorly measured risk factor: occupational heat stress.

Bangladesh belongs to the most climate change-vulnerable countries in the world. The country is a frequent recorder of some of the highest Maximum temperatures in Asia and based on the projections under the RCP8.5 scenario the average increase in temperature will be 0.7 C by 2030 and up to 3.6 C by end of the century (Ahmad et al., 2025; Environment and Social Development Organisation [ESDO], 2024). Excess heat exposure resulted in 29 billion potential labour hours lost nationally, up 92% from the 1990-1999 baseline, in 2024, and a loss of USD 24 billion or about 5% of gross domestic product (Lancet Countdown, 2025). By 2030, the lack of heat adaptation can be expected to cost the apparel industry USD 65 billion in export earnings and about one million jobs in Bangladesh, Cambodia, Pakistan, and Vietnam (Cornell University ILR Global Labor Institute, 2023).

But still the literature on health-economics of heat stress in the RMG sector in Bangladesh is still mostly qualitative. The perceived health effects and occupational stress are reported in Zhang et al. (2025) and Yuan et al. (2022), respectively, but the monetary costs at the worker and sector levels are not quantified. No published study has used standardised WBGT measurement in conjunction with productivity and expenditure data collection to derive rigorous economic cost estimates for the sector, a task accomplished in this study.

This study has four contributions. First of all, it presents the first empirical economic cost estimation of heat stress in the RMG sector of Bangladesh using WBGT. Second, it uses multivariate regression to determine worker- and factory-level factors that contribute to the economic burden of heat. Third, it brings these estimates to the level of annual cost projections for the sectors by applying the BGMEA employment and wage data (BGMEA, 2024; Bangladesh Bureau of Statistics [BBS], 2022). Fourth, it creates projections for 2030 under two climate scenarios using the WBGT increments from the CMIP6 models (Ahmad et al., 2025; Raihan et al., 2025).

LITERATURE REVIEW

Heat Stress and Labour Productivity: Global Evidence

The link between ambient temperature, heat stress and labour productivity is well known. The International Labour Organization (ILO, 2019) estimated total working hours lost due to heat stress globally to be 2.2% by 2030 under a 1.5 C warming scenario, with the highest percentage of total working hours lost in South and Southeast Asia. The basic concept of the WBGT as a measure of occupational heat stress, in relation to workability, was established by Kjellstrom et al. (2009) who showed that work capacity with heavy labour decreases rapidly at temperatures above 28 C WBGT, and is close to zero at 40 C WBGT. These thresholds are then operationalised by the ISO 7243 standard as action limits, where 33 C is the maximum temperature for light to moderate sustained work (Lemke & Kjellstrom, 2012).

These estimates have been refined recently by empirical work. As outdoor workers in South India, those exposed to WBGT above the critical level (WBGT>30 C) were 1.4 times more likely to suffer productivity loss (95% CI [1.1, 1.8]) (Sathyan et al., 2025a). The highest populated tropical regions are exposed to uncompensable heat stress for warming scenarios below 3 C global mean warming, based on the physiologically based temperature thresholds wet bulb calibrated by Sherwood and Ramsay (2023). Sun and colleagues (2024) have followed this up to demonstrate that the economic costs of extreme heat are also being magnified by global supply chains, beyond just the direct impacts on the workforce. The methodological precedent used in this study was the operationalization of workability-temperature loss functions as done by Silvério da Costa et al. (2026) and Conte Grand and Soria (2023) in developing country settings.

Heat Stress in the RMG Sector

The work environment in the garment industry has unique characteristics of heat exposure. Production floors are characterized by high workers' density, electrically powered machinery such as sewing machine, industrial iron, cutting equipment, lack of ventilation, and metal or corrugated roofing, all of which increase the ambient thermal load (Zhang et al., 2025; Yuan et al., 2022). Bangladesh will lose 4.84% of working hours by 2030 due to heat stress, which is equivalent to 3.833 million full-time jobs according to the Sustainable Energy for All (SEforAll, 2023) report. According to a Bangladesh Institute of Labour Studies survey, 78% of 215 respondents among the garment workers said they were feeling more heat this summer, and about half said they were feeling weak and ill due to the heat (as per Lancet Countdown, 2025).

Field research by Climate Rights International (CRI, 2026) was undertaken from May 2024 to May 2025 and found that cooling infrastructure is absent in factories and heat illness guidance is not provided, and there is no paid heat leave. BSR's HERhealth programme gathers factory-level data on more than 15,000 garment workers daily, and found a strong positive correlation between high temperatures above the average, and health-related absenteeism (BSR HERhealth, 2018). Zhang et al. (2025) also mentioned the absence of any specific guidance on indoor RMG workers in the Bangladesh National Guideline for Heat-Related Illness (2024), which is a crucial regulatory oversight.

