International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Research Article)

Evaluation of thermal comfort in residential buildings: A Case Study of Wari, Dhaka

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International Journal of Science and Research Archive, 2024, 13(02), 3213-3222

Publication history: Received on 06 November 2024; revised on 21 December 2024; accepted on 23 December 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.13.2.2576

Abstract

In Dhaka City's tropical climate, achieving thermal comfort in residential buildings remains a critical challenge due to poor architectural designs, inadequate ventilation, and over-reliance on mechanical systems. This study highlights the thermal discomfort experienced by residents in collective housing in the Wari area, where ineffective thermal insulation and ventilation strategies exacerbate indoor temperature extremes, impacting health and increasing energy consumption. The aim of this research is to evaluate the thermal conditions in residential buildings, identify architectural factors influencing thermal comfort, and recommend adaptive solutions to enhance indoor environmental quality. Using an experimental-descriptive method, data was collected through surveys with 67 residents and in-situ measurements in 11 buildings during winter and summer periods. A Rotronic Temperature Data Logger was used to record indoor temperature and humidity at various times of the day. The findings revealed that 96% of residents were dissatisfied with indoor thermal conditions, with 82% reporting significant discomfort during summer. Energy consumption was high, with 81% of participants relying heavily on cooling and heating systems. Poor thermal performance of construction materials and limited ventilation were major contributors to discomfort. Additionally, over one-third of residents reported chronic health issues linked to thermal extremes. The study concludes that architectural solutions such as optimizing window design, enhancing natural ventilation, incorporating shading devices, and improving insulation are critical for mitigating thermal discomfort. These interventions can reduce energy reliance, improve indoor environmental quality, and promote residents' well-being. The findings emphasize the urgent need for sustainable and cost-effective design strategies in Dhaka's housing sector to ensure healthier living environments.

Keywords: Thermal Comfort; Residential building; Indoor Comfort; Architectural Design; Health and well-being

1. Introduction

Designers and architects face the challenge of creating and maintaining a safe and healthy indoor environment with a high quality of life, considering that most people spend about 90% of their time indoors [Klepeis et al., 2011].Highlighting the importance of healthy housing that ensures sanitary comfort and social well-being [Çeter, Alkan, & Turhan, 2021; Boulemaredj & Haridi, 2022; Slipek et al., 2017], significantly impacting quality of life [Al Horr et al., 2016]. Buildings should integrate local bioclimatic principles to enhance living standards and provide optimal thermal comfort tailored to the climate [Samuel et al., 2017; Hailu, Gelan, & Girma, 2021; Akande & Adebamowo, 2010]. However, the reliance on mechanical solutions for thermal comfort has led to substantial energy consumption, with residential buildings accounting for one-third of fossil fuel use [Taleghani et al., 2013]. According to ISO (2005) and ASHRAE standards, a thermal environment is considered acceptable when 80% of the occupants report being comfortable, which aligns with the definition of thermal comfort as a mental state of satisfaction [Kelechava, 2021]. Several studies have assessed thermal comfort criteria, with the ASHRAE models [Lomas & Kane, 2013; Adekunle & Nikolopoulou, 2014] and the adaptive thermal standard [Nicol, 2004; Humphreys, Rijal, & Nicol, 2013] showing strong

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performance in determining ideal comfort temperatures. The interplay of environmental and bodily factors in achieving comfort was supported by Toy & Kántor (2017) and Haruna, Muhammad, & Oraegbune (2018).Numerous in-depth field studies across various climate zones have highlighted the adverse effects of extreme temperatures on thermal comfort in residential buildings. Studies in moderate climates (Lomas & Kane, 2013), tropical climates (Nicol, 2004; Al-Tamimi, Fadzil, & Harun, 2011), and hot and humid climates (Akande & Adebamowo, 2010; M. Adaji, Watkins, & Adler, 2015) have shown that elevated indoor temperatures significantly diminish the comfort of occupants. Additionally, an in-situ study conducted in a hot and dry climate [Ealiwa et al., 2001] found that older buildings offered better thermal comfort than newer ones.

