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Impact of cultural behaviour on indoor comfort: examining the air quality in Homes and exploring observational and experimental methods of representation through filmmaking

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Abstract. There is a limited understanding of householders' cultural differences and their impact on spatial organisation and energy behaviour in dwellings. Indoor air quality directly impacts the health and well-being of occupants. The airborne COVID-19 epidemic has highlighted shortcomings of controlled ventilation systems in recent reports (PHE, Dec 2020). While efficiency interventions can make homes more affordable to heat, they can exacerbate conditions such as asthma, due to reduced indoor air quality and ventilation. Preliminary research conducted in Plymouth by the applicant indicates that British Asians use their homes differently compared to native British in terms of spatial organisation, cooking habits (on average, they spend five times more time cooking the daily meal) and ventilation strategies, all of which have an impact on indoor air quality. This project sets out to establish the impact of culturally informed choices on indoor air quality and the extent to which the norms that guide the design of energy-efficient homes ignore potentially significant cultural and behavioural differences. It will achieve this by focusing on the impact of energy behaviour and choices related to cooking on the indoor air quality of British-Asian households. The project aims to quantify temperature, humidity and air quality by data collected by a pilot study in Plymouth, UK. We will engage the community in a participatory methodology using correlational research and survey questionnaires and IAQ Data Loggers to evidence anomalies from the design norms currently used in the UK. In addition to traditional data analysis, our methodology includes artistic research, utilising observational and sensory ethnographic filmmaking techniques, to support, document, and evidence the impact of cooking in the home. We aim to explore how the intersection between these two methods can reveal and communicate new perspectives. The main outcome is to evaluate the impact of cultural behaviour on the air quality of super-insulated British-Asian homes through an interdisciplinary methodology. This project lays foundations for larger-scale research working with diverse ethnic minority communities to promote engagement in a low-carbon society.

1 Introduction

The US Environmental Protection Agency (EPA) has identified Indoor air pollution as one of the four health risks. In the developed world, people spend nearly 90% of their time indoors and the quality of indoor ambience is crucial as indoor air pollution is on average 3.5 times higher inside the home than outside and in some cases, it has peaked at 560 times higher than outdoors [1]. The level of pollutants defines the quality of indoor air wherein carbon monoxide and radon adversely affect the health of the occupants, whereas body odour and such will inference the comfort and perceived air quality [2].

Indoor air pollution is one of the key environmental causes of death globally accounting to about 4 million premature deaths. Further, HAP accounts for nearly 5 per cent of all disability-adjusted life years. The indoor air pollution further exuberates the condition of women and children below the age of five as they spend more time indoors in homes leading to up to 60 per cent of premature deaths [3]. Poor air quality in terms of an increase in exposure to PM will lead to an increase in hospital admissions, especially in the elderly and people with comorbidity [4]. Recent studies have demonstrated that IEQ could significantly affect occupants cognitive skills and in the process their

learning and working abilities [5]. PM exposure is also linked to cognitive deficits and oxidative stress [6, 7].

The indoor air pollution is believed to cause respiratory health problems and cancer deaths. Further effects include irritation, Nero toxicological behavioural and other adverse effects. According to EPA, the associated economic cost is considerable; in 2001 alone, it was likely to be 150 – 200 billion dollars (in the USA) [1]. Exposure to PM2.5 is a major health concern, as they are small and damage airway cells. The Short-term effects include suffocation, burning eyes, and headaches. Long-term effects include chronic disease and premature death [3].

The airborne COVID-19 epidemic has highlighted shortcomings of controlled ventilation systems in recent reports (PHE, Dec 2020). While efficiency interventions can make homes more affordable to heat, they can exacerbate conditions such as asthma, due to reduced indoor air quality and ventilation.

The level of pollution defines the quality of indoor air. While addressing climate change concerns, energy-efficient houses will be super insulated. These airtight houses, along with the emission of formaldehyde and other VOC have led to poor indoor air quality [8]. Before the advent of airtight homes, most of the existing homes are sufficiently leaky and provided most of the fresh air required [9]. There has been considerable research on solving indoor air pollution problems through efficient stoves, cooking fuel etc. however only some attention is paid to ventilation type and quality [10].

Typically, ventilation rates in UK residences are around 0.5 air changes per hour (ach) [11]. Many guides recommend a ventilation rate of 10 l/s/person [12]. The required ventilation rate depends on many factors like the type of the building, activity, climate and most importantly, culture and user behaviour.

Extensive scientific literature has demonstrated that people (users/ occupants) play an important role in determining the energy consumption of a building and therefore that research concerned with indoor air quality and ventilation must consider the socio-cultural behaviour of users [3]. As argued by Behar S (2013), users' ventilation behaviour will have an impact on indoor air quality [9]. Recent studies have demonstrated that household ventilation behaviour will have a major impact on indoor air quality [3, 13].