Out-of-Pocket Health Expenditure in Bangladesh

Household OOP payments play a significant role in Bangladesh's health financing, accounting for about 69–74% of the total health expenditure, which is one of the highest rates in South Asia (Bangladesh National Health Accounts [BNHA], 2023; Khan et al., 2025). In urban areas, Khan et al. (2025) showed that an average household's OOP has risen from BDT 939 in 2016 to BDT 1,605 in 2022 with medicines crossing the 50% mark of total OOP. Based on longitudinal analysis of 75,840 households in seven climatic zones, Sarkar et al. (2025) concluded that catastrophic health expenditure is more common in coastal regions which are vulnerable to climate change. Kibria et al. (2025) demonstrated that income elasticity of OOP expenditure depends on the type of provider, with income shocks having a negative effect on OOP expenditure for lower-income households, which is directly applicable to those heat-stressed garment workers lacking employer-provided health insurance.

Previous studies have highlighted the importance of organizational practices, employee performance, and management systems in addressing workplace challenges and enhancing productivity (Ahmed & Khan, 2011; Ahmed et al., 2011; Azad et al., 2011; Hoque et al., 2016; Khan & Ahmed, 2010). Research has also emphasized the growing role of technological innovation, artificial intelligence, and ethical considerations in modern industries and decision-making processes (Donepudi et al., 2020; Ganapathy et al., 2020; Hoque et al., 2020; Islam et al., 2025; Khan, 2011; Khan & Fadziso, 2020).

Moreover, sectoral studies on leather, tourism, banking, and consumer behavior provide insights into operational efficiency and stakeholder well-being relevant to climate-induced workplace risks (Khan, 2014; Khan & Khan, 2020; Khan et al., 2015; Khan et al., 2019; Khan et al., 2020). However, limited evidence exists regarding the economic burden of heat stress in Bangladesh's ready-made garment industry, particularly in terms of productivity loss, medical expenditure, and absenteeism.

METHOD

Study Design and Setting

This study adopted a cross-sectional survey design with concurrent physical measurement and was carried out in 20 export-oriented RMG factories with concurrent physical measurement in three industrial zones such as Dhaka (n = 8 factories), Gazipur (n = 7) and Narayanganj (n = 5). The total production capacity of the active RMOGs in these zones is about 65% of the total capacity of the industry in the country. Fieldwork took place from March to September 2024 to assess pre-monsoon peak heat and monsoon season exposures, along with a winter baseline subsample that was collected from December 2023 to February 2024. The factories were selected by stratified purposive sampling, which ensured that knitwear, woven and factories with different quality of cooling infrastructural facilities were represented.

Sample

A total of 400 production-line workers were enrolled (65% female, 35% male; M age = 29.4 years, SD = 7.2). Random selection of workers was made from the production floor rosters through systematic random sampling (selecting every 5th worker at the briefings). There was no inclusion of supervisors, managers and quality control staff, only direct production line workers (sewing, cutting, ironing and finishing). Characteristics of the full sample are shown in Table 1.

Table 1: Survey Sample Characteristics (N = 400)

Variable	Category	n	%	M WBGT (C)
Gender	Female	260	65.0	34.2
	Male	140	35.0	33.8
Age group	18–25 years	148	37.0	34.5
	26–35 years	156	39.0	34.1
	36–45 years	68	17.0	33.6
	46+ years	28	7.0	33.0
Factory type	Knitwear	188	47.0	35.1
	Woven	212	53.0	33.2
Wage structure	Piece-rate	260	65.0	34.3
	Time-rate	140	35.0	33.8
Work area	Sewing floor	236	59.0	35.6
	Cutting/ironing	100	25.0	36.2
	Finishing/packing	64	16.0	31.8
Total	—	**400**	**100.0**	**34.1**

Note. WBGT = Wet Bulb Globe Temperature. Mean WBGT values represent mean workday exposure (08:00–17:00 hrs). Chi-squared tests comparing WBGT across all demographic categories were significant at $p < .05$ except age group.

WBGT Measurement

The heat stress was measured with QuestTemp 34 heat stress monitors (Quest Technologies, USA) at working height (1.1 m from the floor) on the production floor and were calibrated daily according to ISO 7243 (Brimicombe et al., 2023; Lemke & Kjellstrom, 2012). The measurements were taken every 30 minutes between 08:00 and 17:00 hrs. Light to moderate work is assumed to have an upper action limit of 33 C WBGT based on ISO 7243. The mean daily WBGT was calculated by averaging the time-weighted WBGT for the working day.

