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Impact of Escalating Heat Waves on Students' Well-Being and Overall Health: A Survey of Primary School Teachers

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Abstract: Children in developing countries such as India will experience severe consequences of climate change. Primary school students, in particular, are the most vulnerable to extreme weather conditions, such as heat waves intensifying due to climate change. This will adversely impair their development, well-being, and learning outcomes. However, significant research gaps exist in understanding and mitigating children's vulnerabilities. There is an urgent need for a deeper understanding of the impact of heat waves on children's health and well-being in India. Further, the discussion on the state of heat safety in Indian primary schools is limited. This study addresses these gaps by surveying 335 primary school teachers in seven Indian cities. The data gathered from the field survey offers a better understanding of classroom experiences and challenges encountered by children and teachers during heat waves. It underscores several aspects of students' vulnerability to heat exposure and its adverse impact on their health, such as absence from school, physical symptoms of heat distress, etc. Furthermore, it highlights the pressing need for classroom heat risk management in light of climate change and makes several policy prescriptions in primary schools.

Keywords: climate change; Indian heat waves; primary school students; children's health; global warming

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1. Introduction

Climate change is leading to an increase in the frequency and intensity of extreme weather events such as floods, heat waves (HW), droughts, and extreme rainfall [1]. An increase in the frequency of overheating in buildings is one of the major projected effects of climate change on the built environment [2]. Undoubtedly, one of the biggest risks is also the wide range of ill health effects and worsening of allergies when exposed to extreme temperatures [3]. Figure 1 depicts the various impacts of climate change and the vulnerable population most affected by it. Categorically, children with developing physiologies and underdeveloped internal coping capabilities may be more vulnerable to these impacts [3,4]. Children's health is not only significantly threatened by climate change but it also has a serious impact on their academic performance [5]. "As the effects of climate change intensify, children in the tropics will face additional barriers to education" [6].

Favorable learning environments are crucial, especially in light of the cascading impact that educational outcomes have on people's future earning potential [7]. Since the classroom is the anchor of students' daily lives, it is crucial to comprehend and utilize the physical environment in which they study and learn in order to achieve optimal learning results. According to previous studies [8], unfavorable comfort conditions in schools, such as higher temperatures, disruptive noise, inadequate lighting, and a higher occupant density in classrooms, can have a poor impact on kids' academic performance as well as lead to health issues. Numerous studies have focused on the critical significance that Indoor Environmental Quality (IEQ) plays in primary school classrooms [9–12]. Focusing on the thermal comfort of students in a classroom, Jiang et al. [13] highlighted the impact of

thermal comfort on students' test performance as well as the impact on their health. The effects of classroom indoor temperature on the academic performance of 10 to 12-year-old pupils' regular schoolwork were examined by Wargocki et al. [14]. The results showed that the students' performance on assessments based on language and mathematics significantly improved when the temperature was lowered from 25 °C to 20 °C.

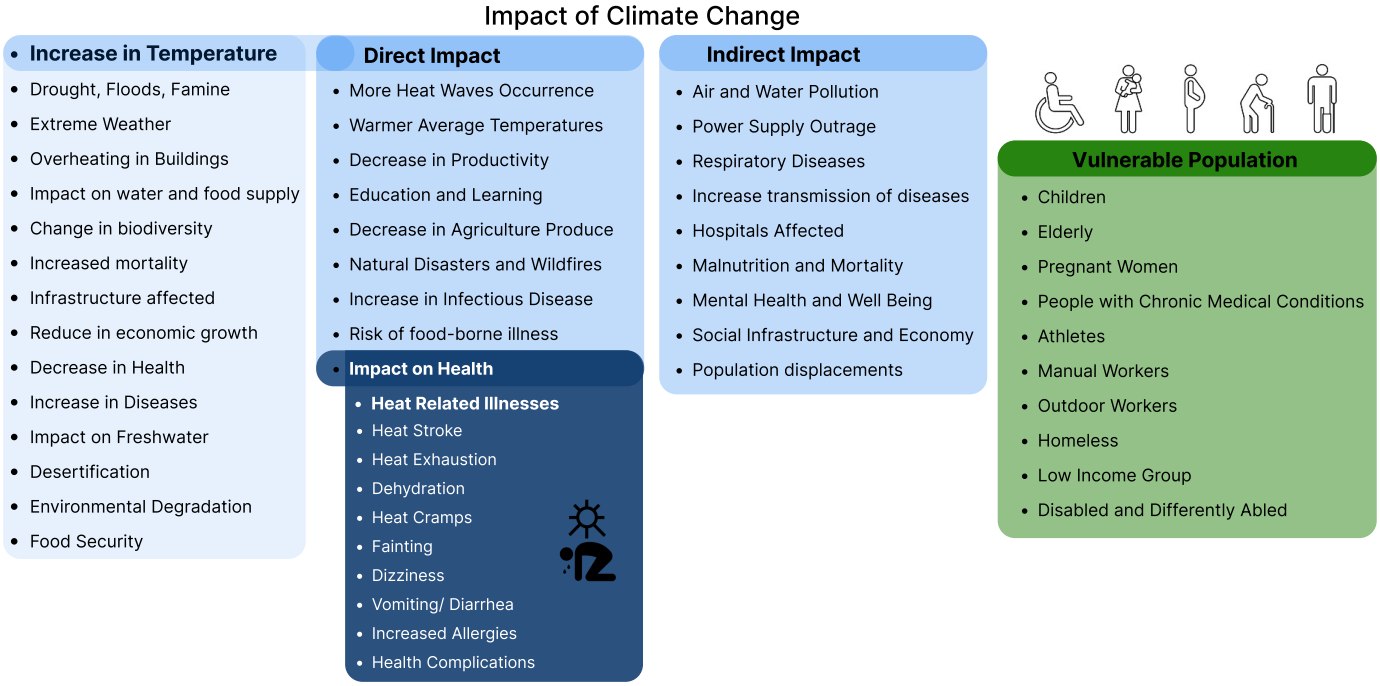

Figure 1. Impact of Climate Change.

