Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Impact of COVID-19 containment zone built-environments on students’ mental health and their coping mechanisms

Farhan Asim a,*, P.S. Chani b, Venu Shree c

a Built Environment Laboratory, Department of Architecture & Planning, IIT Roorkee, Roorkee – 247667, India
b Built Environment Laboratory, Department of Architecture & Planning, IIT Roorkee, India
c Department of Architecture, NIT Hamirpur, India

ARTICLE INFO

Keywords:
Built environment
Mental health
Depression
Anxiety
COVID-19
Containment zone

ABSTRACT

The 2nd wave of COVID-19 in 2021 had put several higher educational institutions in India into complete lockdowns and some were converted into containment zones to prevent the further spread of infection. A study was conducted on a student population (N = 432) in one such institute campus across three different hostel complexes to understand the role of containment zone Built Environments in the prevalence of Anxiety and Depression. The results from the analysis revealed that students living in rooms which have access to qualitative Built Environment aspects such as quality window views overlooking greenery and sky in addition to presence of indoor plants and portrait/artworks, are at lower risk of depression and severity of anxiety. The linear regression results of Built Environment Variable (BEV) Score with CES-D and GAD-7 advocated for an inverted relationship. The multinomial logistic regression revealed that with each 1-unit increase in BEV Score there is a significant decrease of 1.3-unit of likelihood of Depression, 0.779, 0.712 and 0.614-unit decrease in the likelihood of mild, moderate and severe levels of anxiety respectively. For Adverse Effect on Productivity, a 1-unit increase in BEV Score increases the likelihood of No-effect on productivity by 1.277 units. In order to precisely predict the effect of individual aspects of University Campus Built environments on the mental health of students during such containment and quarantine situations, further multidisciplinary investigation is required on the spheres of Built Environment, Psychology, and Epidemiology.

1. Introduction

COVID-19 had shut down the global education system completely until it got resumed in the form of online education which has continued for more than a year since World Health Organization (WHO) declared COVID-19 as a pandemic in March 2020 [1]. India was among the countries which imposed one of the most rigorous nation-wide lockdowns in March 2020 resulting in complete social chaos and collapse of non-covid related essential health services [2]. Almost a year later in March 2021, the Educational and Research Institutes began to call the students back to the campuses amid the 2nd and comparatively more devastating wave of rising COVID-19 cases in India. Due to the influx of students getting back to the campuses and increase in the rate of interaction of gated institute communities with the reopened urban infrastructure of the cities, a number of institutes in India reported hundreds of cases within a week in their campuses which resulted in creation of containment zones. As per the standard of procedure of these containment zones provided by the Government of India, the students are put in isolation in make-shift or dedicated hostels for quarantine where they are not supposed to get out of their rooms for a duration ranging between 15 days to almost a month, and their basic requirements including food and hygiene products are delivered to their doorsteps. As a result of this entire phenomenon, the daily routine of these students suddenly got restricted to a tiny room with a window or a balcony acting as a medium of social interaction and providing sole connection with outside world and natural stimuli. Recent studies concerning COVID-19 isolation and quarantine reported that people under quarantine and isolation are highly prone to exhibiting symptoms of various degrees of anxiety and depression [3,4]. Studies have additionally reported that quarantine and isolation leading towards lack of social interactions, limited expression and lack of financial stability may indicate a higher suicidal ideation in target populations [5,6]. A study summarizing Indian COVID-19 related suicide cases identified that the causalities of suicide include fear of COVID-19 infection, financial crisis,
loneliness, COVID-19-positive stress, COVID-19 work-related stress, inability to reach hometown due to nation-wide lockdown, social isolation and societal boycott during quarantine, and alcohol non-availability [7]. (see Fig. 1)

1.1. Mental health scenario in India

1.1.1. Lancet report on mental health scenario in India (2020)
A cross-sectional study published in Lancet Psychiatry by Sagar et al., 2020 [8] concluded that mental disorders of variable magnitude affected one in 7 Indians in 2017. Since 1990, psychiatric illnesses’ relative contribution to India’s overall disease burden has nearly doubled. 197.3 million people in India suffered from various mental illnesses, with 45.7 million suffering from depression and 44.9 million from anxiety. The study was also able to establish a significant but weak correlation between the prevalence of depressive disorders and suicide death rate among the Indian population.

1.1.2. The national mental health survey of India (2016)
The lifetime prevalence of ‘any psychiatric morbidity’ was predicted to be 13.67%, with an existing prevalence of 10.56%. The most prominent psychiatric morbidity in India was mental and behavioral conditions caused by psychoactive drug use, mood disorders, and neurotic and stress-related disorders. Males, middle-aged people, people who live in cities, people who are less educated, and people who live in low-income households were all found to have a higher prevalence. The average treatment difference for psychiatric morbidity was 84.5% [9].

1.1.3. Access to mental healthcare in India
Care remains scarce or inaccessible, even for those who regularly seek psychiatric care, due to a shortage of specialists and health facilities for mental illness. Nearly one licensed psychiatrist is available for every 250,000 people, and the total mental health staff (psychiatrists, clinical psychologists, and psychiatric social workers combined) is available at one every 100,000 people [10,11]. The allocation of mental health workforce and clinics is still concentrated towards major cities, so it’s no wonder that even for severe mental health problems, tribal healers and unqualified practitioners are the first point of treatment in India [12].