However, thermal performance of residential buildings in Dhaka City has been a subject of considerable research due to the city's tropical climate and rapid urbanization. Studies have identified several factors that influence indoor thermal comfort, including building orientation, insulation quality, and ventilation strategies. For instance, [Ahmed et al. (2014)] found that most urban apartments in Dhaka suffer from inadequate natural ventilation, resulting in significant thermal discomfort during both summer and winter [Safiuddin et al. (2016)] highlighted that the lack of proper insulation in walls and roofs exacerbates indoor heat retention in summer and heat loss in winter [Rahman et al. (2018)] observed that poor building design leads to a high reliance on mechanical cooling, increasing energy consumption and costs for residents. To further explore the factors affecting thermal comfort in Dhaka City, it is essential to clearly understand the thermal performance of buildings. This understanding is crucial for gathering the necessary data to enable detailed analysis and informed decision-making. Designers and architects must prioritize creating homes that ensure high thermal performance, thereby enhancing safety, health, and the overall quality of life for residents. This involves designing, developing, building, and maintaining residential spaces that meet the thermal comfort needs of their occupants effectively.

Effective building design plays a vital role in architectural strategies focused on enhancing natural ventilation and improving thermal performance in residential buildings. Properly sized and strategically positioned windows are essential for facilitating the exchange of indoor and outdoor air, helping to regulate indoor temperatures and mitigate thermal discomfort. However, several critical questions arise in this context:

- Are modern residential buildings designed to meet clients' needs without adequately addressing thermal performance, thereby contributing to indoor temperature discomfort for residents?
- Do these buildings effectively promote natural ventilation and enhance overall thermal performance?

This research aims to highlight the importance of thoughtful window design in achieving thermal comfort. By addressing the challenges of thermal performance, particularly in residential buildings, this study provides architects and designers with a framework for systematically promoting health and well-being through improved architectural solutions.

Aims and Objectives

The study aims to evaluate the rate of thermal comfort in residential buildings and its impact on architectural requirements in Dhaka City. Hence the objective of the study three fold:

- To assess the thermal conditions in residential buildings in Dhaka City.
- To identify architectural factors affecting thermal comfort in residential buildings.
- To recommend adaptive solutions to improve thermal comfort in residential Building

"What are the Architectural Design Effects of Thermal Comfort and Indoor Environmental Quality on Residential Buildings in Dhaka City?"

- **Possible Outcomes:** The research explores innovative and cost-effective solutions for improving indoor thermal conditions in both existing and new residential buildings.
- Scope: The research explores innovative and cost-effective solutions for improving indoor thermal conditions in both existing and new residential buildings.

2. Methodologies

This study aims to assess the performance of the Wari residential area and identify temperature-related issues by investigating thermal discomfort in 11 residential buildings. The research adopts an experimental-descriptive method, using a questionnaire distributed to a sample of 67 residents. Dhaka, the capital of Bangladesh, has a tropical climate with hot, wet, and humid conditions, as indicated by data from the city's meteorological station between 2021 and 2023. The climate is classified as tropical wet and dry according to the Koppen climate classification, with an annual average temperature of 25°C (77°F). Temperatures vary from 18°C (64°F) in January to 29°C (84°F) in August. Dhaka experiences a monsoon season from May to September, contributing to nearly 80% of its annual rainfall (1,854 mm or 73 inches). This study focuses on the collective buildings in Wari, a residential area located in the southern part of Dhaka. Case studies were conducted on 11 buildings, each consisting of three rooms (a living room and three bedrooms), Second, to confirm the respondents' opinions on their thermal comfort, the study was conducted during both winter and summer periods, focusing primarily on a flat located on the 3rd floor of Building 6 (Figure 1). This flat has a living area of 150 m^2 and includes a living room, kitchen, toilet, bathroom, and bedrooms. It is oriented along the north-south axis. The architectural design of the dwellings in Building 6 follows a prototype plan, where the rooms are organized around a central clearance space.