Research indicates that students' health is negatively impacted by excessive heat, which inevitably affects their learning outcomes [5,15,16]. The consequences of heat on cognitive development are anticipated to be more severe in countries such as India where temperatures and levels of poverty are both high [17]. Further, as reported by [6], exposure to excessive heat may make it more difficult for students to complete their secondary education in tropical regions of the world (such as India). An American student typically spends about 12 school days above 32 °C (90 °F) each year, whereas an average Indian student spends more than 100 such days annually [17]. According to the Global Climate Risk Index, India stands tenth in the category of the most climate-affected countries in the world for 2022, with an average of 114 days of heat wave conditions recorded each year [18]. Conforming to a Met Department analysis, India is experiencing an increase in heat wave days every 10 years [19]. The research reveals that, mostly in inland locations, the number of days with exceptionally high temperatures is progressively increasing, going from 413 in 1981–1990 to 575 in 2001–2010 and 600 in 2011–2020 [19].

India will experience more frequent and hotter heat waves in the future due to global warming, according to the World Weather Attribution [20]. Considering that the majority of the nation—more than 90%—could experience severe heat waves and enter an extreme heat "danger" zone [21], it is imperative to examine in detail the physical conditions that students in hot climatic regions are exposed to as heat waves are slotted to become more frequent and prolonged. Children's heat risk is a pressing concern with such a high-temperature threat. According to previous studies [22–24], children are more susceptible and vulnerable to heat-related illnesses since their bodies do not acclimatize to the heat as well as adults do. They also tend to not sweat as effectively and absorb more heat as compared to adults because of their smaller bodies and a higher ratio of surface area to body mass [25,26]. Along with adverse ramifications on students' academic performance

and learning capacity, prolonged exposure to hot environments can also bring about health symptoms of exhaustion and dehydration.

The majority of schools in India rely on natural ventilation when temperatures are high. Windows and doors may be kept open for cross ventilation, and almost all schools provide ceiling fans. However, due to limited infrastructure and financial restrictions, installing mechanical systems or the provision of air conditioners is not an option. In addition, on many occasions, due to power disruptions and load shedding, the use of electric fans in classrooms is restricted. Further, there are many students—about 35 to 40—in a rather small classroom (16 to 20 square meters), which can occasionally result in overcrowding. These factors, along with hot ambient temperature (particularly during heat waves), can make classrooms in primary schools feel uncomfortably warm. Therefore, to help mitigate the challenges of hot days and enable children to cope with hot temperatures in classrooms, a few measures are prescribed by schools, such as recommending schools to start earlier (7 A.M.) and end before noon while also limiting the number of schools hours; relaxing school uniform (discouraging neckties) and wearing canvas shoes instead of leather shoes; limiting outdoor activities, etc. While these measures may help in minimizing the threats caused by high temperatures to primary school students, the impact of heat disruption on learning and students' performance must be studied further.

Understanding children's responses to weather conditions and environmental changes can have a significant impact on teaching and learning, as well as behavioral concerns and parenting, in addition to health [27]. Remarkably, research correlating the climate to effective and behavioral aspects in children is very limited [27,28]. Particularly in the setting of Indian classrooms, to date, there are insufficient studies on how heat stress and risks affect children. Under these circumstances, to better understand the connection between heat waves and children's health in primary schools, a questionnaire survey was conducted by inquiring teachers about their observations and experiences with students during the hot summer school days. The survey offers a new perspective and highlights the challenges of heat stress and discomfort on students inside their classrooms.

2. Outline of Field Survey

In the month of February 2020, a questionnaire survey of primary school teachers was carried out, covering 35 elementary schools in seven Indian cities in hot climate regions. The cities were Delhi, Jaipur, Ajmer, Vadodara, Udaipur, Ahmedabad, and Pune. These cities were specifically chosen since heat waves generally occur over the plains of central and northwest India [29]. Figure 2 illustrates where these cities are in relation to one another. The highest temperatures have consistently exceeded 40 °C for several days, especially over central and western parts of India.

Schools belonging to hot and dry climatic regions were chosen for the survey because these areas typically experience heat waves with temperatures hitting between a maximum of 45 °C and 50 °C. The survey's specifics are displayed in Table 1, together with information about the school's location, its average maximum temperature, and the number of teachers who took part in the surveys. The 35 primary schools were a combination of both privately funded and government-supported institutions. None of the primary schools had air conditioning, and all of the classrooms were naturally ventilated with provisions of ceiling fans.

School authorities were approached via email after a preliminary introduction through coworkers and friends who worked at the relevant primary schools. After receiving formal approval from the school administration, survey dates were scheduled and schools were visited. Primary school teachers were requested to cooperate with the survey by the school administration. Teachers answered the questionnaire after their teaching session, or during their free classes to discourage class interruptions.

A total of 335 primary school teachers from seven cities participated in the questionnaire survey. The majority (58%) of the respondents were male teachers and 56% were in

the age bracket of 30–40 years. A detailed distribution of teachers by age and gender is shown in Figure 3.