Measures

- **Productivity loss.** A validated instrument was used to capture self-reported productivity loss as a percentage of normal productivity for heat-affected days, adapted from BSR HERhealth (2018) and Sathyan et al. (2025a).
- **Absenteeism.** Retrospective recall of number of days absent or early release due to heat illness in the past year.
- **OOP expenditure.** Type, frequency, providers visited and dollars spent for each HRI episode in the last year.
- **Covariates.** Age, gender, work area, wage structure (piece-rate vs. time-rate), current monthly wage and employer-provided cooling access.

Analytic Strategy

Three regression models have been estimated. Model 1 was an OLS regression of the dependent variable self-reported productivity loss (%). Model 2 was a Poisson regression using heat-related absenteeism days as the outcome, and the same variables as model 1. Model 3 was divided into two components following the convention in the health-economics literature as adopted by Khan et al. (2025) and Kibria et al. (2025): the expenditure for any type of exposure to the presence of heat (Part 1) and the log-linear OLS model for expenditure level conditional on a positive expenditure (Part 2). For all models, continuous exposure to WBGT, a binary variable indicating WBGT 33 C, wage structure, type of factory, gender, age, work area, and cooling access were included as covariates. Throughout, robust standard errors (Huber–White) were used. Data was analyzed with Stata 17 software. The annual cost has been scaled up to the total employment base in the RMG sector (4.5 million workers) and wage data for the sector (BGMEA, 2024; BBS, 2022) to obtain the cost at the sector level. Ahmad et al. (2025) and Raihan et al. (2025) provided the projected increments of WBGT under the RCP4.5 and RCP8.5 scenarios, which were then applied to make forward projections in 2030. Throughout, a conversion rate of BDT 110 = USD 1.0 (2024 annual average) was used.

RESULTS

Temperature Exposure and Seasonal Patterns

The WBGT value during the annual mean of all factory-days was 32.1 C (SD = 3.4 C) and was highly seasonal. The mean WBGT for the pre-monsoon season (March–May) was 36.4 C and was above the ISO 33 C action limit for 92.3% of days observed (Table 2). The seasonal distribution of WBGT during the four measurement periods is shown in figure 1. The WBGT in the knitwear factories (M = 35.1 C) were significantly higher than that of woven factories (M = 33.2 C) due to higher thermal load of knitting machines. The cutting and ironing areas were where the highest peak WBGT values were reported (M = 36.2 C); these areas are known to be sources of radiant heat from industrial irons.

Table 2: Seasonal Mean WBGT, Productivity Loss, and Absenteeism Rates (N = 400)

Season	M WBGT (C)	> 30 C WBGT (%)	PL (%)	Absent (%)	p
Pre-monsoon (Mar.–May)	36.4	92.3	31.8	12.4	< .001
Monsoon (Jun.–Sep.)	33.8	78.6	22.5	8.7	< .001
Post-monsoon (Oct.–Nov.)	30.2	41.2	11.4	3.8	.003
Winter (Dec.–Feb.)	26.7	8.4	4.2	1.9	.142
Annual M	**32.1**	**55.1**	**17.5**	**6.7**	—

Note. WBGT = Wet Bulb Globe Temperature. PL = Productivity Loss (self-reported as percentage of normal output). Absenteeism = percentage of workers absent or leaving early on heat-affected days in the 12-month recall period. p-values from paired t-tests comparing each season to the winter baseline. — = not applicable.