The research utilized the Rotronic Instruments Temperature Data Logger for real-time measurements of indoor air's relative humidity and temperature. The analysis incorporated both quantitative data and qualitative observations, examining potential physical issues in the buildings, such as health problems and observable anomalies that could indicate underlying concerns. Measurements were taken on two specific days, DD1 and DD2, which were selected based on the highest and lowest average temperatures, respectively. DD1 represents the warmest day with the highest temperature, while DD2 corresponds to the coldest day with the lowest temperature. The design day selection process used multi-objective optimization techniques to balance the maximization of temperature. The measurements were conducted during summer (April to June 2022) and winter (December 2021 to February 2022), with readings taken three times a day at 7 am, 12 pm, and 6 pm. Temperature fluctuations were influenced by factors such as window openings and the use of indoor environmental controls, including air conditioning, heating, and fans.

Figure 1 Floor plan of the investigated flat (Source: Authors, 2022)

3. Results and discussion

This study was conducted to address the potential thermal discomfort experienced by residents of collective residential buildings in Wari, Dhaka. The analysis of the results is detailed in the following sections.

As shown in (Figure 2), 96% of the residents reported a lack of thermal comfort in their living spaces. This discomfort was primarily attributed to the poor thermal performance of the construction materials, which failed to adequately protect against summer heat and winter cold.

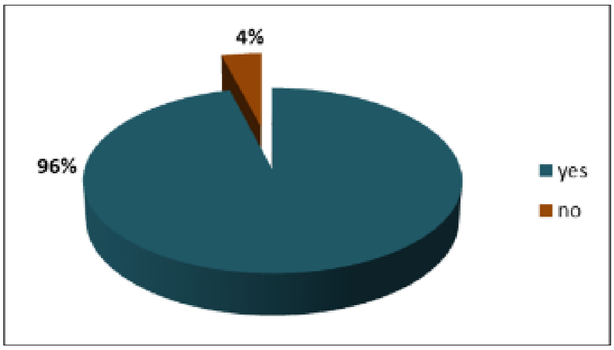


Figure 2 Thermal comfort status of the residents surveyed in the 11 housing estates (Source: Authors, 2022).

Figure 3 presents the responses of 67 participants regarding energy consumption in their homes. The data reveals that 81% of respondents in the 11 residential buildings reported excessive energy consumption. This was primarily caused by the extensive use of heating and cooling equipment during both cold and hot periods, resulting in significantly higher energy bills.

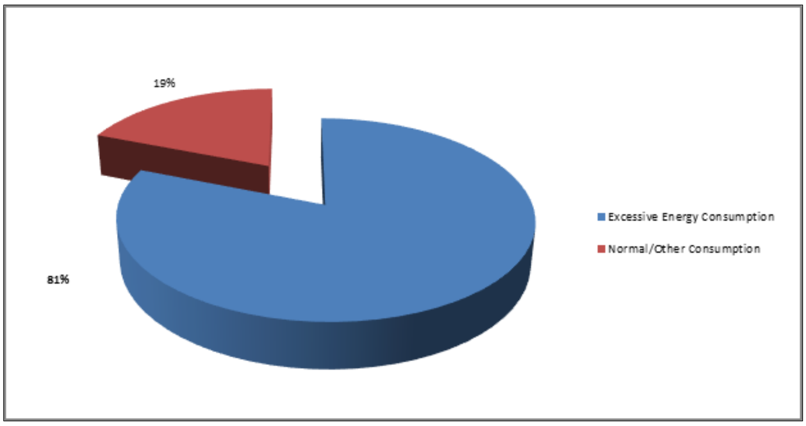


Figure 3 Percentage of respondents' answers on energy consumption (source, authors, 2022)

Similarly, the results of these variables are validated by the operation of the assisted system. The data indicates that the sensible heat in the area is higher from April to June, reaching its maximum temperature during this period. Conversely, the sensible cooling of the studied flat increases during the hot period from mid-December to the end of January, reaching its minimum temperature. These findings align with the opinions expressed by the surveyed residents regarding their thermal comfort experiences.

Furthermore, the respondents' answers regarding thermal comfort during summer in the surveyed buildings highlight a significant lack of satisfaction. A total of 56 respondents (82%) stated that their dwellings were very hot, while only 11 respondents (18%) found the summer temperatures tolerable (Figure4).