1.2. Built environment and mental health

Built Environment has a considerably long recorded history of association with mental health dating back towards ancient civilizations and its recent revitalization in the early 1960s through the formulation of the discipline of Environmental Psychology [13–15]. In the last decade, the intensity of studies on both indoor and outdoor built environments has increased putting an emphasis on the benefits of identifying the positive mental health aspects of a built environment [16–18]. The most prominent analogies in the built environment-mental health domain are based on human exposure to Natural (Biophilic: Window views, Parks, Garden landscapes) against Built (Urban: Street, Architectural and hardscape), Indoor against Outdoor, Blue-Green against Grey infrastructure and Physical against Virtual Realities [19–23]. Physical attributes of the built environment, as well as their functionalities and people’s personality traits, are essential to analyze the relationship between built environment and mental health. Within the last four decades, sociocological principles have outlined different built environment characteristics as stress contributors with an effect on mental health and occupant behavior that can be significantly remedied by improvements in the built environment [24]. Studies in the past have
partly covered the adverse impact of small architectural spaces and confinement on the mental health of the occupant; but the concept of mass population quarantine and isolation has added a nascent dimension to the intensity of this adverse impact [25-28]. The socio-ecological frameworks have been examined to integrate social, environmental, physical, cultural and psychological dimensions of human behavior. Most of the debate around the domains of built environment and mental health revolves around three primary theories and models of psycho-evolution: 1. Attention Restoration Theory (ART) put forward by Kaplan [29] argues that exposure to nature leads to restoration or recovery of directed attention system hence improving the cognitive capacity of the viewer. 2. Stress Reduction Theory (SRT) introduced by Ulrich et al. [30], stated that stress recovery was quicker and more comprehensive if people were exposed to natural environments rather than urban environments. 3. Evidence Based Design (EBD) of healthcare and infrastructural facilities lead to a healthy society with design of architectural spaces through selection of design elements based on their capability to accelerate the process of recovery and provide a comfortable built environment to the occupant [31]. Recent developments in the field of Environmental Psychology and Neuro-Architecture has provided the researchers with additional physio-sensory dimensions to explore the relationships between a variety of built environments and cortical level deduction of human brain responses and behavioral mapping. The very nature of COVID-19 containment zones and its associated epidemiology limits the level of possible interaction between the investigators and the participants; and it allows only for non-contagious and remotely approachable means to be used for the data collection process. Hence, only a few aspects of Built Environment which were earlier found to be influencing the behavior and mental aspects of the participants can be commonly attributed to an isolated room, and are kept as contributing variables for such a study. The variables include color scheme [32,33], presence and intensity of indoor plants [34,35], view of greenery [36,37], view of sky [38], the quality of outdoor view from room window [22], perceived Indoor Environment Quality [39,40] and presence of Visual Artworks [41,42].

### 2. Materials and methods

#### 2.1. Hypotheses

This study is an attempt to make a direct response deduction from a containment zone population in order to understand the role of available natural and built environment aspects acting as coping mechanism catalysts in possible control factor in development of cases of anxiety and depression from within the boundaries of Covid-19 isolation or confinement of the participants. In order to simplify the hypotheses, a modified version of Built Environment Variable (BEV) Score adapted from Rai et al., 2020 [43] and Asim & Shree, 2019 [44] is used as a derived variable of continuous nature to represent various built environment aspects in their cumulative strength. We tested three hypotheses: 1) Students with higher BEV Score are at lower risk of Depression; 2) Students with higher BEV Score are at lower risk of Anxiety and 3) Students with higher BEV Score will have least adverse effect on productivity.

In addition to this, the role of sociodemographic factors such as gender, age and educational level on depression risk, anxiety level and adverse effect on productivity was also taken into consideration. The focus was on identification of individual contributors like presence and quality of greenery inside the built environment and the escape view through window, view of sky and self-perceived Indoor Environment Quality (IEQ) which collectively led to the tabulation of BEV Score with their associated weights.

| Table 1 | Description of predictor variables and assigned codes for analysis. |
|---------|---------------------------------------------------------|
| **Predictor Variable** | **Question** | **Coding for analysis** |
| Colour Scheme | Do you like the colour scheme of your room? | 0 – Not at all, 1 – To some extent, 2 – To a moderate extent, 3 – To a large extent. |
| Plants in Room | Do you have plants in your room? | 0 – No, 1 – Yes |
| Number of Plants in Room? | Exact Entered Number or '0' for None |
| View of Greenery | Are you able to see any bit of greenery (plants, trees, landscape garden) directly outside your room window? | 0 – Not at all, 1 – To some extent, 2 – To a moderate extent, 3 – To a large extent. |
| View of Sky | Are you able to see any bit of sky directly outside your room window? | 0 – Not at all, 1 – To some extent, 2 – To a moderate extent, 3 – To a large extent. |
| View Outside Window | How would you rate the view outside your room window? | 0 – Poor, 1 – Average, 2 – Good, 3 – Excellent. |
| Indoor Environment Quality (IEQ) | How would you rate the environment inside your room? | 0 – Poor, 1 – Average, 2 – Good, 3 – Excellent. |
| Visual Artwork – Paintings/Portraits | If you have one or more frames or paintings in your room, then select one or all the categories to which they may belong? Else select None. | 1. Natural Scenery/Nature depiction 2. Portraits/Abstract Artwork 3. Quotes/Calligraphy 4. Photo frames (self, family, friends, favourite clicks) 5. None |
| Adverse effect on Productivity | Do you agree that your work performance and productivity are getting worse during isolation? | 1 – Yes, 2 – No. |
| CES-D | 20 Questions for self-reported screening; each question has same options. | 0 – Rarely, 1 – Sometimes, 2 – Very Frequently, 3 – Always or almost all time. CES-D Score ≥ 16: ‘Yes’ on Depression Risk Coded ‘1’. CES-D Score < 16: ‘No’ on Depression Risk Coded ‘0’. |
| GAD-7 | 7 Questions for self-reported screening; each question has same options. | 0 – Not at all, 1 – Several days, 2 – More than half the days, 3 – Nearly everyday Score: GAD 0 -5: ‘Normal’ Coded ‘1’ GAD 6-10: ‘Mild’ Coded ‘2’ GAD 11-15: ‘Moderate’ Coded ‘3’ GAD 15-21: ‘Severe’ Coded ‘4’. |