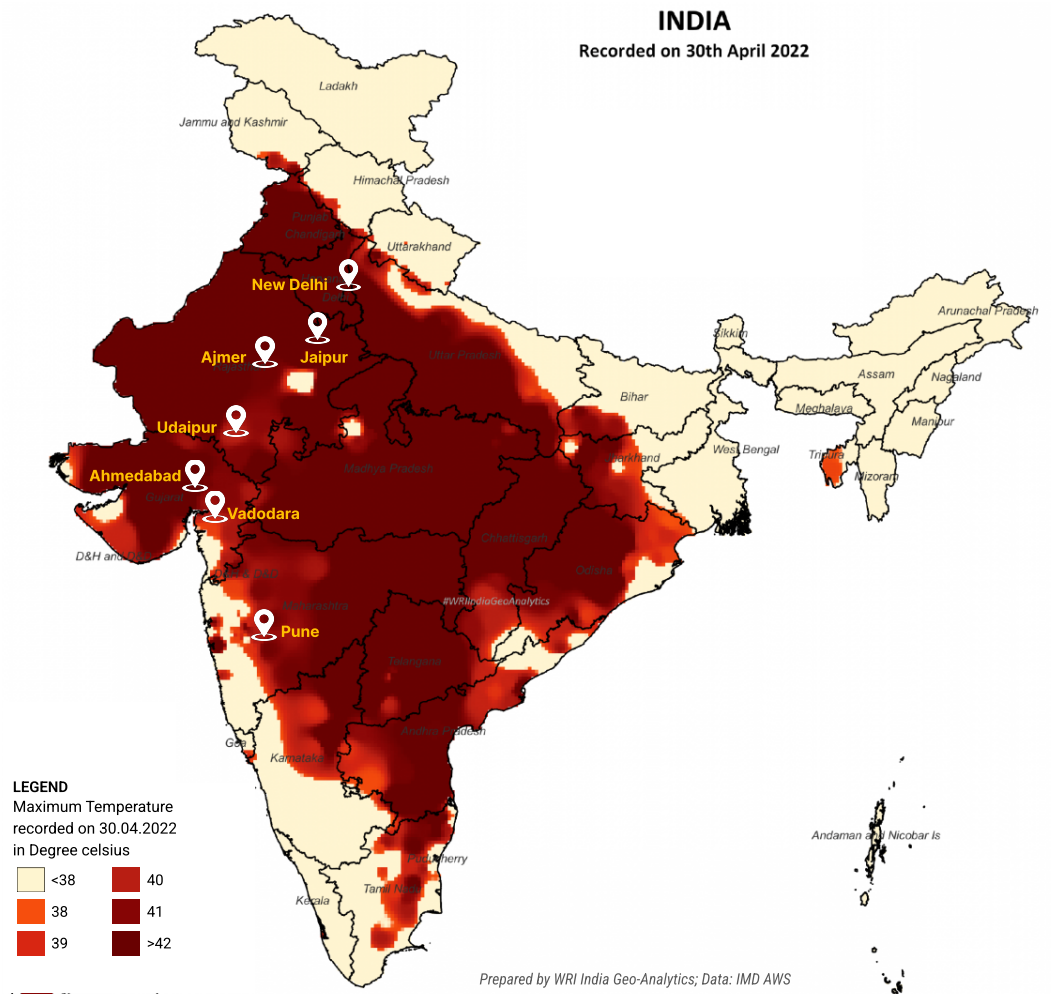

Figure 2. Location of schools where the teacher surveys were conducted. Source of India Map: WRI India Geo-Analytics [30].

Table 1. Survey Details.

Cities	Maximum Temperature during Summer 2021	Relative Humidity%	No. of Schools	No. of Teachers Who Participated in Survey
Delhi	44.3 °C	61%	10	116
Ajmer	42 °C	79%	7	85
Jaipur	42 °C	74%	6	52
Vadodara	44.4 °C	71%	7	71
Udaipur	43 °C	40%	2	28
Ahmedabad	42 °C	58%	2	25
Pune	39 °C	64%	1	22

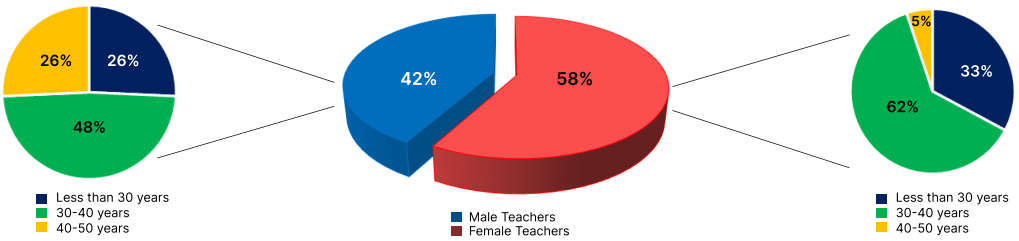

Figure 3. Distribution of teachers by gender and age group.

The questionnaire comprised 37 questions about the teachers' perspectives and observations on the illnesses and discomfort of students caused by heat inside the classrooms during the summer months. The questionnaire was translated into Hindi too, in the event that the teachers were less comfortable with English questions. The objective of the survey was to elucidate further the numerous negative impacts of heat waves and extremely hot classrooms on students' overall health and academic performance. Table 2 exhibits the various sections and details of the questions included in the survey. The paper-based survey contained questions that were designed as multiple choice questions (MCQ). The questionnaire also used a five-point Likert scale (1 = Strongly disagree to 5 = Strongly agree) to rate various thermal conditions. The surveys lasted 15 min maximum, and a few teachers further elaborated in the form of short interviews about the current conditions during summer months inside their classrooms. Figure 4 shows teachers filling in the questionnaire.

Table 2. Detail of questionnaire for teachers.

Sections	Number of Questions	Details of Questions
Personal Information	9 Questions	Age, Gender, Name of school, City, number of years working as primary school teachers, etc.
Personal Observations	4 Questions	Do you feel thermally uncomfortable in your classrooms? Describe the source of this discomfort?
Classroom conditions	9 Questions	Classroom direction, location, window shades or not, well ventilated or not, etc.
Teachers opinion	9 Questions	Opinion about overall classroom environment, students illnesses, affect of hot classroom son students, etc.
Students and their thermal discomfort	8 Questions	How does hot classrooms cause discomfort to students, do students report their disocomft and how often, How do students adapt themselves, How often do students return home due to sickness, etc.
Awareness and Precautions against Heat Risk	8 Questions	Precautions are taken by the school to avoid extreme heat, awareness of guidelines provided by the Government, special training provided by schools, etc.

Figure 4. Teachers filling in the questionnaire survey.

3. Survey Results

3.1. Teachers' Personal Observations during Summer

The first part of the questionnaire asked the primary school teachers about their personal information such as age, gender, name of school, years teaching primary students, etc. Their personal experiences and observations were asked in the second section of the questionnaire. Table 3 shows the ratio of each response to the question "During summer, do you feel thermally uncomfortable in your classrooms?" and what time of the day they felt most uncomfortable. The table indicates that more than 50% of teachers felt thermally uncomfortable inside their classrooms on a daily basis and usually in the afternoons (76%). Considering the fact that the daily outdoor temperature in surveyed regions frequently exceeded 40 °C during summer and none of the classrooms were equipped with air-conditioning systems, this finding is not surprising. Similar findings were also found in Swedish preschools during extreme summer, in a study by [31], where eight out of ten kindergarten teachers categorized their classrooms as hot and said that heat was an issue, indicating that the issue extended beyond just heat waves. A total of 76% of the teachers said that the time after noon (12 P.M. to 2 P.M.) was the most uncomfortable time of the day, as shown in Table 4.