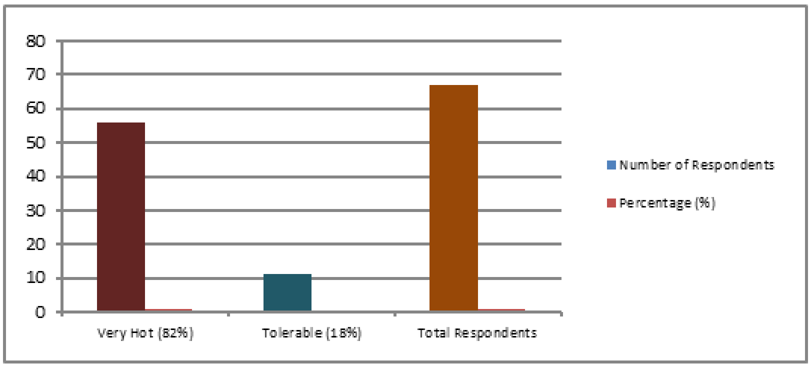


Figure 4 Thermal comfort level in summer (source, authors, 2022)

Figure 5 illustrates the responses from inhabitants regarding their level of thermal comfort in their homes during hot periods. The majority of respondents (74.5%) expressed dissatisfaction with the thermal conditions, particularly during the high-summer heat, especially in June. In contrast, 25.5% of respondents reported being thermally satisfied with the conditions in their dwellings.

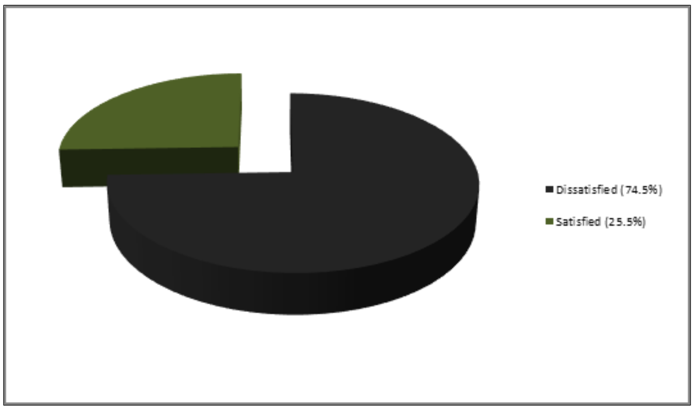
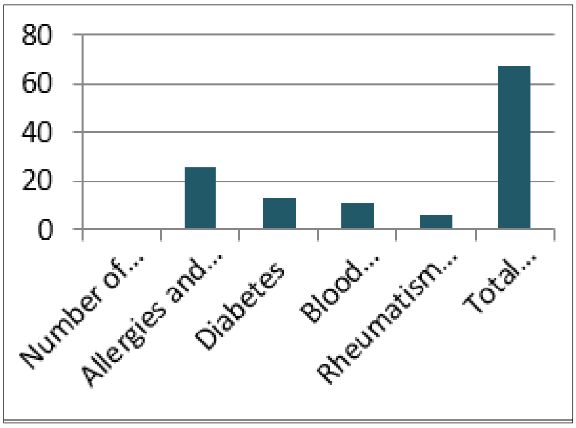


Figure 5 Level of thermal comfort in summer (source, authors, 2022)

Moreover, an inadequate temperature-humidity comfort range has a significant and detrimental impact on the health of the occupants. As shown in Figures 6 and7, one-third of the respondents suffer from chronic health conditions due to poor thermal comfort. The main health issues identified include allergies, blood pressure instability, and diabetes. Specifically, 26 out of 67 respondents reported suffering from allergies and respiratory disorders, 13 had diabetes, and 11 had blood pressure issues. Additionally, rheumatism and osteoarthritis were found to affect 6 out of 67 respondents, particularly in winter due to low temperatures. Similar health complications linked to thermal discomfort in residential buildings have also been observed in other studies.

In results obtained from the sociological survey and simulations clearly show that approximately 95% of the surveyed residents experience significant thermal discomfort in their homes. To address this issue, the first step is to understand the temperatures individuals endure in their homes and the upper limits of comfort they can tolerate.