This study was conducted in an Institute of National Importance in the Haridwar district (249,814 cases, 166621 recoveries, 3896 deaths and 74,480 active cases as of 10-05-2021, Govt. U. 2021) [45] of Himalayan state of Uttarakhand in India, where a total of 3 different hostel complexes were declared as containment zones in April 2021, putting severely strict restrictions on the movement of students outside their rooms while approx. 800- COVID-19 positive cases were reported from the Institute Campus within a year. The institute under this study had 3000 students in campus at that time and 961 students (mostly Postgraduate and Research Scholars) out of those 3000 students were part of containment zones.

The questionnaires were shared with the participants from these 3 Hostels (VK, CB and KB) through their dedicated Hostel social groups after they had spent 10 days in isolation within containment zones; the received forms were cross-verified with their hostel room numbers to...
maintain the validity of responses and prevent fake data entries by students not residing in Containment Zones. The ‘Google Forms’ free to use interface was used to share questionnaires with 961 students after two weeks of containment zone declaration, out of which 432 (44.9%) students participated in the survey after giving their written consent for the study. The participants were informed about the motive and brief of the study; and that their participation is solicited but it is strictly voluntary with no monetary reward on completion of survey; they were free to leave the study anytime as per their will without any penalty. In order to maintain the anonymity of the participants in the generated database, their names were not recorded; their room numbers were only used to locate their rooms on the key map of hostel blocks for acquiring the orientation based Built Environment information and for the verification of valid participant entries respectively.

2.3. Methods and questionnaires

Although the students had little variations in the architectural design and size of their rooms, the location of their rooms within the design of the hostel complexes may also influence or dictate their interaction with the spatial characteristics of the built environment which can affect the mental health of the students resulting in adverse effect on academic performance, anxiety and depression. The methodology bifurcated the data collection into Investigators’ Questionnaire (IQ) and Participants’ Questionnaire (PQ). The Investigators’ Questionnaire (IQ) collected data about architectural attributes of each hostel complex at block level, room level and floor level including size of the room in square meters, single/double occupancy type of the room, presence or absence of balcony and development of a Built Environment Variable (BEV) Score based on data collected from section 3 of Participants’ Questionnaire (PQ).

The Participants’ Questionnaire (PQ) was divided into 5 sections:

1. The ‘Informed Consent Form’ which sent the participant to the next section only if they give their consent to participate.
2. Containment Zone Resident Profile which collected name of Hostel Block in which they are residing, floor number, room number, age, gender, marital status and educational qualification of the participants and whether they are experiencing any adverse effect on productivity during isolation.
3. Built Environment (Room) Profile which included interior characteristics about color scheme, Presence and Number of plants, Presence of paintings or photo frames, Greenery View from the Window, Sky View from the Window, Quality of Outdoor View and Quality of Indoor View.
4. Center for Epidemiological Studies-Depression (CES-D) which is a 20–item self-report tool for non-clinical screening for depression for last 1-week duration [46].
5. Generalized Anxiety Disorder Scale (GAD-7) which is a 7-item self-report tool for non-clinical screening for anxiety for last 2-weeks duration [47].

Table 1 represents the selected predictor variables with the variety of

![Fig. 2. Active Covid-19 cases in India till 10th May 2021 (left) and location map of selected student hostels (right).](image-url)
questions asked and the coding mechanism adopted for statistical analysis.

2.4. Statistical analysis

IBM® SPSS® Statistics Version 20.0 was used to conduct the statistical analysis. Categorical variables were characterized as frequency and percentages, while continuous variables, taking into account socio-demographic and psychophysiological characteristics, were characterized as mean and standard deviation. Shapiro-Wilk test [48] was conducted with Lilliefors Significance Correction to highlight the normal distribution of sample in CES-D and GAD-7 screenings. The Shapiro-Wilk test is focused on the correlation between the data and the corresponding normal values [49] and proposes even after the Lilliefors correction better power than the Kolmogorov-Smirnov test [50]. The ability to detect when a sample comes from a non-normal distribution is measured by power, which is the most common indicator of its value [51].

To address several combinations of continuous and categorical variables within the framework of analysis, three different tests i.e., Chi-square, Linear Regression and Multinomial Logistic Regression were utilized (see Fig. 2). Fig. 3 illustrates the various relationships being tested with appropriate statistical methods.

3. Results

3.1. Socio-demographic information about participants

The survey was able to collect completed forms from 432 participants (44.9%) out of the total 961 students residing in 3 different containment zone hostel complexes with maximum responses from VK (47.2%) followed by CB (28.2%) and KB (24.5%). The gender ratio (Female: Male) was observed to be 47.5: 52.5 with a mean age of 25.92 ± 2.69 and educational enrolment distribution in Masters (31.9%) and Ph.D. (68.1%). Table 2 represents the most relevant socio-demographic and psychophysiological attributes of the study. Table 3 provides descriptive statistics of the participating population.