Further, households have a limited understanding of potential health and comfort conditions due to their actions [13]. Indoor activities like cooking, cleaning etc will result in the generation and re-suspension of particulate matter (PM2.5) [14, 15]. Cooking generates a range of organic and inorganic compounds, including species that are identified as possible carcinogens such as polycyclic aromatic hydrocarbons (PAHs). Studies have shown that the risk of lung cancer increases three-fold with the increasing number of meals prepared per day [16]. Certain types of cooking related to the culture of the people such as frying, roasting, and grilling can exert a significant impact on pollutant emissions [17].

According to the studies published in NHBC (2009), NO2 concentration is significantly higher in the kitchen than in bedrooms. Further, CO levels are higher in winter compared to summer and highest in kitchens associated with cooking activities [1].

The recently published National Design Guide (Jan 2021), including the emphasis on good design in the code for sustainable homes, is underpinned by the quality of life for the occupants and users of buildings. The Guide aims to promote good ventilation, avoid overheating, minimise sound pollution and promote good air quality while providing comfort and personal control for users. During these discussions, there is hardly any reference to the socio-cultural background of the occupants and how it informs the way we use spaces and hence its impact on indoor thermal comfort, overheating and air quality. The building specifications, therefore, risk failing to accommodate the needs of inhabitants from cultural backgrounds which differ from the ‘generic’ (White, British, Working class etc).

Preliminary research conducted in Plymouth by the authors indicates that British Asians use their homes differently compared to native British in terms of spatial organisation, cooking habits and ventilation strategies, all of which have an impact on indoor air quality. This paper sets out to establish the impact of culturally informed choices on indoor air quality and the extent to which the norms that guide the design of energy-efficient homes ignore potentially significant cultural and behavioural differences. It will achieve this by focusing on the impact of energy behaviour and choices related to cooking on the indoor air quality of British-Asian households. This paper aims to quantify temperature, humidity and air quality by data collected by a study in Plymouth, UK.

We question current designs of super-insulated homes which are based on set models of home use. To achieve this, we are conducting an in-depth study of cooking habits, temperature and air quality preferences in British-Asian homes in Plymouth in comparison with the white British homes within the same housing typology and neighbourhood, using qualitative and quantitative methods. The main aim of this research is therefore to develop insights into the realities associated with the social and physical context of cooking within given cultural and environmental circumstances and we achieve this by studying the impact of cooking on indoor air quality in British-Asian homes in comparison with white British homes through a detailed study of households in Plymouth.

2 Methodology

To achieve the objectives of this study, we review the behaviour patterns and spatial usage, specifically related to cooking practices and associated spaces, by comparing British-Asian households and native-British households.

1) Survey questionnaires are deployed to collect data related to cooking patterns and associated issues from a minimum of forty homes. This study will be used to shortlist four comparable homes in the same neighbourhood with similar housing typology; construction, insulation, and spatial qualities: two occupied by British-Asian households and two native-British households.

2) Measurements of air quality are taken in the homes in summer and winter with data loggers and other non-intrusive tools to quantify the difference in mean daily temperature, relative humidity, and air quality index. Calibrated Testo 480 IAQ Pro loggers will be used to record the indoor climate temperature (±0.3°C), humidity (±1.0 %), CO_2 (±50 ppm CO_2) and airflow (±59fpm) in the kitchen using 5-minute time intervals for data logging. The loggers will be sited away from heat sources and direct sunlight. The same set of data will be collected over a month, once during the summer and again during winter.

3) Observational Documentary film techniques are employed in order to elicit spatial and cultural aspects of living in British housing. Sound and film documentation during the time it takes for meals to be prepared and cooked will provide an insight into the realities of homeowners' active engagement with air quality management during cooking times. The final short films will therefore examine vernacular domestic spaces and provide the project with a way of discovering and reflecting on the activities of the households we encounter. The methodology of filmmaking with each household during a set period will give the framework of the process continuity but will also allow the variations of experience within each home to be seen. The final construction of the films will examine the sensory qualities of heat, vapours and ventilation and work to create an artistic representation of the conditions of the home and the people who live within these spaces.

3 Analysis and discussion:

Using the data loggers in neighbouring houses, nearly 4100 sets of data are collected over 15 days, including daily temperature, relative humidity, and air quality in terms of CO2 level.

3.1 Carbon Dioxide (CO2) indoor level

The literature review suggests that there will be a normal background concentration of 250 – 400 ppm in outdoor ambient air and up to 1000 ppm of CO_2 in occupied indoor spaces. Once the CO_2 concentration increases beyond 1000 ppm, occupants will experience health effects in buildings.