(source, authors, 2022)

Figure 6 Percentage of the respondents with and without sickness (source, authors, 2022)

In Dhaka, health issues related to temperature extremes have become increasingly concerning due to inadequate thermal comfort in residential buildings. Studies have shown that residents face challenges from both high temperatures during summer and low temperatures during winter. For instance, high summer temperatures exacerbate conditions such as heatstroke, dehydration, and respiratory issues, while low winter temperatures contribute to problems like rheumatism and respiratory infections (Shah et al., 2020).

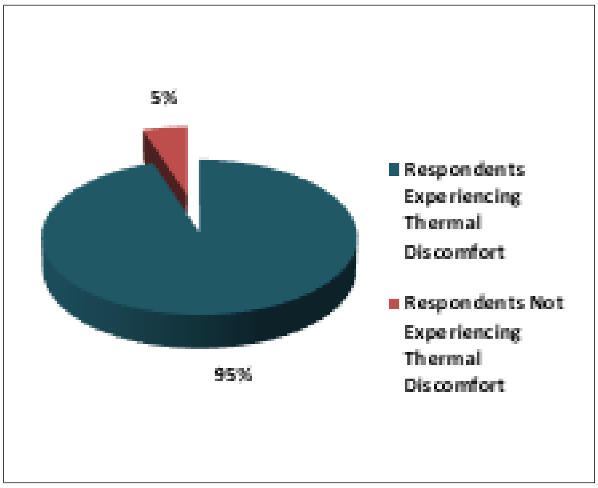


Figure 7 Number of sicknesses found throughout the survey

A study by Rahman et al. (2019) found that a significant portion of Dhaka's urban population suffers from heat-related illnesses during the summer due to the lack of proper insulation and cooling systems in residential buildings. Furthermore, according to Islam et al. (2021), the temperature extremes in residential areas of Dhaka are linked to a rise in chronic health issues such as cardiovascular diseases, hypertension, and respiratory disorders.

3.1. Observation of Ventilation and Thermal Discomfort in summer and winter

In this section, the focus is on evaluating the ventilation conditions and the resulting thermal discomfort in the residential buildings during the summer months. Summer in Dhaka, characterized by high temperatures and humidity, often leads to an increased demand for indoor cooling. Observations were made regarding the ventilation patterns in the buildings, specifically how airflow was managed and whether it helped alleviate or exacerbate thermal discomfort.

The assessment involved noting how the natural ventilation (i.e., window openings, cross-ventilation between rooms) and mechanical ventilation (e.g., fans or air conditioning) influenced the indoor temperature and humidity levels. It was observed that rooms with poor ventilation, particularly those with limited window openings or those obstructed by neighboring buildings, exhibited higher levels of thermal discomfort. In contrast, areas with better airflow, such as rooms with larger windows or those oriented for cross-ventilation, reported relatively more comfortable indoor environments.

Table 1 Recording of temperature and humidity measurements in building 6 during the summer period

Time	**Outdoor temperature**	**Indoor temperature**
07:00 AM	29 °C	27 °C
12:00 PM 06:00 PM	34 °C 30 °C	33 °C 29 °C
Humidity	**07:00:0AM**	**12:00:00 PM 06:00:00 PM**
Kitchen	81	72 76
Living	77	69 68
Room	79	77 71
Bathroom	80	74 79

Table 2 Recording of temperature and humidity measurements in building 6 during the winter period

Time	**Outdoor temperature**	**Indoor temperature**
07:00 AM	17 °C	23 °C
12:00 PM	26 °C	28 °C
06:00 PM	18 °C	24 °C
Humidity	**07:00:0AM**	**12:00:00 PM 06:00:00 PM**
Kitchen	84	63 66
Living	81	61 65
Room	77	59 57
Bathroom	92	67 66

The recorded data indicates a disparity between outdoor and indoor temperatures throughout the day, which contributes to thermal discomfort for the inhabitants. Figure 8