Table 3. Frequency of uncomfortable classrooms during summer season.

Is Your Classroom Thermally Uncomfortable in Summers?		
1.	Everyday	53%
2.	Once a Week	19%
3.	Twice Weekly	17%
4.	More Than Twice	10%
5.	Never	1%

Table 4. Source of discomfort in Summer Season.

If Uncomfortable, What Time of the Day?		
1.	Morning (before 11 A.M.)	0%
2.	Mid-day (11 A.M.–12 P.M.)	24%
3.	Afternoon (12 P.M.–2 P.M.)	76%

Table 5 shows the ratio of responses to the question, "How would you best describe the source of discomfort in classrooms?". It can be seen here that 53% of the teachers answered that the source of the discomfort in classrooms is temperature; 19% of the teachers blame the harsh sun penetrating inside the classrooms, 17% indicated humidity and 10% say it is due to the movement of hot air. It is noteworthy that these physical challenges due

to heat and uncomfortable classrooms are substantially different from many developed countries located in lower temperate or subarctic climates. For example in the UK, indoor air temperature exceeding 28 °C is considered a condition of overheating in classrooms [32].

Table 5. Source of Discomfort inside classrooms.

How Would You Best Describe the Source of Discomfort in Classrooms?		
1.	Temperature	53%
2.	Humidity	17%
3.	Hot air movement	10%
4.	Harsh sun inside classrooms	19%
5.	Hot surfaces (Hot walls, etc.)	1%

Table 6 shows the answer to the question, "If temperature is an issue, does this disturb your work?". It is interesting to note that of teachers who only voted temperature as the source of discomfort, 61% of them reported that temperature disturbs their teaching and thus affects their work. This makes it evident that hot classrooms do not just prove a threat to students learning and studying, but also affect teachers' work productivity.

Table 6. Ratio of teachers whose work is affected due to temperature.

If Temperature Is the Reason for Discomfort, Does It Disturb Your Work?		
1.	No, temperature does not affect work	9%
2.	Yes, temperature affects my work	61%
3.	I do not know	30%

Further, the incidence of ill health due to working in these hot environments is summarized in Table 7. To the question, "In the past 3 years, have you experienced any health effects or sickness due to working in excessive heat?", only 4% of the teachers responded to not being sick working in hot conditions. At least 32% have experienced some form of sickness or illness due to excessive heat in classroom environments. The underlying fatigue brought on by being in a hot environment is therefore affecting the health and performance of teachers. Similar results were found in a study by [33] through telephone surveys of 428 teachers that the most significant negative impact on teaching capacity came from an extreme classroom thermal condition (i.e., too hot or too cold). A survey to study the impact of the 2018 heat wave in Sweden further reveals that 21% of the teachers reported health effects such as exhaustion, headaches, and nausea and demonstrated how the heat wave affected their general health and caused minor health issues [31].

Table 7. Ratio of teachers who got sick due to working in excessive heat in the past 3 years.

In the Past 3 Year Any Health Effects or Sickness Due to Working in Excessive Heat?		
1.	Once, past 3 years	32%
2.	2 to 3 Times	44%
3.	3 to 5 Times	18%
4.	More Than Times	1%
5.	Never	4%

3.2. Classroom Condition and Design

The third section of the questionnaire inquired about the layout (direction) and indoor conditions of the classrooms, the floor the classrooms were situated, classroom orientation, and if they were exposed to direct sunlight. A total of 14% of the classrooms were located on the ground floor and 46% on the first floor, while 6% and 34% were on the second and third floors, respectively. A total of 45% and 33% of the classrooms faced east and north directions, respectively, which was usually in line with the design principles described

by vaastu shastra (Indian science of architecture and buildings). On being asked if their classrooms got direct exposure to the sun and at what time of the day, 98% of the teachers responded "yes", among which 53% reported direct solar radiation inside their classrooms post noon (12 P.M. to 2 P.M.), 41% during mid-day (11 A.M. to 12 P.M.) and only 6% during the morning hours as shown in Figure 5.

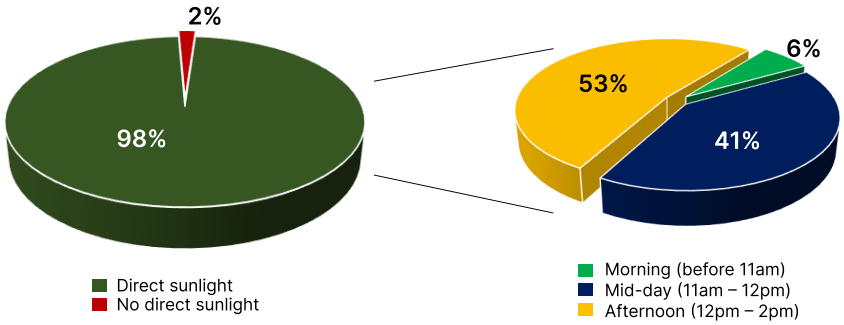

Figure 5. Incidences of direct sun exposure inside classrooms during teaching.

When it gets very hot, all the teachers (100%) admitted to opening doors and windows and adjusting the speed of fans to help in controlling the temperature inside classrooms. Although 79% of the teachers stated that windows were opened every day, a shocking 96% felt classrooms were not well-ventilated. This is concerning since the potentially harmful health effects of inefficient ventilation and indoor air pollution have resulted in an increase in the number of illnesses associated with sick building syndrome [34,35]. Considering children may be more vulnerable to environmental contaminants and the consequences of indoor toxins may be more severe than adults [36,37], attention to cross ventilation is crucial to avoid extreme heat levels and poor indoor air quality inside classrooms.

On further inquiry, it was found that only 9% of the schools provided blinds or curtains inside classrooms. However, 99% of the schools were equipped with effective measures to reduce heat such as outdoor shade provisions, sheltered hallways, clean cold water facilities, and indoor activity areas for children.

3.3. Teachers' Opinions and Views Relating to Heat

Teachers were asked, "What is the overall description of temperature inside the classrooms during summer season?". The thermal description of teachers inside their classrooms is shown in Figure 6a. A total of 67% and 7% felt the indoor environment inside classrooms was hot and very hot, respectively, during the summer season.