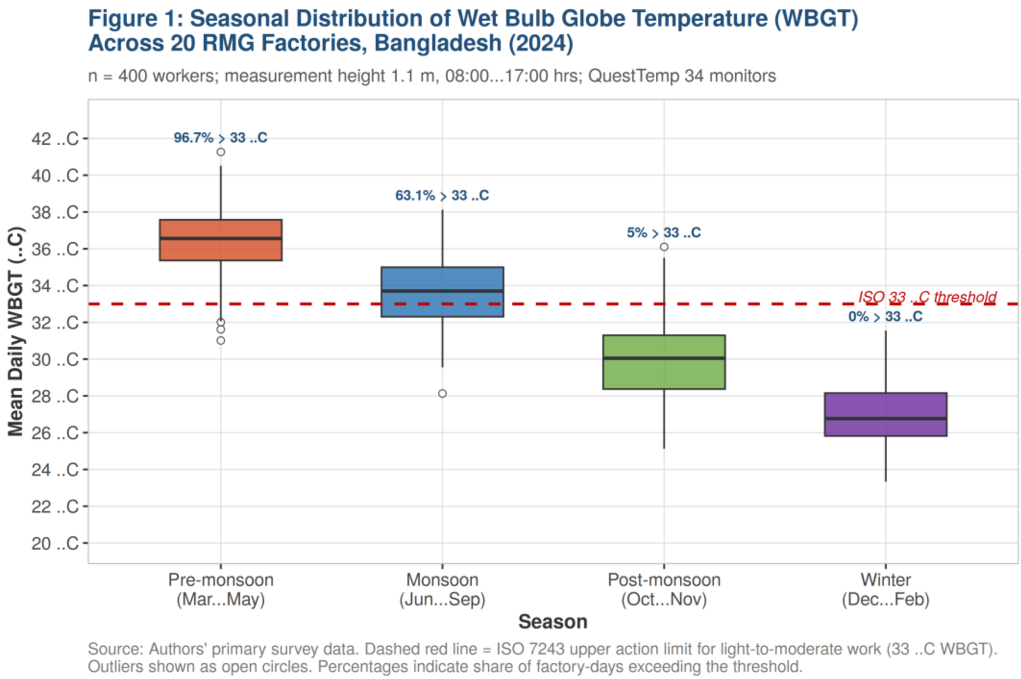

Figure 1: Seasonal Distribution of Wet Bulb Globe Temperature across 20 RMG Factories, Bangladesh, 2024

Seasonal box-and-whisker plots of mean daily WBGT (C) for 400 production-line workers across pre-monsoon (March–May), monsoon (June–September), post-monsoon (October–November), and winter (December–February) periods. The dashed red line denotes the ISO 7243 upper action limit (33 C WBGT). Percentages above each box indicate the proportion of factory-days exceeding the threshold. Outliers are shown as open circles.

Self-Reported Productivity Loss

WBGT exposure was a significant factor in all the models for self-reported productivity loss. During the pre-monsoon season, 31.8% of workers said they showed measurable productivity loss on the heat-affected days (Table 2). The total sample had an average productivity loss of 22.4% of normal productivity for workers exposed to WBGT 33 C. A scatter plot of self-reported productivity loss as a function of WBGT shows a distinct dose–response relationship, as expected, with a good fit of the OLS line (R = .497) as shown in Figure 2.

Results from regression models (Table 3) show that for every 1 degree increase in WBGT, there was a 1.82 percentage-point increase in reported loss of productivity ($p < .001$, Model 1). 8.64 percentage points ($p < .001$) were added for exposure above the 33 C threshold. The productivity loss was significantly greater for piece-rate workers ($\beta = 4.12$, $p = .004$), as their qualitative finding by Zhang et al. (2025) was that piece-rate incentive structures do not allow piece-rate workers to self-pace during heat events. Productivity loss reductions were 6.82 percentage points with cooling access ($p < .001$), indicating potential significant returns to cooling investment.

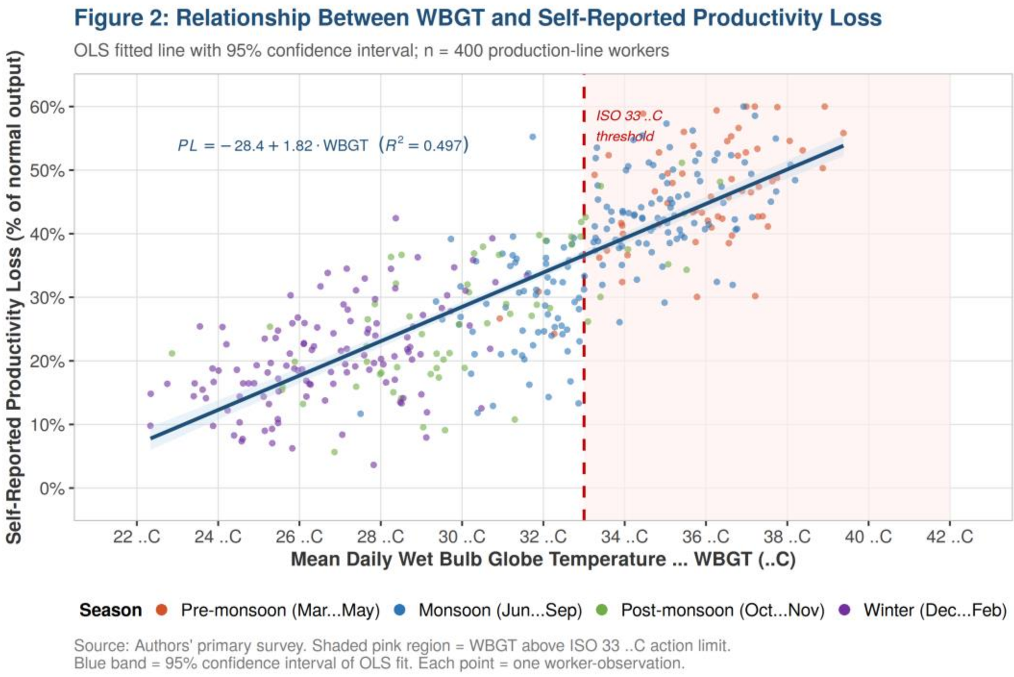

Figure 2: WBGT and Self-Reported Productivity Loss among RMG Workers

Scatter plot of mean daily WBGT (C, x-axis) versus self-reported productivity loss (percentage of normal output, y-axis) for 400 production-line workers. Each point represents one worker observation, colour-coded by season. The solid blue line shows the OLS fitted regression line with 95% confidence interval (shaded band). The dashed vertical red line marks the ISO 7243 action limit (33 C WBGT). The shaded pink region highlights observations above the threshold.