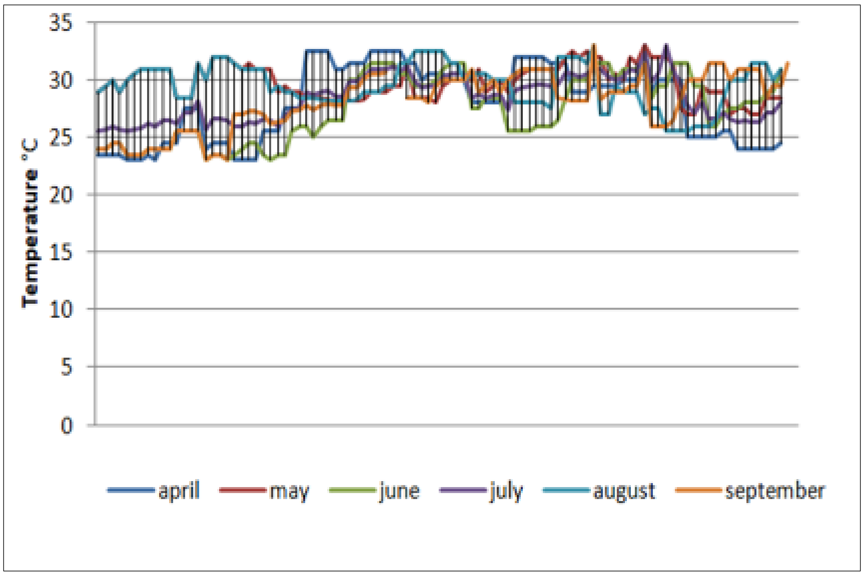


Figure 8 Level of thermal comfort in summer (source, authors, 2022)

The research results Table 1 and Table 2 shows from Building 6 reveal distinct variations in temperature and humidity between the summers and winter periods. During the summer, outdoor temperatures range from 29 °C in the early morning to a peak of 34 °C at noon, gradually dropping to 30 °C by evening. Indoor temperatures remain slightly lower but follow a similar pattern, ranging from 27 °C to 33 °C. Humidity levels are notably high throughout the day, particularly in the kitchen (81% in the morning and 77% in the evening) and bathroom (79%). The living room exhibits slightly lower humidity, ranging from 72% to 77%. These findings suggest that the building's indoor environment during summer is characterized by elevated temperatures and high humidity, potentially leading to discomfort for occupants, especially during midday.

In contrast, the winter period presents more favorable thermal conditions. Outdoor temperatures range from 17°C in the morning to a maximum of 26°C at noon, while indoor temperatures remain consistently warmer, between 23°C and 28°C. Morning humidity is relatively high in the kitchen (84%) and bathroom (77%), potentially causing slight discomfort, but it drops significantly by noon and evening, enhancing comfort levels. The indoor environment in winter benefits from better insulation, as indicated by the moderate indoor temperatures. Overall, the building provides a more thermally comfortable environment in winter compared to summer, though localized humidity control in high-moisture areas like the kitchen and bathroom could further optimize indoor comfort.

The study also explored the influence of sunlight exposure and wind on the thermal performance of the buildings. Rooms facing direct sunlight for prolonged periods, especially those with insufficient shading, experienced higher indoor temperatures, leading to greater thermal discomfort. The presence of wind, although beneficial in cooling the indoor spaces, was often insufficient to offset the high temperatures during the hottest days of the summer.

Overall, the observations indicated that inadequate ventilation combined with high external temperatures contributed to significant discomfort in many of the buildings. The findings highlight the need for improved ventilation strategies, such as optimizing window placement, enhancing airflow, and incorporating shading devices to reduce solar gain and improve indoor thermal comfort.

During the winter months in Dhaka, when temperatures drop and humidity levels decrease, residents commonly close their windows to retain indoor warmth. However, this practice can intensify thermal discomfort due to insufficient ventilation. This section explores the impact of closed windows during winter on indoor air quality and thermal comfort.

With the windows closed, natural ventilation within the buildings was significantly reduced, leading to a buildup of indoor pollutants such as carbon dioxide, humidity, and volatile organic compounds. This lack of fresh air exchange contributed to increased thermal discomfort, as residents reported feelings of stuffiness despite the relatively cooler outdoor temperatures.

The indoor temperature remained relatively stable but often fell below the comfortable threshold due to inadequate passive heating or insulation. Rooms exposed to colder outdoor conditions, especially those with external walls facing prevailing winds, experienced greater heat loss. The absence of airflow hindered efforts to regulate these lower temperatures, making it more challenging to achieve a comfortable indoor environment.

