The Association Between Apartment Layout and Depressive Symptomology among Hispanic/Latino Residents in Low-Income Housing: the AHOME Study

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Abstract In this study of low-income Hispanic/Latino adults living in 291 individual apartments in the Bronx, New York, the apartment layout was significantly associated with the odds of depressive symptomology. Women living in apartments in which the most central rooms were the living, dining, or kitchen (i.e., rooms commonly used for communal activities) were less likely to have depressive symptomology (OR = 0.44, 95% CI = 0.22–0.86) than women in apartments where the central rooms were lobbies or corridors, adjusting for demographics, health conditions, and housing and neighborhood characteristics. No statistically significant association was observed in men. We present the logic underlying the use of layout variables in this study and discuss the implications it may have for understanding

the role of the home environment on psychological distress among inhabitants. The results of this study show how space syntax analysis can be used to better understanding disparities in the risk of depression and offer an additional opportunity for public health stakeholders to identify those most at risk for depression.

Keywords Built environment · Depression · Hispanic/Latino · Space syntax · Housing

Introduction

In the USA, the prevalence of depression and psychological distress is higher among the Hispanic/Latino population than non-Hispanic/Latino whites [1–3]. Hispanic/Latino women are twice as likely to experience depressive symptoms as Hispanic/Latino men [4]. Low-income Hispanic/Latinos have a disproportionate burden of mental health problems stemming, in part, from the neighborhoods in which they live [3, 5]. Hispanic/Latino residents are more likely than white residents to live in a poor neighborhood with poor-quality housing and less access to health resources [6–8].

The Centers for Disease Control and Prevention recognize that community design, including neighborhood and housing characteristics, can influence the mental health of residents [9, 10]. Community design that supports mental well-being like access to green and park space or deterring crime and traffic fatalities should extend to include the design of housing units. Research

Highlights

- Depression among low-income Hispanic/Latino adults was associated with apartment layout.
- For women, odds of depression for women in living-centered apartments were 44% of the odds of those in circulation-centered apartments.

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shows that poor-quality housing characteristics—e.g., pests, dampness and mold, deterioration—are associated with psychological distress including depression [11–15]. However, insufficient evidence exists that can inform interventions that consider the design elements of housing and its potential to influence the mental health of residents. More work is needed in this area of investigation as it may offer opportunities for identifying those most at risk for depression and offer inroads to housing design-related interventions that can promote mental well-being.

Prior work has shown that the apartment can be an important environment influencing psychological distress and the risk of depression among residents [11, 14, 16]. A study using the Affordable Housing as an Obesity Mediating Environment (AHOME) cohort showed that physical aspects of the apartment environment particularly related to maintenance and structural deficiencies were associated with an increased risk of depressive symptomology among residents. The results of this study are consistent with others showing that physical aspects of the environment as well as the perception of esthetic qualities of buildings and neighborhoods are associated with mental health among residents [16–18]. An issue that has yet to be explored in such studies is the influence on health of aspects of the environment that are not always consciously perceived by the residents. Of these aspects, one that seems promising is the way rooms are laid out within the apartment. The Space Syntax research program in architecture provides a theoretical framework for this work and a growing body of empirical evidence shows the existence of a systemic relationship between spatial layout of buildings and human behavior and perception [19, 20]. Based on this prior work, it is a logical next step to explore whether layout patterns are associated with specific health outcomes.

Patterns of Layout, Depth, and Psychological Distress

Apartments constituting the housing stock of the AHOME study exhibit two distinct layout patterns. In one type, which we call ‘circulation-centered’, rooms are connected to an armature of corridors or lobbies, that is, to spaces that are designated almost exclusively for circulation. In the other type which we call ‘living-centered’, there are few such

corridors or lobbies, and rooms are connected to each other through a room that is used for communal activity—a living room, or a dining room, or even a kitchen. In the first type, the communal rooms have a greater ‘depth’ from the other rooms in the apartment as compared to at least one such room in the second type. The term depth as used here refers to a construct that describes the separation of rooms in terms of the number of doors or thresholds that an occupant needs to cross in order to go from one room to another.

There is precedent for linking depth to health outcomes such as stress. Evans and his colleagues, for instance, proposed that increased depth between rooms of an apartment could help reduce distress caused by overcrowding by offering more opportunities for retreat and privacy [21]. They found limited support for the moderating influence of depth on the association between crowding and stress but argued this was because the relationship was mediated by behavioral coping mechanisms such as social withdrawal. Depth, however, is not a reliable measure of the ability of a layout to allow physical withdrawal; it is possible to arrange the rooms of a house to keep the depth between them to a minimum and still allow extensive opportunities for physical withdrawal. There are other grounds, however, for considering the association of stress with depth. Since the depth of a room from other rooms in the house is a measure of its separation from them, it can be considered an indicator of the degree of isolation the room provides. Studies in the history of domestic architecture have shown that increased depth between rooms corresponds either to demands of increased privacy or to increased formality in social life [22–24]. Both these qualities, privacy and formality, imply an increase in social isolation since they are achieved by reducing opportunities of unplanned, casual, social interaction. In fact, the mapping of depth to privacy or formality is a common feature of studies of building morphology [25, 26], and empirical studies of movement in buildings have also shown reduced social interaction in spaces of greater depth [27]. Social isolation, in turn, has been found to be a significant predictor of health problems [28, 29] including stress [30]. It follows from all these studies that the depth between the rooms of the house can influence the psychological health of the residents. Increased depth of a room can

increase social isolation of residents if they rely on the room for social interaction, and that in turn can contribute to their depression.