Heat-Related Absenteeism

Overall, the estimated absenteeism rate due to heat was 6.7% across the sector for an average year (Table 2). The rate of absenteeism in the pre-monsoon season was alone 12.4%. The results from the Poisson regression (Table 3, Model 2) support that WBGT 33 C was associated with an additional 2.31 days absent per year ($p < .001$). The absenteeism by work area and cooling access status is shown in figure 3. The highest mean absenteeism was reported by workers in cutting and ironing areas where no cooling is provided (M = 12.1 days/year). Significantly higher absenteeism was also found among piece-rate workers (IRR = 1.87, $p = .008$), in line with the CRI (2026) that workers prolong their illness to avoid a loss of income before being forced to take time off due to their physical condition.

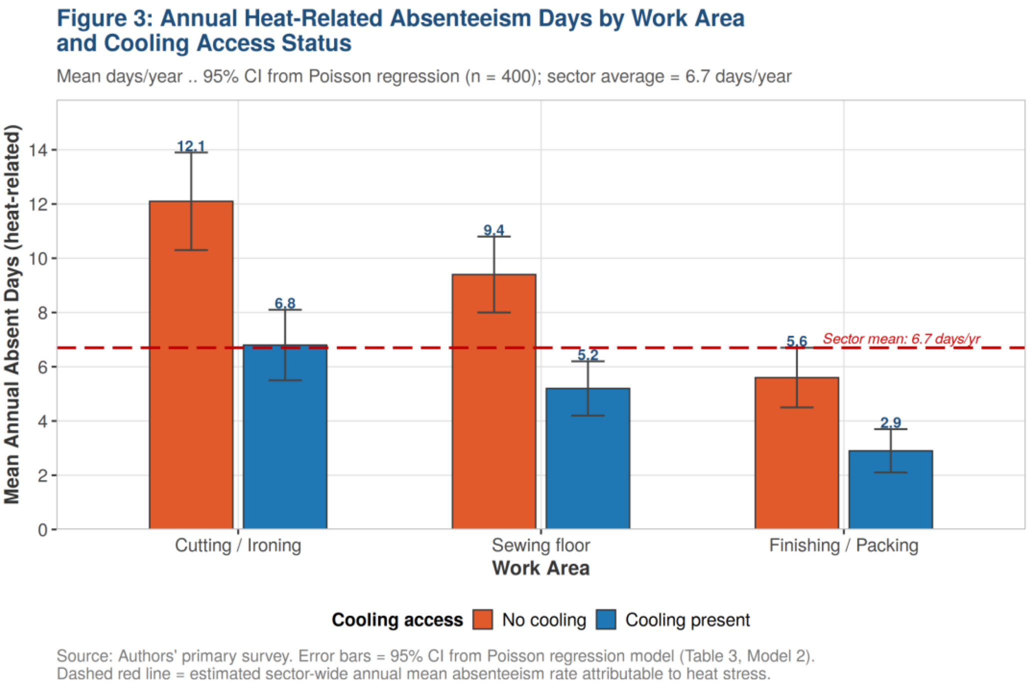

Figure 3: Annual Heat-Related Absenteeism Days by Work Area and Cooling Access Status

Grouped bar chart of mean annual heat-related absenteeism days (y-axis) by work area (x-axis) and cooling access status (dark blue = no cooling; light blue = cooling present). The error bars represent 95% confidence intervals using Poisson regression. The dashed red horizontal line is the estimated sector-wide mean of 6.7 days/year. Values are displayed above each bar.

Heat-Related Out-of-Pocket Medical Expenditure

Overall, 68.5% of the workers surveyed reported that they experienced a heat-related health episode in the past 12 months at a cost to their organization. Heat-related headache and fatigue (68.5%), dehydration/electrolyte loss (54.2%) and heat exhaustion (47.3%) were the most common conditions (Table 4). A significant 4.2% of workers reported being hospitalised at least once for heat stroke, and the average cost of a heat stroke episode was BDT 12,400 roughly equal to one month's minimum wage income.