In the case of the two kitchens compared, the CO_2 level was below 90 per cent of the time below 1000 ppm in the White British home (Figure 2), whereas only 45 per cent of the time the kitchen air quality was below 1000 ppm. The comparison of air quality in the British Asian and White British house kitchens clearly demonstrates the poor air quality in the British Asian homes as nearly 13 per cent of the time the CO_2 level is more than 1500 ppm in the kitchen (figure 1).

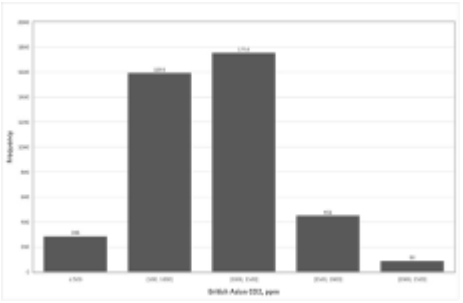

Fig. 1. CO2 concentration in the kitchen of a British Asian home

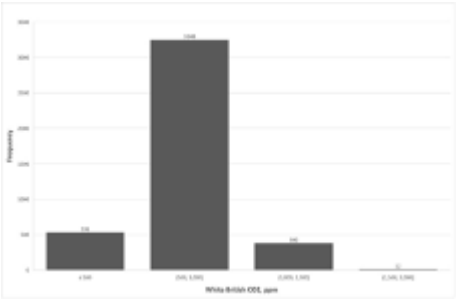

Fig. 2. CO_2 concentration in the kitchen of a White British home

While comparing the CO_2 level in the British Asian and White British homes. Barring a couple of days, CO_2 level has been consistently higher in British Asian homes with many days CO_2 touching 2000 ppm and dangerously reaching 2500 ppm on three occasions (figure 3).

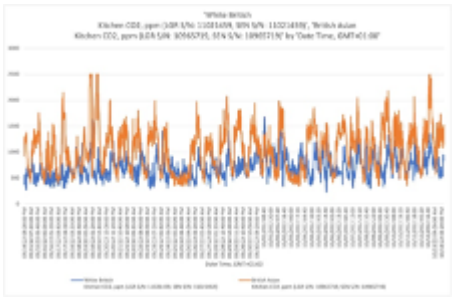

Fig. 3. Comparative CO_2 level in the British Asian and White British home

Analysis of one representative day clearly demonstrates the impact of cooking on CO_2 levels in kitchens. The CO_2 level is nearly the same in both British Asian and White British homes early morning between 2.00 am to 6.30 am (figure 4). The CO_2 level starts raising in the British Asian home with morning kitchen activities and due to the nature of cooking activities, stays above 1000ppm for the most part of the day and reaches a peak by 8.00 pm, by the end of cooking evening meals.

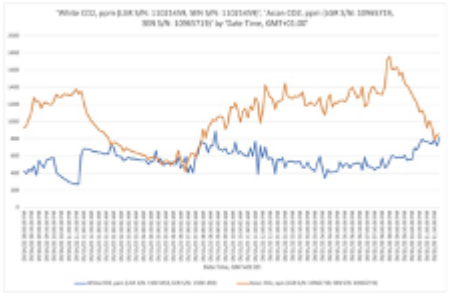

Fig. 4. Comparative CO_2 level in the British Asian and White British home-one day

The marked difference in the co2 levels in British Asian and White British homes is due to many reasons but could be mainly attributed to the cooking and ventilation habits of the households. The higher and prolonged levels of CO_2 in British Asian homes are due to the duration of cooking. Based on the survey conducted in Plymouth, UK, British Asians spend 3.3 hours per day in the kitchen during the weekday, while White British spends around 1.5 hours per day in the kitchen. The gap further widens during the weekend, wherein, White British cook around 1.75 hours/ day while British Asians spent nearly 4.16 hours/day cooking.

All the White British respondents (100 per cent) said that in summer, during the weekday, most of the time they keep the windows open. Whereas only about 16 per cent of the British Asians responded said that they keep the windows open in the morning. Further, 22 per cent of the British Asian respondents hardly ever open the windows and nearly 40 per cent of them open the windows for one to two hours in the morning. Although it is slightly better during the weekend as it is dropped to 30 per cent. During the weekend, British Asians tend to open their windows more than during the weekdays with nearly 30 per cent of them opening the windows most of the time. Concern for heat loss is evident as they tend to keep the window closed most of the time. As 30 per cent of them never open the windows and nearly 25 per cent open only 1 to two hours in the evening, whereas most of the White British keep them open for most of the time.