Aims of the Study

The aim of the current study was to examine the relationship between apartment layout (henceforth referred to as layout) and the prevalence of depressive symptomology among Hispanic/Latino residents of the AHOME study. We expected residents in circulation-centered apartments to be more likely to report depressive symptoms, as a whole compared to residents in living-centered apartments. The living or dining rooms in circulation-centered apartments, although nominally communal and public, would still be relatively more isolated within the apartment as whole, and these types of apartments would offer fewer opportunities for unplanned social interaction with other members of the household.

Prior research shows gender disparities in risk of depression [4]. Characteristics of the apartment environment may offer insights into the higher risk of depression among women. Therefore, we also examined whether the association between layout and depression differs by gender.

Methods

Data for this study were drawn from the AHOME study. The AHOME study is a cross-sectional survey of 385 low-income Hispanics/Latinos residing in public housing, housing subsidized by Section 8 vouchers, and housing with no federal assistance, all located in the Bronx, NY. The AHOME consists of a survey interview and clinical assessment conducted between January 2011 and August 2012. Details regarding the study design, recruitment, and data collection are described in a prior publication [31]. Institutional Review Board approval was obtained from both the Albert Einstein College of Medicine and Fordham University, and all participants gave written consent in either English or Spanish. Of the 385 individuals sampled in the AHOME study, layout data for their apartments of residence were available for a sub-sample of 291. The sub-sample closely matched the original sample over all demographic and neighborhood variables except for housing type, where the sub-sample had a slightly larger proportion of participants residing in public housing

apartments. Each participant in AHOME was drawn from a unique apartment.

Depressive Symptomatology

The Center for Epidemiological Studies Depression Short Form 10 item scale (CES-D 10) was used to measure depressive symptomology. This scale has been shown to have a high internal reliability when used to evaluate various groups including Hispanics/Latinos [32, 33]. CES-D short form is scored by summing the responses across all 10 items of the scale (items scored 0 to 3) [33], and a score ≥ 10 was considered positive for depressive symptomology. This cutoff is consistent with other studies that have used the short form of the CES-D for the screening of depressive symptoms in various populations [34, 35].

Apartment Layout: Centrality Type and Mean Depth

The main predictor variable in our study is the Centrality Type of the apartment. It can take two values—circulation-centered or living-centered. The classification of apartments into either of these types was produced by computing the depth between all pairs of rooms in each apartment, deriving mean depths for each room with respect to all others in the apartment, and then identifying whether the room with the lowest mean depth was used exclusively for circulation or for communal activities. The depth values were computed from plans of each subject's apartment recorded by the interviewers. The interviewers were trained to construct sketches that recorded the relative adjacencies of rooms in the apartment and all the doors connecting them, as well as the activity labels assigned to them (e.g. living room, kitchen, bedroom, etc.).

The computation of depth values entails the construction of a graph whose nodes represent the individual rooms and the links represent doorways or any sharp threshold between them (Fig. 1). The procedure for doing this has been established within the space syntax research program [36] and parts of it are now automated in open-source software packages [37]. The depth between any two rooms in an apartment is a measure of the distance between them. The term distance in this case refers not to Euclidean distance measured in feet or meters, but rather to the network distance, that is, to the number of links that separate the nodes in the graph that describes the layout. It is also worth noting that although depth is always registered in integer values, it

Fig. 1 Four apartments from the study sample illustrating how depth values are computed. Each apartment is considered as a graph—a network of rooms connected by doors or thresholds. Depth between any two rooms is the number of links connecting the shortest path between the two nodes that correspond to the rooms in the graph. In Apartment 3, for example, the Kitchen (K) is at a depth of 2 from the corridor 1 (C1; black node), and the living room (L) has a depth of 1 from the same corridor 1. All

graphs shown here are drawn with the most central space of each apartment as the root (black node). The computation of depths in this study entailed the construction of such graphs for each room in each apartment in the sample. The diagram also illustrates the differences between circulation- and living-centered apartments and shows that in principle either of these types can have low or high apartment mean depth values.

is standard practice, in network theory at large not just the space syntax studies, to interpret depth values on an interval scale, allowing fractional values [38, 39].

UCL Depthmap software (version 10.14.00b, Copyright: University College London, Alasdair Turner, Eva Friedrich, 2010-11) was used to convert the sketches into graphs and to compute the depth values for each room in all the apartments. Thirty apartments were selected to be converted to graph manually, and their depth values computed using the *iGraph* package for R [40] as a validation for values computed by *Depthmap*.