In some cases, mechanical heating sources such as space heaters or portable heaters were used to compensate for the cold. However, these were often inefficient, resulting in uneven heating throughout the space. This created thermal discomfort, with some rooms feeling too cold while others, especially those near heating sources, were more comfortable.

The closed window condition also limited the ability to regulate indoor humidity effectively. Without adequate ventilation, moisture from cooking, bathing, or other indoor activities remained trapped, increasing indoor humidity levels. This higher humidity contributed to a sense of discomfort and made the cold feel more penetrating.

In results shows, keeping windows closed during winter in Dhaka, while intended to conserve heat, led to poor ventilation, uneven temperatures, and heightened thermal discomfort. These findings underscore the need for a balanced approach that ensures both insulation and adequate ventilation to maintain indoor comfort during the colder months.

4. Conclusion

This research highlights the critical role of thermal comfort in residential buildings, particularly in Dhaka's tropical climate. The study identified significant thermal discomfort among residents in collective residential buildings in Wari, Dhaka, primarily due to poor thermal performance of construction materials, inadequate ventilation, and the extensive use of mechanical cooling and heating systems. These factors resulted in excessive energy consumption and increased utility costs, affecting the quality of life for residents.

Key findings include:

- A significant percentage of residents (96%) reported dissatisfaction with the thermal conditions in their homes, both in summer and winter, with high temperatures in summer and inadequate insulation during winter being major contributors.
- About 81% of the respondents reported high energy consumption, driven by the reliance on heating and cooling systems.
- Poor thermal comfort was associated with several chronic health issues, including respiratory disorders, allergies, and blood pressure instability, with approximately one-third of the residents suffering from such health problems.
- Inadequate ventilation, both natural and mechanical, exacerbated thermal discomfort. Rooms with limited airflow experienced higher indoor temperatures and humidity levels, contributing to discomfort.

- The study found that window placement, size, and orientation played a significant role in the thermal performance of buildings. Rooms facing direct sunlight or lacking shading devices experienced higher indoor temperatures, while proper ventilation and cross-ventilation could alleviate discomfort.

The study's results emphasize the need for improved architectural design strategies to enhance natural ventilation, optimize window placement, and incorporate shading devices to reduce solar gain. Additionally, addressing insulation and passive heating and cooling techniques could reduce the reliance on energy-intensive mechanical systems, leading to better thermal comfort and reduced energy consumption.

These findings underline the urgent need for improved thermal insulation and sustainable cooling strategies to enhance indoor comfort and reduce energy consumption in residential buildings.It is possible to improve the thermal comfort and indoor environmental quality of residential buildings in Dhaka, enhancing the health, well-being, and overall quality of life for residents. Further research is needed to assess the long-term impact of these interventions and explore more cost-effective and innovative solutions to address thermal discomfort in housing sector.

Compliance with ethical standards

Funding

The author(s) did not receive any financial support for the research, authorship, or publication of this article.

Disclosure of conflict of interest

The author(s) declare that there are no competing interests

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Adaji, A., Watkins, R. & Adler, G. (2015). Thermal comfort in residential buildings in a hot and humid climate: A field study in Nigeria. Renewable Energy, 75, pp. 550–559.

[2] Adekunle, T.O. & Nikolopoulou, M. (2014). Thermal comfort and adaptation in outdoor spaces in the hot humid climate of Nigeria. Building and Environment, 75, pp. 308–320.

[3] Ahmed, Z., Islam, T., Hasan, R. & Alam, F. (2014). Thermal performance analysis of apartments in Dhaka city. Asian Journal of Civil Engineering, 15(7), pp. 1079–1088.

[4] Akande, O.K. & Adebamowo, M.A. (2010). Indoor thermal comfort for residential buildings in hot-dry climate of Nigeria. Proceedings of Conference: Adapting to Change: New Thinking on Comfort, Windsor.

[5] Al-Horr, Y., Arif, M., Katafygiotou, M., Mazroei, A., Kaushik, A. & Elsarrag, E. (2016). Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature. International Journal of Sustainable Built Environment, 5(1), pp. 1–11.