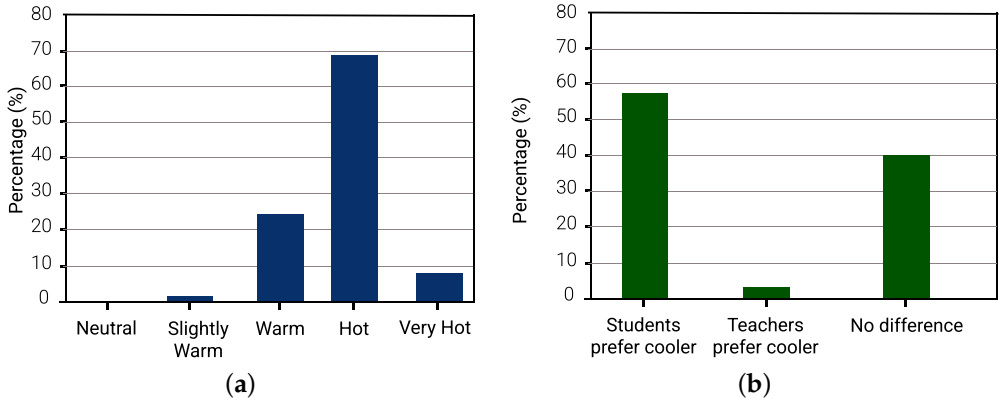

Figure 6. (**a**) Overall description of temperature inside the classrooms in summer according to teachers; (**b**) Is there any difference between the thermal comfort preferences of students and teachers during summer season.

On inquiring whether students tend to have different preferences in hot environments than them as reflected in Figure 6b, 57% teachers were of the view that students preferred cooler temperatures and 40% of them felt there were no differences in thermal preferences between teachers and students. This is consistent with published research, where children's thermal sensations may differ from standard thermal comfort models, with a cooler thermal preference than adults [38–41].

Additionally, teachers were asked to consider the following statements and register whether they 'strongly agree' or 'strongly disagree', as shown in Figure 7. A total of 90% of teachers strongly disagree and dispute that the indoor temperature of their classrooms is usually within a comfortable range in the summer season, while 64% of them reject the contention that the students are acclimatized to the hot classroom environment in summer. All of the teachers acknowledged that as the temperature rises, there are more incidents of illnesses and absences due to poor health. Significant evidence from prior studies points in the same direction, indicating that there is a substantial and positive correlation between an increase in ambient temperature and children's health problems [5,42]. The teachers also admit that installing air conditioners in classrooms will contribute to improving indoor thermal conditions. Once more, this is consistent with the traditional longstanding assumption that air-conditioning is an effective solution to provide indoor thermal comfort and protection against heat exposure and heat stress [43,44]. Although the use of air conditioning in India is predicted to increase each year, the main concern for most primary schools is affordability, especially for schools that lack regular access to electricity, those located in low-income neighborhoods, and schools with limited infrastructure.

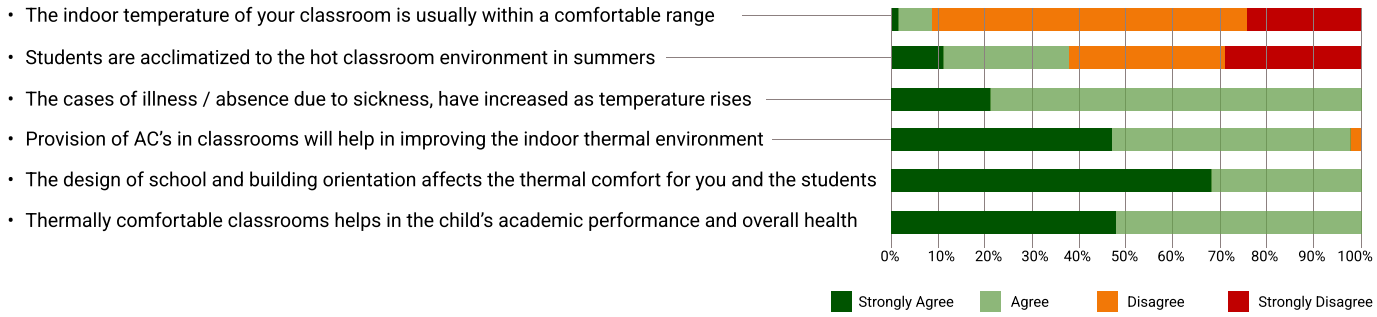

Figure 7. Teachers' opinions of the classroom environment.

3.4. Teachers' Experiences Related to Children's Heat Risk

The next section included questions appertaining to teachers' observations and the perceived heat-related sickness/symptoms they noticed in their students. A total of 36% of teachers strongly agreed and 64% agreed that hot conditions inside classrooms caused discomfort to students. The most evident discomfort was fatigue (76%) while the percentage of other indicators vary between feeling dehydrated, too lazy to do class work, and being restless, as presented in Figure 8. Children may exhibit signs and symptoms of mild heat exhaustion before a serious heat stroke event. On account of children being unaware of the need to take preventative measures and their bodies being less able to adjust to temperature changes [45], it becomes imperative for teachers and school authorities to recognize symptoms of heat stress and exhaustion to prevent heat-related illnesses.

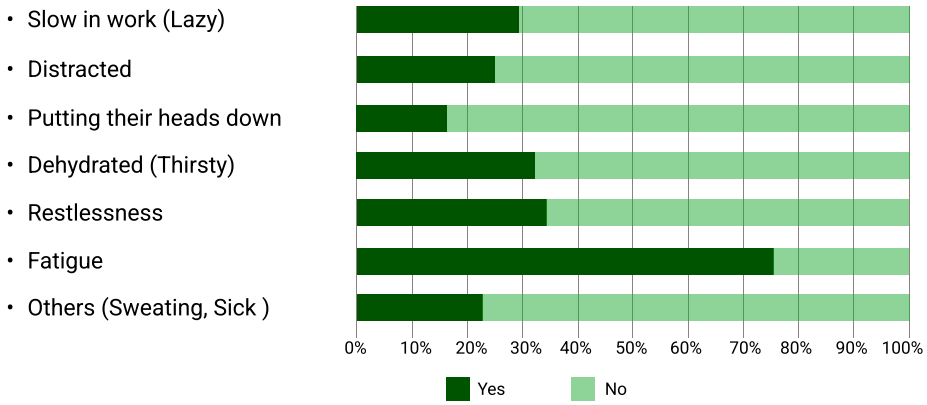

Figure 8. Teachers' observations of students in classrooms- physical discomfort of hot days on children.