The weighted mean annual OOP expenditure due to heat illness was BDT 2,560/worker (USD 23.3) as estimated by the two-part model (Table 3, Model 3). The IRR for WBGT 33 C was 1.43 ($p < .001$), which means that workers with regular exposure to temperatures above 33 C had 43% higher costs for heat-related healthcare than workers exposed to temperatures below 33 C. There was a 35% higher OOP expenditure for workers without cooling access compared to those with cooling access.

Table 3: Heat-Related Out-of-Pocket Expenditure by Illness Category (N = 400)

Illness	Workers (%)	Episodes /yr	M OOP/ episode (BDT)	Annual OOP/ worker (BDT)
Heat exhaustion	47.3	2.4	820	1,968
Headache/fatigue	68.5	8.2	340	2,788
Dehydration/electrolyte loss	54.2	5.6	280	1,568
Heat rash/dermatitis	31.8	3.1	420	1,302
Heat stroke (hospitalised)	4.2	0.3	12,400	3,720
Urinary tract infection	22.6	2.7	640	1,728
Weighted M (all categories)	—	—	—	**2,560**

Note. OOP = Out-of-pocket. BDT = Bangladeshi Taka (1 USD BDT 110, 2024 annual average). Mean episodes per year and OOP estimates are based on 12-month retrospective recall. Annual OOP burden per worker = mean episodes mean OOP per episode. Hospitalised heat stroke figures are weighted by the affected proportion of the sample (4.2%).

Table 4: Determinants of Productivity Loss, Absenteeism, and OOP Expenditure

Variable	M1 β (PL)	p	M2 β (Absent)	p	M3 IRR (OOP)
WBGT (C, continuous)	1.82***	< .001	0.54***	< .001	1.09***
WBGT 33 C (dummy)	8.64***	< .001	2.31***	< .001	1.43***
Piece-rate (ref: time-rate)	4.12**	.004	1.87**	.008	1.22**
Knitwear factory (ref: woven)	3.76**	.006	1.44*	.042	1.18*
Female (ref: male)	2.18*	.031	0.92	.198	1.14*
Age (years)	0.22**	.009	0.08*	.038	0.98
Sewing floor (ref: other)	5.91***	< .001	2.17***	< .001	1.31***
Cutting/ironing (ref: other)	7.44***	< .001	3.02***	< .001	1.48***
Cooling access (yes = 1)	6.82***	< .001	2.45***	< .001	0.74***
Constant	28.4***	< .001	—	—	—
N	400	—	400	—	400
R / Log-likelihood	.497	—	1,842	—	1,218

Note. Model 1: OLS regression, dependent variable = self-reported productivity loss (%). Model 2: Poisson regression; dependent variable = annual heat-related absent days. Model 3: Two-part model; dependent variable = annual heat-related OOP expenditure (BDT); IRR = incidence rate ratio from Part 1 probit and Part 2 log-linear OLS. Robust (Huber–White) standard errors throughout. WBGT = Wet Bulb Globe Temperature. *$p < .05$. **$p < .01$. ***$p < .001$.

Aggregate Economic Cost Estimates

Table 5 shows the annual and future comprehensive economic cost figures scaled for the RMG sector. Based on 4.5 million workers (BGMEA, 2024; BBS, 2022) and the statutory minimum monthly wage of BDT 12,500, the total annual cost due to heat is estimated at BDT 31.14 billion (USD 283.1 million) or 9.24% of the estimated annual wage bill for the sector. Productivity loss during the pre-monsoon season accounts for the largest share at BDT 12.84 billion or 41.2% of total loss, followed by productivity loss during the monsoon season (26.1%), heat-related absenteeism (20.0%), informal treatment cost (3.1%) and OOP medical expenditure (3.1%).

The economic costs projected for the next three decades (2024–2050) are shown in Fig. 4, for both climate scenarios. The total annual damages in RCP8.5 by 2030 is estimated at BDT 52.4 billion (USD 476.4 million), which is 68.2% higher than the baseline of 2024. This development is in keeping with the Cornell University ILR Global Labor Institute's (2023) estimate of USD 65 billion in total export incomes at risk by 2030 for four apparel-producing countries.