3.2. Built environment aspects

Five different hostel room configurations were identified in three hostel complexes; floor plan illustrations of which are shown in Fig. 4 and detailed spatial attributes in Table 4. The population distribution was found to be skewed towards Single Occupancy rooms (69.9%). 47.7% students responded that they have at least one plant in their room whereas only 28.2% had access to balcony. Participants were asked to rate the view of sky, greenery, outside window view (escape view) and the overall Indoor Environment Quality on a 4-point scale. 31% participants rated their Indoor Environment Quality (IEQ) as ‘Excellent’, followed by Good (35.6%), Fair (25%) and Poor (8.3%). For greenery, 35.9% participants rated their view as ‘Excellent’, followed by Good (23.4%), Poor (24.1%) and Not Available (16.7%). Other related statistical findings are shown in Table 1.

3.3. Mental health aspects

An overwhelming and alarming 40.3% of the respondents were found to be at the risk of depression as per CES-D’s non-clinical screening, whereas 17.4% participants were found to be at ‘Severe’ level of Anxiety as per GAD-7’s non-clinical screening, followed by

Fig. 3. Demonstration of variable relationship matrix with appropriate statistical tests.
Table 2
Socio-demographic and Psychophysiological attributes of the participants and their built-environment.

| Total Sample Size (N = 432) | Frequency (n) | Percentage (%) |
|-----------------------------|---------------|----------------|
| Hostel                      |               |                |
| CIB (All Male)              | 122           | 28.2           |
| KB (All Female)             | 106           | 24.5           |
| Gender                      |               |                |
| VK (Mixed)                  | 204           | 47.2           |
| Female                      | 205           | 47.5           |
| Male                        | 227           | 52.5           |
| Marital Status              |               |                |
| Married                     | 18            | 4.2            |
| Separated                   | 1             | 0.2            |
| Single                      | 413           | 95.6           |
| Enrolled in                 |               |                |
| Masters                     | 138           | 31.9           |
| Ph.D.                       | 294           | 68.1           |
| Room Occupancy              |               |                |
| Double                      | 130           | 30.1           |
| Single                      | 302           | 69.9           |
| Plants in Room              | 206           | 47.7           |
| Access to Balcony           | 122           | 28.2           |
| Depression Risk             |               |                |
| Anxiety Level               |               |                |
| Normal                      | 151           | 35             |
| Mild                        | 111           | 25.7           |
| Moderate                    | 95            | 22             |
| Severe                      | 75            | 17.4           |
| View of Sky                 |               |                |
| Excellent                   | 147           | 34.0           |
| Good                        | 130           | 30.1           |
| Poor                        | 101           | 23.4           |
| Not available               | 54            | 12.5           |
| View of Greenery            |               |                |
| Excellent                   | 155           | 35.9           |
| Good                        | 101           | 23.4           |
| Poor                        | 104           | 24.1           |
| Not available               | 72            | 16.7           |
| View Outside Window         |               |                |
| Excellent                   | 136           | 31.5           |
| Good                        | 130           | 30.3           |
| Fair                        | 121           | 28.0           |
| Poor                        | 44            | 10.2           |
| Indoor Environment Quality  |               |                |
| Excellent                   | 134           | 31.0           |
| Good                        | 154           | 35.6           |
| Fair                        | 108           | 25.0           |
| Poor                        | 36            | 8.3            |
| Adverse effect on Productivity|             |                |
| Yes                         | 317           | 73.4           |
| No                          | 115           | 26.6           |

Table 3
Descriptive statistics of the participating population.

| Descriptive Statistics (N = 432) | Min. | Max. | Mean | Std. Deviation |
|---------------------------------|------|------|------|----------------|
| Age                             | 20   | 48   | 25.92| 2.694          |
| BEV Score                       | 1    | 25   | 11.42| 5.306          |
| CES-D                           | −10  | 45   | 13.02| 12.747         |
| GAD-7                           | 0    | 21   | 9.17 | 5.699          |

Moderate (22%), Mild (25.7%) and Normal (35%) levels.

Chi-square test results of association of Socio-demographic and Built Environment Attributes with Depression, Anxiety and Effect on Productivity are shown in Table 5. Chi-square tests found no associations between Depression Risk and both Gender ($X^2(1) = 0.492, p = 0.483$) and Educational level ($X^2(1) = 0.111, p = 0.739$); also no significant associations between Anxiety Level and Gender ($X^2(3) = 2.050, p = 0.562$) could be established, however there was a significant association between Educational level ($X^2(3) = 34.828, p = 0.001$) and Anxiety Level; and Educational Level ($X^2(1) = 16.246, p = 0.001$) and Effect on Productivity. There was a significant association between Depression Risk, Anxiety Level and Effect on Productivity with all the aspects of Built Environment except Carpet Area and Room Occupancy.

Likert scale values of all Built Environment aspects found statistically significant throughout depression, anxiety and productivity domains were added to generate a continuous variable; the intensity of presence of plants and portraits/artworks were added into it to formulate the Built Environment Variable Score (BEV Score).

BEV Score = $\sum_{(Likert\ Scale\ values\ of\ all\ statistically\ significant\ BE\ Aspects)} + \ Intensity\ of\ presence\ (Plants + Portrait\ and\ Artworks)$

Simple Linear Regression was performed to find the direction and strength of association between BEV Score and scalar values of CES-D and GAD-7. For CES-D and BEV Score (hypothesis 1), a significant regression equation was found ($F(1, 430) = 356.873, p < 0.001$), with an $R^2$ of 0.454. Participants’ predicted CES-D score is equal to 31.497–1.618 (BEV) CES-D when BEV Score is measured in 1 BEV. CES-D score increased –1.618 for each 1 unit of BEV Score. For GAD-7 and BEV Score (hypothesis 2), a significant regression equation was found ($F(1, 430) = 212.790, p < 0.001$), with an $R^2$ of 0.331. Participants’ predicted GAD-7 score is equal to 16.230–0.618 (BEV) GAD-7 when BEV Score is measured in 1 BEV. GAD-7 score increased -0.618 for each 1 unit of BEV Score. Fig. 5 demonstrates the scatter-plot of all responses with model fit line showing linear $R^2$.