A total of 96% of the teachers also admitted that students often got distracted and lost their concentration towards studying due to heat and 54% of them completely acknowledge that this affects the students' academic performance. This observation is consistent with findings that academic learning and scholastic achievement are disrupted significantly by elevated temperatures [17,46].

In the course of our earlier field survey in India during the summer season [47,48], it was observed that numerous primary school students were sent home early after they complained about being unwell (due to overheating and the extreme heat in the classrooms). In Table 8, the percentage of students who returned home early from their school schedule because of feeling unwell due to heat, as reported by the current survey, is demonstrated. Teachers responded that on 96% of such occasions, at least 3–10 students returned home early in a week citing heat-related illness (dizzy, fainting, nauseous, feeling weak, and headache). Excessive heat in classrooms was possibly the cause of the illnesses, which left students complaining of heat stroke symptoms such as tiredness, excessive sweating, and dehydration. Teachers also recount that on many occasions, parents avoid sending their children to school in the wake of intense heat. This may furthermore disrupt studies and influence student performance.

Table 8. The percentage of students who return home early from the school due to heat-related illness.

According to Teachers, Students Returning Home Early Every Week Due to Heat Related Illness		
1.	Average one student daily	0%
2.	Less than 3 students in a week	0%
3.	3–5 students in a week	1%
4.	5–10 students in a week	24%
5.	>10 students per week	67%

Children adjust to their surroundings at a slower rate than adults as they may require as many as eight to ten exposures (of 30 to 45 min each) every day to acclimatize to a warmer environment [49,50]. Additionally, children's response to thirst and voluntarily drinking water is different compared to adults [49,51], and therefore, they are more prone to become dehydrated. Consequently, children complaining of any indication of nausea, vomiting, headache, dizziness, etc., must be given immediate attention. Figure 9 presents the number of occasions when students have complained or informed their uneasiness and symptoms to teachers. A high proportion of students complained personally to their teachers about feeling tired (70%) and sweating profusely (62%). Excessive sweating can lead to dehydration and heat exhaustion. Exposure to heat can aggravate pre-existing medical conditions [52,53]. Accordingly, recognizing, treating, and managing heat-related illnesses in children should be the focus of prevention measures.

The teachers reported that 43% of the students complained daily about their discomfort due to hot temperature, and 52% of students complained often (more than once a

week). Apart from adjusting themselves to the indoor conditions, students sometimes also informed the teachers about their heat discomfort. The questionnaire further asked teachers how students cope and adapt themselves in classrooms when the temperatures are high. To the question, "How do students cope and adapt themselves in classrooms with high temperatures?", the teachers' answers are presented in Figure 10.

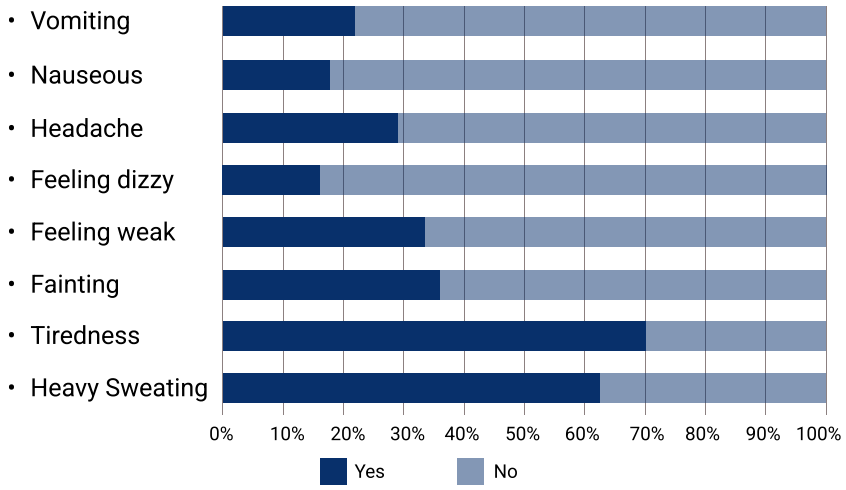

Figure 9. Students reporting the following symptoms during summer season.

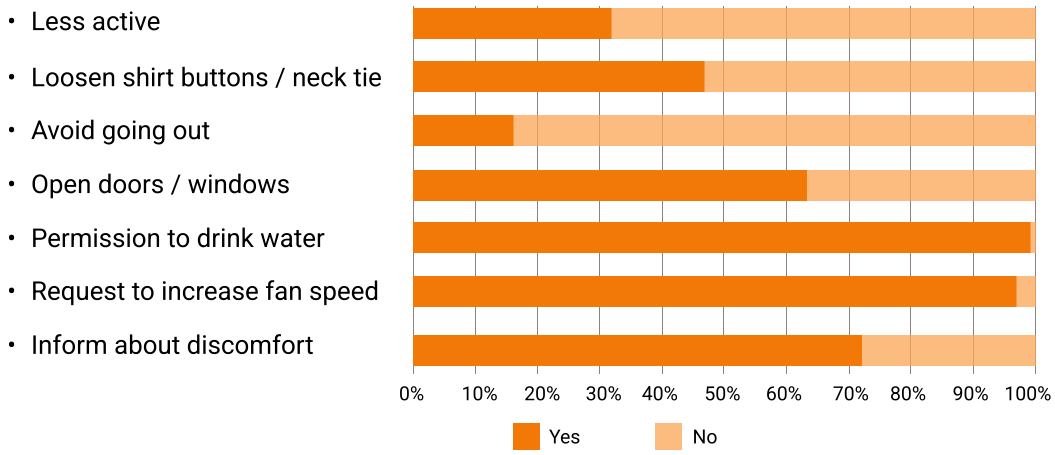

Figure 10. How students adapt themselves to hot temperatures according to teachers.