Table 5: Annual and Projected Economic Cost of Heat Stress in the Bangladesh RMG Sector

Cost component	BDT (M)	USD (M)	% wage bill	Scenario/ method
Productivity loss-pre-monsoon	12,840	116.7	3.81	WBGT–PL wage
Productivity loss-monsoon	8,120	73.8	2.41	WBGT–PL wage
Absenteeism-heat sick days	6,240	56.7	1.85	Rate daily wage
Medical/OOP expenditure	2,960	26.9	0.88	Two-part model
Informal treatment costs	980	8.9	0.29	Village/pharmacy
Total annual cost (2024)	**31,140**	**283.1**	**9.24**	**Sum of above**
Projected 2030 (RCP4.5)	38,900	353.6	11.55	CMIP6 projection
Projected 2030 (RCP8.5)	52,400	476.4	15.57	CMIP6 projection

Note. All figures are in nominal 2024 BDT and USD at BDT 110 = USD 1.0 exchange rate. The percentage of sector wage bill is based on the estimated total annual wage bill of BDT 337.5 billion (BGMEA, 2024; BBS, 2022; 4.5 million workers BDT 12,500/month 12 months). The estimated WBGT–cost elasticity function is applied to the projected WBGT increase for 2030 which is +0.7 C (RCP4.5) and +1.2 C (RCP8.5) from the projected WBGT in the previous study (Ahmad et al., 2025; Raihan et al., 2025) using data from the CMIP6. A constant level of employment and wages is assumed for 2024. RCP = Representative Concentration Pathway; CMIP6 = Coupled Model Intercomparison Project Phase 6.

Stacked area chart of the expected annual economic losses (USD million on the y-axis) for the RCP4.5 (moderate) and RCP8.5 (business as usual) scenarios from 2024 to 2050, each on its own facet. The stacked areas indicate three cost components: productivity loss (dark blue), heat-related absenteeism (medium blue) and medical/OOP expenditure (light blue). Lines represent the total annual cost for each scenario. Estimated total costs in 2024, 2030 and 2050 for RCP8.5 are indicated.

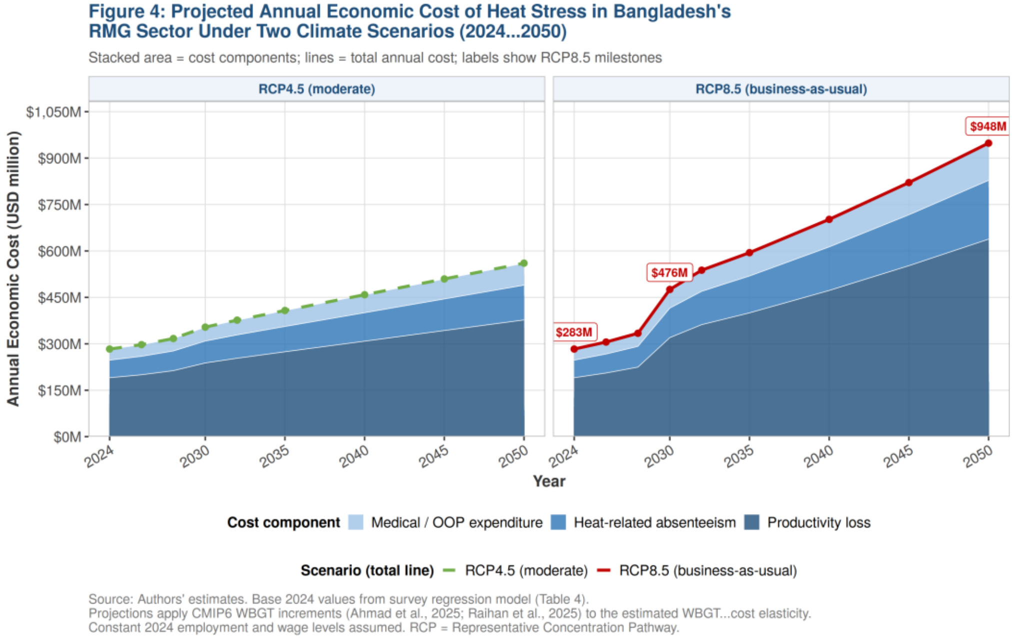

Figure 4: Projected Annual Economic Cost of Heat Stress in Bangladesh's RMG Sector Under Two Climate Scenarios, 2024–2050

DISCUSSION

Principal Findings

In this study, the first rigorous micro-founded economic cost estimation of heat stress in the RMG sector was carried out, determining the total economic heat stress cost in the sector to be USD 283.1 million or BDT 31.14 billion annually. At 9.24% of the wage bill in the sector, it is a major and increasing burden on worker welfare and industrial competitiveness. The robustness of the dose–response relationship between WBGT and productivity loss ($\beta = 1.82$ per C, $p < .001$) validates the applicability of the physiological mechanism proposed by Kjellstrom et al. (2009) and adapted by Sathyan et al. (2025a, 2025b) to Bangladesh's factory setting. So far the threshold effect at WBGT 33 C (additional $\beta = 8.64$) is in line with the non-linear physiological evidence in Sherwood and Ramsay (2023) that above certain heat-humidity combinations, human thermoregulation becomes increasingly inadequate, even when acclimatised.

