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Indoor Environmental Quality of Low-Income Housing in Delhi, India: Findings from a Field Study

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Abstract

Indoor environmental quality has crucial links to occupant health and well-being. Delhi has experienced rapid population growth and, as a result, there has been a substantial escalation of informal housing that now accounts for up to half of the housing stock. In this work, we investigate the indoor environmental quality in a sample of low-income households in order to make recommendations for housing provision and to improve the health of occupants. The study takes a mixed-method approach to provide a wider understanding of the indoor environmental quality. Indoor temperature monitoring was carried out over a winter period, allowing a review of building performance. Focus groups with household residents allowed comparison between measured and perceived conditions and highlighted a number of housing issues, which is useful in guiding interventions. Indoor temperature ranges were found to vary significantly within and between dwellings, with the greatest range seen in dwellings constructed with temporary materials. All dwellings failed to provide comfortable temperatures above 21°C for more than 40% of hours during the winter monitoring period, suggesting occupant discomfort and risk to health from exposure to cold temperatures. Occupants were found to have multiple adaptive strategies to overcome poorly performing dwellings. However, health is compromised by some approaches, such as the open use of firewood indoors. Thus, substantial work is necessary to improve indoor environmental quality. Interventions which replace roof materials and increasing window areas could potentially improve both actual and perceived conditions.

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Keywords: Indoor environmental quality, thermal monitoring, mixed-method approach, perceived conditions, low-income homes

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1. Introduction

Indoor environmental quality has crucial links to occupant health and well-being. In particular, public health risks resulting from the indoor environment quality are considered to be higher among children and the poor, and have considerable societal costs due to related illnesses [1]. This understanding has recently led to research focused on the health impacts of energy-efficient measures in homes in high-income countries with temperate climates. In the context of low-income counties, research linking housing and indoor environmental quality to health is rare. In some locations, such as Delhi, rapid urbanization has led to unprecedented growth of informal housing that is likely to be substandard in providing adequate environments, which poses a risk to the health of the occupants.

Firdaus & Ahmad, 2012, have called for more research to examine the positive and negative impacts of housing, and what interventions are needed to improve the health of urban dwellers in Delhi [2]. Currently, there is limited work addressing the indoor environmental quality of dwellings in Delhi. There is some evidence suggesting that traditional dwellings perform better than modern housing in providing adequate temperatures during the summer [3], and as a result modern housing depends more on electrical devices for cooling [4], but there are no studies reviewing the annual range of indoor temperatures experienced. Indoor air quality (IAQ) monitoring studies in Delhi found that pollutant levels were higher in low-income housing [5] and that levels reach a maximum in winter [6]. However, these are limited to a small sample of dwellings and they fail to consider the impact of dwelling characteristics. Perceived IAQ surveys collected in 5949 households indicated some dwelling aspects (lack of kitchen, poor ventilation, lack of open space) have significant influence on perceived IAQ [7]; however this study does not link these factors quantitatively. Thus, substantial work is still needed to assess indoor environmental quality across Delhi's housing, and identify fundamental building characteristics that influence indoor environment quality.

This paper details an initial study looking at low-income housing performance in Delhi, which included monitoring of indoor temperatures and occupant focus groups, during the winter of 2013. This understanding can help inform interventions and building design, as well as support the validation of models. The specific objectives of this study were to:

- Carry out an indoor temperature monitoring study in low-income households to gain evidence of indoor environmental quality and building performance;
- Understand how residents perceive the indoor quality of their homes and identify what strategies they use to improve indoor conditions;
- Review how the perceptions of indoor environment quality relate to monitored conditions, and how this may affect housing interventions, and thus suggest guidelines for improved housing.

2. Case Study Housing

The case study is a resettlement colony located on the edge of Delhi, developed by the Delhi Urban Shelter Improvement Board. The settlement was initiated in 2006, to re-house slum dwellers from inner city areas and at present, the colony is home to nearly 8,500 families. The area to the North-West of New Delhi will be home to 20,000 families when fully occupied making it likely the biggest resettlement area. Families have been provided with small plots of 12.5m2 or 18m2, depending on when they settled in Delhi. The sites provided are empty and must be built upon; - the area is characterized by self-built poor quality housing.

The dwellings can be broadly divided into six types, details of each type is given in table 1. Dwellings range from one-storey 'katcha' constructions to two-storey 'pucca' constructions with roof space and toilet. The building process is incremental, and relies on available skills, economic capabilities, materials and resources, with little or no external assistance. Generally, dwellings have concrete bases, one facade exposed (except houses located on the end of the rows) and have no heating devices. Construction materials are homogeneous (except for katcha dwellings), and are a combination of brick walls with/or without plaster and corrugated galvanized iron (CGI) or concrete slab roofs. It is uncommon for the housing to have glazed areas; however, external facades often have holes or grills for ventilation. The built quality between dwellings is extremely varied. Generally, the internal layout of homes consists of either one multi-purpose room (used for sleeping, cooking and other household activities) or semi-partitioned rooms.