Teachers have raised concerns of students falling ill during school hours and reports of students fainting and suffering heat stroke were noted. Figure 11 shows the number of incidences when students have fainted or gotten ill on school premises (for example, during the recess break, morning assembly, or sports activities) and inside their classrooms due to heat cramps or heat exhaustion. Considering that "No cases reported" is 0%, and the extremely harmful effects of heat and climate change exposure are predicted to increase and worsen, this trend is unfortunately expected to continue rising.

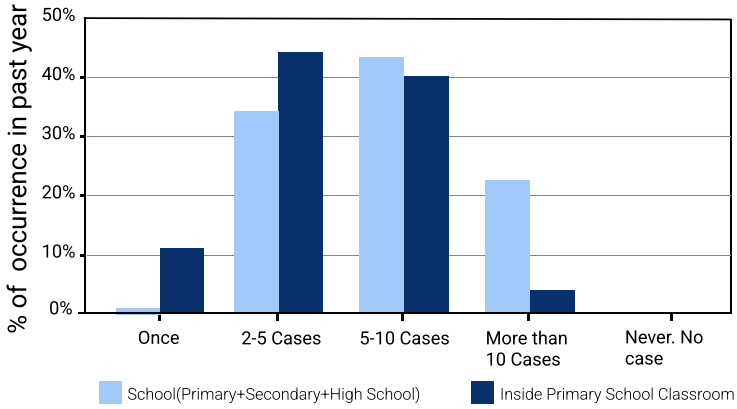

Figure 11. Percentage of incidences when students have fainted or gotten sick due to heat related illness.

3.5. Awareness and Precautions against Heat Risk

The questionnaire's final segment evaluated how well the teachers understood the risks associated with heat and how they took precautions to avoid heat stress. All the teachers responded that safe and cool drinking water was readily available to the students and provided by the school. A total of 84% of the teachers said they reminded students to regularly drink water and stay hydrated.

It is crucial that all schools have contingency measures in place to assist both faculty and students in managing hot days. Figure 12 shows the responses to the question, "What precautions are taken by the school to avoid extreme heat in summer?". It is evident that none of the surveyed schools had provision of air conditioners to mitigate heated classrooms. A total of 90% of the teachers informed that school hours were limited (to morning hours), from during very hot days. On days when a 'heat-wave day' was issued by the local government, schools usually remained closed. The morning assemblies were sometimes held indoors or in shaded areas. While outdoor play, exercises, and sporting activities were also limited. However, only about 30% implemented strategies to educate and advise parents and students about heat risks, heat management, and guidelines. It is pertinent that comprehensive awareness-raising and learning initiatives should be part of schools' heat policies since it is constantly acknowledged as one of the fundamental approaches to combat heat-related sickness in schools. This includes training students on the significance of preventing heat-related illness, particularly factors within their own control; instructions to parents on how to prepare their children for extreme temperatures and what they can anticipate from schools; and finally, teaching school staff, teachers, and sports trainers how to recognize and manage illnesses brought on by excessive heat in children.

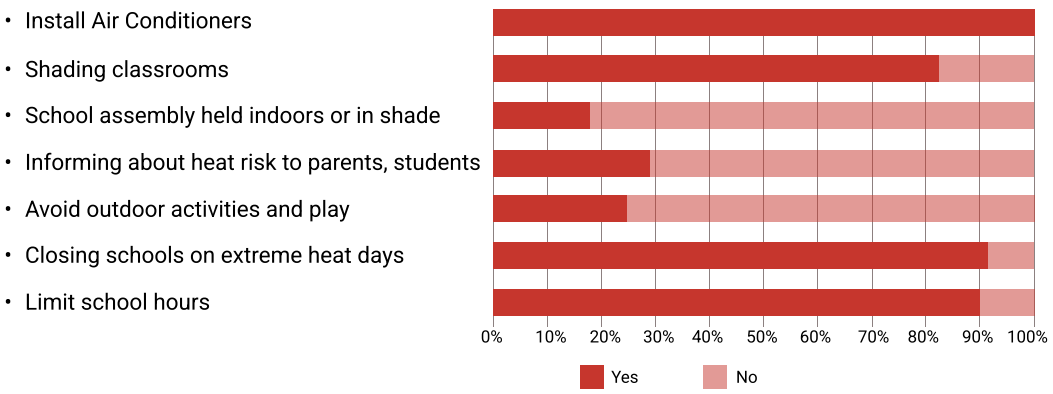

Figure 12. Precautions taken by the schools to avoid extreme heat in summer.

When asked if the teachers had any additional recommendations to the school authorities to ensure students' thermal comfort and safety from heat stress, the following responses

were collected as shown in Figure 13. Scarcely 2% of the teachers preferred no change in the existing conditions. A total of 99% of the teachers replied that a practical measure would be to provide window blinds or curtains as an effective measure to reduce summer heat gain inside classrooms. A good majority of 93% and 72% teachers also acknowledged that equipping classrooms with air-conditioners or air-coolers, respectively, would help improve classroom indoor environments. Other suggestions included changes in timetable slots such as replacing classes with activities during earlier school hours, modifying school opening and closing hours, and improving classroom design and layout.

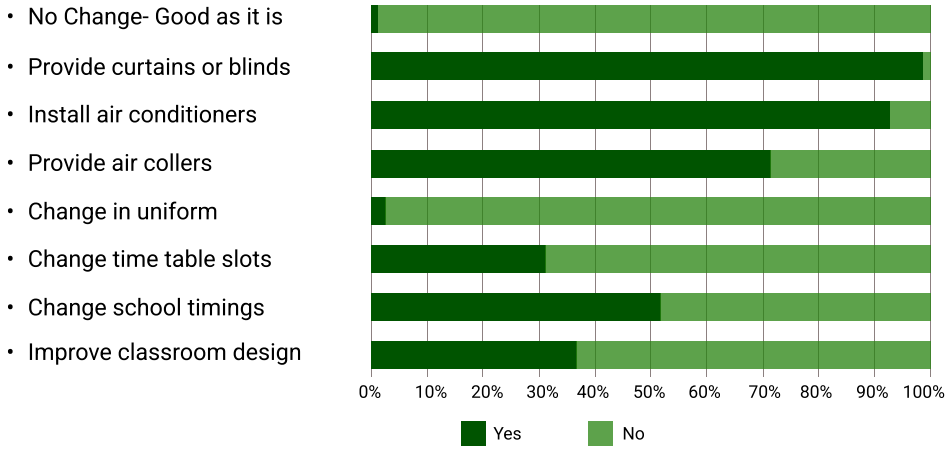

Figure 13. Recommendations to school authorities to further enhance safety against extreme heat in summer.