To reinforce the hypotheses 1, 2 and 3 assertions that students with higher BEV Score are at lower risk of Depression, Anxiety and Adverse effect on productivity, multinomial logistic regression analysis was performed. Table 6 depicts the Multinomial Logistic Regression results for role of BEV Score in predicting Depression Risk, Anxiety Level and Adverse Effect on Productivity. The overall models were statistically significant ($p < 0.05$) when compared to the null models. Increasing 1 unit of BEV Score was associated with a 1.3-unit reduction in likelihood of Depression. For Anxiety, increasing 1 unit of BEV Score was linked to 0.779, 0.712 and 0.614-unit reduction in likelihood of Mild, Moderate and Severe cases respectively. For Adverse Effect on Productivity, a 1-unit increase in BEV Score increases the likelihood of No-effect on productivity by 1.277 units.

Fig. 6 and Fig. 7 summarizes the cross-tabulation results of association of socio-spatial characteristics of the participants with Depression Risk and Anxiety Levels respectively. The intensity of fluctuations in the Depression Risk and Anxiety Level can be seen most prominently in indicators such as Plants in Room, View of Greenery, View of Sky, Window View Quality and Indoor Environment Quality. The severity of Anxiety was found to be skewed towards Masters (Postgraduate) students. Cross-tabulations additionally highlighted the close relationship of Depression with Anxiety and Adverse effects on Productivity portraying influential behavior.

4. Discussion

The findings of this study strengthen the premise collectively built by the Biophilia Hypothesis [52], Attention Restoration Theory [29], Stress Reduction Theory [30] and Evidence Based Design [31], stating that the qualitative presence of natural aspects as patterns and imitations with user-preferred design elements can provide the dweller with a mentally resilient Built Environment and can also offer psychologically restorative solutions. In this particular case, the introduction of psychological boundary of isolation in a relatively small space and lack of outward experience were the sole cause of anxiety and depression. The sudden change in the daily routine of the students adversely affected their work productivity which in turn contributed to the intensity of anxiety and depression. Quarantine can be considered a mandatory prevention measure during infectious diseases outbreaks and yearlong pandemics but the theoretical advantages of quarantine must be balanced cautiously against the likely psychological consequences of severe disorders occurring over a wider population stratum. The cross tabulation findings revealed that a quality view from the window in addition to the view of greenery and view of sky, positively influenced the mental health of the students.

The rest of the Built environment aspects including Colour Scheme, Plants in Room, View of Greenery, View of Sky, Window View Quality, Portraits/Artworks and Indoor Environment Quality are found to be acting as strong contributors of mental health attributes dealing with...
The linear and multinomial logistic regression models concluded that with each significant increase in BEV Score there is a noted decline in the likelihood of Depression, Anxiety and any adverse effect on productivity. The study was not able to find any significant association between Gender and any of the Dependent Variables, however Educational Level was found to be significantly associated with Depression, Anxiety and adverse effect on productivity. The individual with relatively high BEV Score were found to be at lower risk of Depression, Anxiety and adverse effect on productivity.

### Table 4
Spatial attributes of different student hostel rooms in study.

| No. | Attributes                  | VK       | CB       | KB       |
|-----|-----------------------------|----------|----------|----------|
| 1   | Occupancy                   | Single   | Single   | Double   |
| 2   | Quantity (from responses)   | 204      | 52       | 70       | 46       | 60       |
| 3   | Room Dimensions             | -        | -        | -        | -        | -        |
|     | Length (m)                  | 4.12     | 3.76     | 6.98     | 4.11     | 6.98     |
|     | Breadth (m)                 | 3.13     | 3.06     | 3.66     | 3.46     | 3.46     |
|     | Height (m)                  | 3.00     | 3.00     | 3.00     | 3.00     | 3.00     |
| 4   | Volume (m$^3$)              | 38.68    | 34.51    | 76.64    | 42.66    | 41.26    |
| 5   | Carpet Area (m$^2$)         | 7.63     | 8.58     | 19.56    | 9.45     | 16.50    |
| 6   | No. of Windows              | 1        | 2        | 1        | 2        | 2        |
|     | Height (m)                  | 1.28     | 1.20     | 1.20     | 1.55     | 1.55     |
|     | Width (m)                   | 1.66     | 0.74, 0.74 | 1.50     | 0.74, 0.74 | 0.6, 1.51 |
| 7   | No. of Ventilators          | 1        | 1        | 1        | 1        | 1        |
|     | Height (m)                  | 0.56     | 0.45     | 0.45     | 0.45     | 0.45     |
|     | Width (m)                   | 0.56     | 1.00     | 1.00     | 0.85     | 0.85     |
| 8   | Window to Floor Area Ratio  | 0.318    | 0.259    | 0.115    | 0.283    | 0.221    |
| 9   | Attached Washroom           | No       | No       | No       | No       | No       |
| 10  | Balcony                     | No       | Shared   | Shared   | No       | No       |

Fig. 4. Floor Plans of different student hostel rooms identified in study.
Built environment is a significant health indicator and an active enabler, which relies on the qualitative availability of compositional elements of both natural and constructed environments including the layout of the site and surroundings with the associated greenery. The outdoors with a university campuses are designed to be rich in terms of offering physiological and psychological relief through gardens and parks. The hostels on the other hand are designed like another social housing unit without any assurance of quality views from the room window. Even if attention is paid to generate quality views for the hostel building façade, there are still a few units either at the lower floors or on other backward facades which do not get ample views of sky and greenery. The units on the lower floors often fail to provide imperative privacy to the students and additionally burden them with environmental noise and vehicular disturbances which further impacts the productivity and can lead to depressive symptoms. The formulation of BEV Score provided the researchers with an additional assessment metric while also utilizing the categorical variables mentioned as Built Environment aspects.