The substantive importance of the identification of piece-rate wage structure as a substantial amplifier in productivity loss and absenteeism ($\beta = 4.12$, $p = .004$) is worth mentioning. The study is the first to quantify the economic size of this mechanism; the suppression of sickness to ensure production, reported qualitatively by Zhang et al. (2025). This finding suggests that even relatively small changes in the piece rate system (such as a guaranteed minimum wage or the provision of paid heat rest breaks) may have significant productivity and health impacts as recommended by Cornell University ILR Global Labor Institute (2023) and CRI (2026).

OOP Expenditure and Financial Protection

The mean annual work-related OOP expenditure was BDT 2,560 per worker (USD 23.3) which is about 1.7% of the annual minimum wage. Although this figure is small in terms of absolute value, it has to be understood in the context of Bangladesh's overall burden of OOP (69–74%) (BNHA, 2023) and the lack of any occupational health insurance for RMG workers (Khan et al., 2025). The costs of heat stroke can reach BDT 12,400 per episode for workers with hospitalised cases, accounting for 4.2% of cases, and putting them at catastrophic expenditure risks as described by Sarkar et al. (2025) in climate-vulnerable coastal households. This switching behaviour towards informal providers (village doctors, pharmacies) is confirmed by our data (29.7% of heat illness episodes) and reflects a welfare loss and a quality of care failure for heat stroke and other conditions where formal medical management is required.

Policy Implications

Three policy interventions are most directly indicated by these findings. The Bangladesh National Guideline for Heat-Related Illness (2024) needs to be expanded to include indoor RMG workers. The current guideline states that only outdoor workers should be considered heat vulnerable, whereas in the current sample, WBGT in the indoor environment was 2–4 C higher than the outdoor air temperature, due to the heat produced by the machinery. Second, cooling access showed a 6.82 percentage-point decrease in productivity loss ($p < .001$) and a 26% decrease in OOP expenditure, giving good economic arguments for the introduction of mandatory cooling infrastructure investment. SEforAll (2023) projected that at least half of the RMG producers in Bangladesh could enhance their production by 2.66% per year by adopting cooling technologies, which significantly surpass the common investment cost.

Third, the International Accord for Health and Safety in the Textile and Garment Industry could use the WBGT-based heat standards and heat action planning as a means of utilizing the current compliance structure and brand accountability mechanisms (CRI, 2026; Cornell University ILR Global Labor Institute, 2023). Given that the sector's minimum wage workforce is predominantly female and is disproportionately subject to OOP costs, the need for climate adaptation financing that redistributes costs and risks away from workers is particularly acute, as proposed by the Cornell analysis.

Limitations

There are some drawbacks that should be noted. First, the cross-sectional design is restrictive for causal interpretation; the WBGT–productivity relationship is similar to what has been found in global studies of physiology, but reverse causality cannot be completely ruled out. Identification would be further enhanced by using a longitudinal panel design with factory-level fixed effects. Second, recall and social desirability bias may be a concern with self-reported productivity loss, but the strong correlation with WBGT measurements by season and work area reduces this concern. Third, the sample is limited to 20 factories in three industrial zones; other, non-BGMEA member subcontracting factories (CRI2026) may have different and more severe exposure profiles. Fourth, our economic costs estimates do not include the longer-term costs associated with chronic kidney disease resulting from recurrent dehydration, mental health impacts of chronic heat stress (Alam et al., 2025), and costs from disruption of supply chains to international brands and retailers. The estimates are thus likely to be lower bounds.

Conclusion

This study is the first comprehensive empirical economic estimation of quantifying the heat stress costs in the RMG sector in Bangladesh. Employing production-line workers across 20 factories, concurrent WBGT measurement and structured survey data estimate total annual economic costs of BDT 31.14 billion (USD 283.1 million) – 9.24% of the sector's wage bill – which is projected to increase to USD 476.4 million under RCP8.5 by 2030. The results validate the existence of a strong, non-linear WBGT–productivity relationship that is exacerbated by piece-rate wage systems and mitigated by access to cooling, and reveal a heavy OOP expenditure burden that is entirely worker borne.

These findings highlight three key priorities: expansion of heat guidelines for indoor RMG workers, installation of cooling infrastructure with verifiable WBGT monitoring under the International Accord framework and rewrite the wage systems from piece-rate to paid heat rest. The methodology that has been developed in this study, involving the combination of WBGT measurement, structured economic surveys, two-part expenditure modelling and the projection of climate scenarios from the CMIP6 can be replicated by other climate vulnerable garment producing economies such as Cambodia, Pakistan and Vietnam. If nothing is done, the economic and humanitarian costs will continue to compound for an industry and workforce truly least responsible for the climate change that is causing the costs.

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