When teachers were asked if the awareness program provided by the Indian Government for heat waves is sufficient, only 36% agree that the information is adequate. While 39% disagree that the awareness provided is sufficient, a staggering 25% were not even aware of any schemes and information specified for heat waves. Moreover, when inquiring about the guidelines for 'Preparation of Action Plan–Prevention and Management of Heat Wave', issued by the National Disaster Management Authority (NDMA), only 18% responded to know about the guideline. This information sheds light on the fact that there exists limited knowledge and training of heat stress despite guidelines and preventive measures provided by the Indian government for heat-related illnesses and extreme heat waves preparedness.

Furthermore, the fact that 84% of the teachers reported receiving no specific training or information from the schools regarding heat-related illnesses is a daunting result. This is worrisome information as teachers' knowledge of how to handle heat risks and related symptoms must be made compulsory.

4. Discussion

This study examined the direct and indirect effects of climate change, particularly heat waves, on Indian primary school students' health, learning, and overall well-being. The findings of the current survey serve as a crucial first step in developing and implementing evaluation criteria for heat preparedness in primary schools.

It is worth noting that due to a lack of adequate cooling measures at home, children continue to be exposed to hot environments despite returning home after complaints of heat-related sicknesses. Vulnerable communities that lack access to or cannot afford air conditioning are particularly at risk due to this particular problem [54]. Therefore, installing ACs in primary schools can be seen as a way to improve student learning outcomes and foster the best possible learning environment. Additionally, air-conditioned schools can provide temporary cooling places for vulnerable populations during heat waves, similar to certain European cities where air-conditioned public buildings can be used as evacuation

centers or climate shelters. This is an important factor to take into consideration given the frequency and severity of extreme weather events around the world.

However, implementing such solutions within Indian contexts poses various challenges. There are funding limitations and maintenance expenses that prevent institutions from investing sufficient resources [55]. The installation cost of an AC system is high and ongoing maintenance expenses add up over time. Additionally, power outages prevalent in many parts of India could further undermine the viability of AC systems. Moreover, cultural factors may pose significant challenges to implementing these solutions within Indian society. Therefore, more research is required on effective strategies for implementing such solutions within the Indian context while addressing various challenges such as costs, infrastructure requirements, and cultural factors.

Further, in this study, we focused on primary schools in the hot climatic region of India, and our findings provide valuable insights into the impacts of heat waves on children in this specific context. Moving forward, expanding the scope of our research to include kindergarten and secondary schools, along with elaborate surveys in different contexts (socioeconomic factors, and infrastructural conditions), and climatic regions will provide a better understanding to the specific vulnerabilities of children during heat waves.

5. Way Ahead

Given the likelihood of more severe summer temperatures in the future, it is critical to recognize this problem and allocate resources in preparation for more such events occurring. Some suggestions on future research directions regarding heat waves, specifically focusing on children in India, can be elucidated as below:

1. Monitoring and evaluating the educational system's response to climate change.
    (a) Collect evidence and identify the impact of heat risks on the Indian school education sector;
    (b) Multidisciplinary and interdisciplinary collaboration between researchers, health professionals, and local stakeholders towards prevention and adaptation to heat stress, especially for children.
2. Incorporate awareness and strategies to ensure children's heat stress safety.
    (a) Develop early warning systems and raise awareness of health hazards of extreme heat through campaigns and community outreach;
    (b) Promote training to teachers and educators to recognize signs and symptoms of heat-related illness in children (heat cramps, heatstroke, and heat exhaustion) and further equip them with basic first-aid training.
    (c) Ensure awareness among students about the heat risk factors along with recognizing heat stress symptoms and preventing heat related illnesses.
3. Heat management preparedness and planning in schools.
    (a) Consider incorporating heat risk management as a health education curriculum for students and emergency preparedness training for teachers;
    (b) Implement school policy to schedule flexible time-table, leniency over enforcement of uniforms,
    (c) Improve the quality of physical infrastructure to restrict sun mitigation and heat exposure such as shade provisions and covered play spaces, provide blinds or curtains, improve indoor cross-ventilation, and plant trees for shade.
    (d) Allocate medical resources like first-aid and emergency assistance to timely assess and monitor heat-related illnesses.

6. Conclusions

The profound impact of climate change on children, particularly in developing countries such as India, poses a significant threat to children's vulnerabilities and impedes their future development significantly. While various field surveys have investigated the indoor thermal environment in classrooms and children's perceptions of temperature, the

majority of them have primarily focused on determining the range of thermal comfort, rather than assessing the risks associated with excessive heat. There is a noticeable absence of quantitative research and longitudinal studies on children in primary schools and hot classrooms, restricting a clearer understanding to comprehend the effects of climate change on children's well-being and health. To address these gaps, a field survey among primary school teachers was conducted to gain insights into children's experiences with heat waves within their classrooms, as well as their susceptibility to heat exposure and potential health impacts. The results from the questionnaire contribute to an understanding of the challenges associated with heat discomfort for both students and teachers in classrooms.

According to the questionnaire surveys, primary school teachers agreed that students are significantly exposed to heat waves throughout the summer months. 96% of the teachers reported being sick and having their teaching work hindered by the excessive heat. 100% agree that as the temperature increased, the number of students who reported feeling sick also escalated. During the heat wave conditions, 74% of teachers characterized the indoor environment within their classrooms as uncomfortably hot and very hot, revealing that 96% of these times, at least 3–10 students have left school early due to heat exhaustion, while complaining of being drowsy, lethargic, and experiencing fatigue. The findings are consistent with studies that children are found to be considerably more susceptible to heat than the average population [56]. In view of the fact that heat-related illnesses and symptoms are potentially a problem especially in schools with limited resources where providing air conditioners are not possible; and the limited awareness of 'Guidelines for Prevention and Management of Heat Wave' (82% of teachers were unaware), it is essential to educate students, parents and school faculties equally about the threat of heat waves and explain the undermining risks associated with it.

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