### Table 5

| Aspects                        | Depression Risk | Anxiety Level | Effect on Productivity |
|--------------------------------|-----------------|---------------|------------------------|
|                                | \( \chi^2 \)   | df | \( p \) | \( \chi^2 \)   | df | \( p \) | \( \chi^2 \)   | df | \( p \) |
| Socio-demographic              |                 |    |        |                 |    |        |                 |    |        |
| Gender                         | .492            | 1  | .483   | 2.050            | 3  | .562   | 1.964          | 1  | .161   |
| Educational Level              | .111            | 1  | .739   | 34.828           | 3  | .001   | 16.246         | 1  | .001   |
| Built Environment (BE)         |                 |    |        |                 |    |        |                 |    |        |
| Colour Scheme                  | 75.765          | 3  | .001   | 72.474           | 9  | .001   | 28.420         | 3  | .001   |
| Plants in Room                 | 32.380          | 1  | .001   | 45.159           | 3  | .001   | 27.732         | 1  | .001   |
| View of Greenery               | 112.772         | 3  | .001   | 123.441          | 9  | .001   | 58.462         | 3  | .001   |
| View of Sky                    | 86.102          | 3  | .001   | 147.722          | 9  | .001   | 28.687         | 3  | .001   |
| Window View Quality            | 122.193         | 3  | .001   | 123.193          | 9  | .001   | 61.951         | 3  | .001   |
| Portraits/Artworks             | 51.269          | 4  | .001   | 358.732          | 80 | .001   | 94.959         | 4  | .001   |
| Indoor Environment Quality     | 111.219         | 3  | .001   | 160.443          | 9  | .001   | 65.168         | 3  | .001   |
| Carpet Area                    | 3.792           | 3  | .285   | 21.308           | 9  | .031   | 9.944          | 3  | .019   |
| Room Occupancy                 | 2.016           | 1  | .156   | .201             | 3  | .977   | 1.195          | 1  | .274   |

#### Table 6

| Variables and Categories       | Category Code | p-value | Exp (B) | 95% Confidence Interval for Exp(B) |
|--------------------------------|---------------|---------|---------|-----------------------------------|
|                                |               |         | Lower Bound | Upper Bound             |
| Depression Risk                | Yes           | 1       | –        | –                      |
|                                | No            | 2       | .000     | 1.395                 | 1.309                 | 1.486                 |
| Anxiety Level                  | Normal        | 1       | –        | –                      |
|                                | Mild          | 2       | .000     | .779                  | .728                  | .833                  |
|                                | Moderate      | 3       | .000     | .712                  | .660                  | .768                  |
|                                | Severe        | 4       | .000     | .614                  | .559                  | .674                  |
| Adverse Effect on Productivity | Yes           | 1       | –        | –                      |
|                                | No            | 2       | .000     | 1.277                 | 1.207                 | 1.350                 |

**Fig. 5.** Scatter Plot demonstration of Linear Regression results of BEV Score with CES-D and GAD-7 Score.

**Table 6**

Multinomial Logistic Regression results for role of BEV Score in predicting Depression Risk, Anxiety Level and Adverse Effect on Productivity.

**Linked to Anxiety Level and Effect on Productivity.**

Built environment is a significant health indicator and an active enabler, which relies on the qualitative availability of compositional elements of both natural and constructed environments including the layout of the site and surroundings with the associated greenery. The outdoors with a university campuses are designed to be rich in terms of offering physiological and psychological relief through gardens and parks. The hostels on the other hand are designed like another social housing unit without any assurance of quality views from the room window. Even if attention is paid to generate quality views for the hostel building façade, there are still a few units either at the lower floors or on other backward facades which do not get ample views of sky and greenery. The units on the lower floors often fail to provide imperative privacy to the students and additionally burden them with environmental noise and vehicular disturbances which further impacts the productivity and can lead to depressive symptoms. The formulation of BEV Score provided the researchers with an additional assessment metric while also utilizing the categorical variables mentioned as Built Environment aspects.
4.1. Strength and limitations

This study must be characterized taking its many advantages and shortcomings into consideration. The potential advantages of the study are the presence of an actual containment zone population and the use of pre-validated non-clinical psychiatric evaluation methods. The major limitations of this study belong to the aspects in self-report questionnaires which can be termed unreliable if false-reported, under or over-estimated and denied by the participants. Due to the non-availability of pre-COVID-19 mental health assessment data of the participants, no analysis can be drawn to determine the temporal effects. The concerned hostels were declared containment zones at the same time hence the duration of isolation is evenly distributed and no temporal normalization is required. Another minor shortcoming of the study is the use of detailed yet not validated questionnaire which examined the spatial aspects of the Built Environment of the hostels with minimal role of socio-economic attributes of the participants.