[6] Al-Tamimi, N., Fadzil, S. & Harun, W. (2011). Thermal comfort in residential buildings in Malaysia under hot-humid climate conditions—A preliminary study. Indoor and Built Environment, 20(4), pp. 389–399.

[7] Boulemaredj, A. & Haridi, A. (2022). Sanitary comfort and well-being in urban housing: A comparative study. Housing Studies Journal, 14(3), pp. 22–38.

[8] Çeter, I., Alkan, C. & Turhan, E. (2021). Sustainable design in housing: The role of sanitary comfort. International Journal of Architecture, 12(4), pp. 18–34.

[9] Ealiwa, M.A., Taki, A.H., Howarth, A.T. & Seden, M.R. (2001). An investigation into thermal comfort in residential buildings in the hot dry climate of Libya. Renewable Energy, 14(1–4), pp. 773–778.

[10] Hailu, D., Gelan, A. & Girma, H. (2021). Bioclimatic housing design for thermal comfort in Ethiopia's urban areas. Journal of Architectural Research, 7(2), pp. 45–56.

[11] Humphreys, M.A., Rijal, H.B. & Nicol, J.F. (2013). Updating the adaptive relation between climate and comfort indoors; new insights and an extended database. Building and Environment, 63, pp. 40–55.

[12] ISO (2005). ISO 7730: Ergonomics of the thermal environment—Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria. Geneva: International Organization for Standardization.

[13] Kelechava, B. (2021). Thermal comfort and its role in sustainable housing. Journal of Thermal Analysis, 9(3), pp. 154–162.

[14] Klepeis, N.E., Nelson, W.C., Ott, W.R., Robinson, J.P., Tsang, A.M., Switzer, P., Behar, J.V., Hern, S.C. & Engelmann, W.H. (2001). The National Human Activity Pattern Survey (NHAPS): A resource for assessing exposure to environmental pollutants. Journal of Exposure Analysis and Environmental Epidemiology, 11(3), pp. 231–252.

[15] Lomas, K.J. & Kane, T. (2013). Summertime temperatures and thermal comfort in UK homes. Building Research & Information, 41(3), pp. 259–280.

[16] Nicol, F. (2004). Adaptive thermal comfort standards in the hot–humid tropics. Energy and Buildings, 36(7), pp. 628–637.

[17] Rahman, M.M., Islam, M.Z. & Hossain, A. (2018). Assessment of energy consumption and thermal comfort in urban residential apartments in Dhaka, Bangladesh. Energy and Buildings, 170, pp. 240–249.

[18] Samuel, D., Tumbat, A. & Andoh, E. (2017). Local bioclimatic principles and housing design: Towards sustainable living standards in Ghana. Architectural Science Review, 60(2), pp. 115–123.

[19] Safiuddin, M., Hossain, K.M.A. & Mahmud, M.A. (2016). Thermal comfort analysis of urban apartments in Dhaka city: Challenges of insulation. Urban Sustainability Journal, 4(2), pp. 91–103.

[20] Slipek, M., Torney, M. & Bradley, J. (2017). Healthy housing: A multidisciplinary approach to improving quality of life. Journal of Public Health Research, 9(4), pp. 50–60.

[21] Taleghani, M., Tenpierik, M., Kurvers, S. & van den Dobbelsteen, A. (2013). A review into thermal comfort in buildings. Renewable and Sustainable Energy Reviews, 26, pp. 201–215.

[22] Toy, S. & Kántor, N. (2017). Environmental and bodily factors influencing thermal comfort: A study in hot climates. Journal of Environmental Management, 200, pp.

[23] Islam, M., Rahman, T. and Sarker, M., 2021. Impact of temperature extremes on chronic health issues in Dhaka's residential areas. Journal of Urban Climate Studies, 8(3), pp.45–59.

[24] Rahman, A., Khan, M. and Chowdhury, S., 2019. Heat-related illnesses and lack of insulation in Dhaka's residential buildings. Bangladesh Journal of Environmental Research, 11(2), pp.88–102.

[25] Shah, F., Alam, R. and Hossain, M., 2020. Inadequate thermal comfort and health risks in Dhaka's urban housing. International Journal of Building Performance Analysis, 5(1), pp.25–40.