3.2 Observational Documentary films

This film project draws from the key texts of De Certeau to consider the 'practice of everyday life' [18] by exploring tactics that are not only interested in how cooking impacts homes and air quality, but also how this can be made visible via a creative filmmaking process coalescing ethnography and creative film practice. To consider these approaches as a way to represent and communicate impact and not just as a representational documentary. This was a central idea at the onset of the project. How could a film move beyond documentation to reveal air quality in a space so that an audience can experience its impact? Can this project explore a kind of filmic tacit knowledge, by representing different cultures and families and the cooking process in homes in a new and fresh way?

We shot twice in winter and twice in late summer. As we planned, rather than attempting to fictionalise or control these spaces, we recorded only what we saw and heard during the time it took for the participants to finish the cooking process, paying close attention to small details as the food was cooked and the kitchen and houses were changed. We decided to use a small crew of two people and used two cameras and a sound recording device. We filmed the characters chopping onions, using ovens and discussing their cooking habits and rituals. We wanted to look at this process with fresh eyes (through the camera lens), as an aesthetic study. The camera captured heat, steam, and condescension. We looked and filmed in a way that didn't prioritize one aspect of the process over the other. In this way, everything was seen as being of value within the space of the frame.

Fig. 5. Cooking and condescension – a split-screen still image from film project in Plymouth, UK

Our approach to editing has included testing and experimenting with a number of filmic methods in

order to convey the environment. The figure 5 references our utilisation of split-screen techniques. This editorial method allows the films to further communicate the environmental changes present in the kitchen and some of the consequences of the cooking process in the homes. This approach connects with our initial aims of exploring experimental-ethnographic artistic research and film methods to attempt to convey the space beyond moving image documentation. As you can see in the above image, the interplay between the condescension and the pressure cooker creates a montage on the screen and a simple yet effective third meaning; the spatial montage of images, juxtaposing time, and the poetics of the split-screen. The film can therefore reflexively examine how filmmaking and moving image practice, as a medium supporting this kind of research question, can support and open up further thinking and feelings; and at the same time, consider the expressive and poetic possibilities of this kind of filmmaking.

The ethnographic film methods enabled us to examine the home and do two important things: 1, to support the overall research aims; 2, to attempt to make a piece of work which could uncover new ideas and unknowns, as it relates to the key research aims. We were interested in how the film could examine a place and the spatial relationship between cooking and environment; and in doing so, potentially enhance these 'unknown' details.

4 Conclusion

4.1 Applications for the research

The results of this study will be of key interest to government policymakers and building industry stakeholders. The study identifies the specific areas where homeowners' *cultural behaviour impacts the air quality.*

4.2 Summary

While acknowledging the need to develop air-tight homes, emphasis needs to be given to the importance of lifestyle and cultural preferences. This research focuses on cooking and associated indoor air quality as a social and cultural phenomenon that can allow insights into the effective formulation of localised and relevant indoor air quality and low-carbon strategies and thus provide a bottom-up tool to implement the policies and targets set by the professional bodies and the UK government.

The study in this paper, using a literature review and survey fieldwork, has highlighted the similarity and differences in the socio-cultural value systems of British and British Asian households and the resultant indoor air quality. From the outcome of the IAQ Data Loggers and questionnaire survey, this paper examined one key aspect of lifestyle and cultural preferences.

The particular points are as follows:

1. Particularly higher levels of CO2 in British Asian homes for a prolonged period of time is alarming and as discussed in the literature review, poor air quality in BA homes could put them at severe health risk.

2. Consistently higher level of temperature and humidity in BA Houses has to be closely studied as lack of ventilation due to lack of window opening and cooking preferences could lead to mold and risk the health and wellbeing of the households.

4.3 Limitation and further research

From the outcome of the *survey questionnaires and IAQ Data Loggers*, this paper examined the impact of one of the homeowners' *cultural behaviour, cooking and associated behaviours on indoor air quality*. Further studies with the ethnographic survey and interview of households triangulated with environmental analysis would be helpful to further develop this research and develop a healthy living environment for ethnic minority households.

The research has shown that there is a direct correlation between the social and cultural values and energy behaviour of households. Further examination of specific aspects like hourly activities in the kitchen and other spaces within the house, would provide greater insight into the extent of the impact of behaviour on indoor air quality and would go a long way in designing the built environment for the health and wellbeing of the households and sustainable communities for the future.

The filmmaking aspect of the research has already posed further interesting questions as to how this approach could potentially play a role in communicating the importance of this kind of

study to audiences. Filmmaking, as a popular form, could be a key asset in conveying the research and experimenting with more of an expansive use of techniques often associated with experimental filmmaking, which could potentially lead towards conveying and further understanding how moving images can support this kind of vital work.

This study reviewed selected elements and the survey was limited to Plymouth and British Asians. Further examination of other places in the UK and other ethnic minority groups would be helpful to develop an exhaustive understanding of the indoor air quality in ethnic minority homes to enable a more sensible and inclusive understanding of indoor air quality requirements and inform policy decisions.

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