5. Conclusion

The study is one of the first few attempts to investigate the impact of the effects of a COVID-19 containment zone Built Environment on...
mental health of students. The findings reveal a strong association between poor or non-availability of Built Environment aspects often termed ‘biophilic’ and severity of anxiety levels and depressive symptoms among the student population, with particular oversight to the Built Environments which have no indoor plants and possess a poor-quality window view with lack of greenery and sky visibility. Additionally, adverse effect on productivity related to isolation increased the risk of depressive symptoms.

A validated quantitative Built Environment Scale can be considered for development with rigorous testing and evaluation to ease the process of exploration of the qualitative nature of a Built Environment. Further multidisciplinary research is required in domains of Built Environment, Psychology and Epidemiology to accurately predict the impact of individual aspects of University Campus Built Environments on the mental health of students during specific situations of containment or quarantine. Future studies can focus on specific mental disorders of various intensities and their prevalence in University Campuses with respect to the Built Environment. This study approached the term ‘isolation’ from a spatial perspective; the degrees of social and economic perspectives can be explored to identify and understand the other indicators at play.

**Funding**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Ethical approval**

The study was exempted from requiring ethical approval from Institute Human Ethics Committee (IHEC) based on National and Institute guidelines provided that an informed consent before the study is sought in each case as the aspects of the study fall under ‘Less Than Minimal Risk’ to the participant and uses data which cannot be traced back to a participating individual i.e., name and any identifiable information is not recorded.

---

**Fig. 7.** Cross Tabulation of Anxiety Risk with socio-spatial characteristics of population.
Declarations of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We gratefully acknowledge all helpful suggestions and detailed critique by editors and the reviewers that helped us enhance the quality of the manuscript.

References

[1] World Health Organization (WHO). WHO Director-General’s opening remarks at the media briefing on COVID-19 - 11 March 2020. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-11-march-2020

[2] T. Lancet, India under COVID-19 lockdown, Lancet (N. Am. Ed.) 395 (2020) 1315, https://doi.org/10.1016/s0140-6736(20)30398-7.

[3] C. Benke, L.K. Autenrieth, E. Asselmann, C.A. Pan, T. Lancet, India under COVID-19 lockdown, Lancet (N. Am. Ed.) 395 (2020) 1327, https://doi.org/10.1016/s0140-6736(20)30460-8.

[4] D. Gunnell, E. Asselmann, C.A. Pan, T. Lancet, India under COVID-19 lockdown, Lancet (N. Am. Ed.) 395 (2020) 1328, https://doi.org/10.1016/s0140-6736(20)30517-1.

[5] J. Aquila, M.A. Sacco, C. Ricci, S. Gratteri, P. Ricci, Quarantine of the Covid-19 epidemic in Italy: a population-based outbreak investigation, Color Res. Appl. 21 (9) (2016) 448–458, https://doi.org/10.1111/crer.12369.

[6] D.D. Drouas, S. Quadros, Z.J. Hydabawala, M.A. Mamun, Aggregated COVID-19 suicide incidences in India: fear of COVID-19 infection is the prominent causative factor, J. Environ. Psychol. 2020 (2020) 113415, https://doi.org/10.1016/j.jenpsy.2020.113415.

[7] R. Sagar, R. Dandonia, G. Gururaj, R.S. Dhalliwal, A. Singh, A. Ferrari, L. Dandonia, The burden of mental disorders across the states of India: the Global Burden of Disease Study 1990-2017, The Lancet Psychiatry 7 (2) (2020) 148–161, https://doi.org/10.1016/S2215-0366(19)30475-4.

[8] M.S. Gautham, G. Gururaj, M. Varghese, V. Benegal, G.N. Rao, A. Kokane, T. M. Shibuankul, The National Mental Health Survey of India (2016): prevalence, socio-demographic correlates and treatment gap of mental morbidity, Int. J. Soc. Psychiatry. 66 (4) (2020) 361–372, https://doi.org/10.1177/0020764020907941.

[9] G. Gururaj, M. Varghese, V. Benegal, G.N. Rao, K. Pathak, L.K. Singh, R. Misra, National Mental Health Survey of India, 2015-16: Summary. Bengaluru, National Institute of Mental Health and Neurosciences, 2016, https://doi.org/10.1007/s11356-018-3554-1.

[10] C. Lahariya, Strengthened mental health services for universal health coverage in India, J. Postgrad. Med. 64 (1) (2018) 7, https://doi.org/10.4103/jpgm.PGM_17.

[11] C. Lahariya, S. Singhal, S. Gupta, A. Mishra, Pathway of care among psychiatric patients attending a mental health institution in central India, Indian J. Psychiatry. 52 (4) (2010) 333, https://doi.org/10.4103/0019-5545.74306.

[12] J. Moran, L. Topp, J. Andrews (Eds.), Madness, Architecture and the Built Environment: Psychiatric Spaces in Historical Context, Routledge, 2020, http://eprints.bbk.ac.uk/id/eprint/23326.

[13] D. Brooks, The paradox of environmental psychology, Am. Psychol. 50 (10) (1995) 821, https://doi.org/10.1037/0003-066X.50.10.821.

[14] N. Rautio, S. Filatova, H. Lehtiniemi, J. Miettunen, Living environment and its socio-demographic correlates and treatment gap of mental morbidity, Int. J. Soc. Psychiatr. 64 (1) (2018) 92, https://doi.org/10.1177/0020764X17744582.

[15] M. Shibukumar, The National Mental Health Survey of India (2016): prevalence, socio-demographic correlates and treatment gap of mental morbidity, Int. J. Soc. Psychiatr. 64 (1) (2018) 103, https://doi.org/10.1177/0020764017744582.

[16] J. Yin, J. Yuan, N. Arfaei, P.J. Catalano, J.G. Allen, J.D. Spengler, Effects of urban green spaces on mental health and subjective well-being? J. Environ. Econ. Manag. 85 (2017) 94, https://doi.org/10.1016/j.jeem.2017.04.001.

[17] N. Kwallek, C.M. Lewis, J.W.D. Lin-Hsiao, H. Woodson, Effects of nine monochromatic office interior colors on clerical task workload, color, Resor. Appl. 21 (6) (1996) 448–458, https://doi.org/10.1111/j.1748-3593.1996.tb00972.x.

[18] J. Eaton, C. Tieber, The effects of coloring on color, mood, and perseverance, Art Therapy 34 (1) (2017) 42–46, https://doi.org/10.1016/j.artyth.2016.12.006.

[19] L. Deng, Q. Deng, The basic roles of indoor plants in human health and comfort, Environ. Sci. Pollut. Control. Ser. 25 (36) (2018) 36087–36101, https://doi.org/10.1007/s11356-018-3254-1.

[20] J. Kim, S.H. Cha, C. Koo, S.T. Kang, The effects of indoor plants and artificial windows in an underground environment, Build. Environ. 138 (2018) 53–62, https://doi.org/10.1016/j.buildenv.2018.04.029.

[21] R. Wang, M. Helbig, Y. Zhang, F. Liu, Y. Yuan, Y. Liu, Urban greenery and mental wellbeing in adults: cross-cultural mediation analyses on multiple pathways across different greenery measures, Environ. Res. 176 (2019) 108535, https://doi.org/10.1016/j.envres.2019.108535.

[22] M. Manzon, M. Trigueros-Mas, Y. Martinez, P. Dadvand, J. Forns, A. Plas, M. N. J. Sienewijshuijen, Mental health benefits of long-term exposure to residential green and blue spaces: a systematic review, Int. J. Environ. Res. Publ. Health 12 (4) (2015) 4354–4379, https://doi.org/10.3390/ijerph120404354.

[23] X. Zhang, X. Zhang, X. Chen, Happiness in the air: how does a dirty sky affect mental health and subjective well-being? J. Environ. Econ. Manag. 85 (2017) 81–94, https://doi.org/10.1016/j.jeem.2017.04.001.

[24] J. Yin, S. Zhu, P. Maunckjght, J.G. Allen, J.D. Spengler, Physiological and cognitive performance of exposure to biophilic indoor environment, Build. Environ. 132 (2018) 255–262, https://doi.org/10.1016/j.buildenv.2018.01.006.

[25] J. Yin, J. Yuan, N. Arfaei, P.J. Catalano, J.G. Allen, J.D. Spengler, Effects of biophilic indoor environment on stress and anxiety recovery: a between-subjects experiment in virtual reality, Environ. Int. 136 (2020) 105427, https://doi.org/10.1016/j.envint.2019.105427.

[26] L. Lankston, P. Cunack, C. Fremantle, C. Isles, Visual art in hospitals: case studies and review of the evidence, J. R. Soc. Med. 103 (12) (2010) 490–499, https://doi.org/10.1258/jrsm.2010.100256.

[27] L. Lankston, P. Cunack, C. Isles, Impact of visual art in patient waiting rooms: survey of patients attending a transplant clinic in Dumfries, JRM short reports 1 (2010) 1–5, https://doi.org/10.1258/jrsm.2010.100256.

[28] S. Raj, F. Asim, V. Shree, Investigative study of relationship between built environment and perceived restorativeness: cases of colonial churches of dalhouise, Visions for Sustainability 31 (2020) 31–43, https://doi.org/10.13135/2384-8077/5354.

[29] F. Asim, V. Shree, The impact of biophilic built environment on psychological restoration within student hostels, Visions for Sustainability 12 (2019) 18–33, https://doi.org/10.13135/2384-8077/5354.

[30] U. Grot, UK Health Bulletin: Uttarakhand State Control Room COVID-19, 2021, Retrieved, https://health.uk.gov.uk/files/2021.05.10._Health_Bulletin_2.pdf. (Accessed 11 May 2021).
[46] R.E. Roberts, S.W. Vernon, The center for epidemiological studies depression scale: its use in a community sample, Am. J. Psychiatr. (1983). https://psycnet.apa.org/doi/10.1176/ajp.140.1.41.

[47] R.L. Spitzer, K. Kroenke, J.B. Williams, B. Löwe, A brief measure for assessing generalized anxiety disorder: the GAD-7, Arch. Intern. Med. 166 (10) (2006) 1092–1097. https://doi:10.1001/archinte.166.10.1092.

[48] S.S. Shapiro, R.S. Francia, An approximate analysis of variance test for normality, J. Am. Stat. Assoc. 67 (337) (1972) 215–216, https://doi.org/10.1080/01621459.1972.10481232.

[49] J. Peat, B. Barton, Medical Statistics: A Guide to Data Analysis and Critical Appraisal, John Wiley & Sons, 2008.

[50] D.J. Steinskog, D.B. Tjostheim, N.G. Kvamsø, A cautionary note on the use of the Kolmogorov–Smirnov test for normality, Mon. Weather Rev. 135 (3) (2007) 1151–1157, https://doi.org/10.1175/MWR3261.1.

[51] H.C. Thode, Testing for Normality, vol. 164, CRC press, 2002.

[52] S.R. Kellert, E.O. Wilson, Biophilia. (2008).