“Apartment Mean Depth” (ApMD), the second layout variable included in our study, is simply the mean depth between all possible pairs of rooms in an apartment, thus:

$$\bar{D} = \frac{1}{N(N-1)} \sum_j \sum_{i \neq j} d_{ij}$$

where $\bar{D}$ is value of ApMD for a particular apartment, N is the number of rooms in the apartment, and d_{ij} is the depth between room i and room j . ApMD is positively correlated with the number of rooms in the apartment ($R = 0.7, p = 2.2 \times 10^{-16}$) and was used to adjust for the effect of apartment size on rates of depression. We considered it a better descriptor of room size than the raw number of rooms because it takes into account the organization of the rooms as well.

Covariates

The covariates selected for inclusion were based on a prior study of depression in this cohort [11]. The following demographic variables were adjusted for in the analysis: age (years), gender, education status (less than high school degree, high school, greater than high school degree), and employment status (employed,

unemployed, out of labor force). The housing and neighborhood characteristics were measured by participant's perception of crowding within the apartment, the number of maintenance/structural deficiencies, social cohesion, and physical disorder. Perceived apartment crowding was measured using 4 Likert-type items with responses ranging from 1 = strongly disagree to 4 = strongly agree. Items assessed how strongly participants agreed with the following: (1) at home, there are too many people around; (2) in this house, I have almost no time alone; (3) in my home, people get in each other's way; and (4) at home, I do not have room to do things conveniently. The perceived crowding measure takes the mean of responses across the items.

The items used to measure maintenance/structural deficiencies include (1) presence of mice or rats, (2) broken plaster, (3) cracks on the walls, (4) leaks from the outside, (5) any toilet breakdowns, (6) any breakdowns of heating equipment, (7) and holes in the floor or walls. Affirmative responses were summed across the seven items for a count of deficiencies. Physical disorder was measured using items that asked participants how big a problem these five conditions are (1) vacant lots with trash or junk; (2) litter, broken glass, or trash on the sidewalks and streets; (3) vacant or deserted housing or storefronts; (4) vandalism, like people breaking windows or windshields, or spray painting buildings; (5) and graffiti on buildings and walls. Response options were coded on a 3-point scale where 1 = not a problem, 2 = somewhat of a problem, and 3 = big problem. The mean score was taken on these five items.

Social cohesion was measured by determining the degree to which respondents agreed with the following: (1) people around here are willing to help their neighbors; (2) this is a close-knit or unified neighborhood; (3) people in this neighborhood can be trusted, (4) people in this neighborhood do not share the same values, and (5) people in this neighborhood generally do not get along with each other. Likert-type responses ranged from 1 = strongly disagree to 4 = strongly agree. A self-reported history of past health conditions—i.e., comorbidity—was measured using the Charlson Comorbidity Index [41]. Participants were asked if at any time in the past they have experienced a heart attack, high blood pressure, wheezing/asthma, stroke, diabetes/high blood sugar, or cancer. This yes/no question was used in analysis as a summary index counting the number of affirmative responses. Participants were also asked if they have had

a prior diagnosis of depression; however, this was not included in the comorbidity index.

Housing characteristics included the type of housing (public housing, section 8, private market), perceived crowding, the reported number of maintenance deficiencies within the apartment, and the presence of neighborhood physical disorder and social cohesion. A more detailed description of these metrics is available in a previous publication [11].

Analysis

Preliminary analysis was conducted to determine the distribution of the study variables and identify potential outliers or discordant values. Pairwise correlations were performed to identify any strong associations between the explanatory variables. Continuous variables entered into the model were all re-centered around their mean values. Bivariate analyses, using ANOVA and chi-square tests of independence, were conducted to determine the association of apartment centrality type, apartment mean depth, and gender with depressive symptoms. Logistic regression models were used to examine the relationship between apartment centrality type and depressive symptomology in stratified analyses by gender adjusting for covariates. Quality check for all final models included the computation of variation inflation factor (VIF) values for all variables to identify those with undesirably high correlations, and the examination of residuals using locally weighted scatterplot smoothing (LOWESS). The conventional α level of 0.05 was used to determine statistical significance. All statistical analyses were performed using R (R version 3.3.0 (2016-05-03)—Copyright (C) 2016; The R Foundation for Statistical Computing).

Results

The majority of the participants in the study were female (75.6%), and the average age was 46.6 (s.d. = 0.26) (Table 1). Approximately 47% of the participants lived in a living-centered apartment. Forty percent (40%) of the participants had depressive symptomology. The proportion of female residents screening positive for depressive symptomology in circulation-centered apartments (50%) was higher than that of female residents in living-centered apartments (35%); ($\chi^2 = 4.14$, $df = 1$,

Table 1 Summary statistics of study variables ($N = 291$)

Variable	Mean (SD) or N^a (%)	Range
Spatial configuration		
Apartment centrality		
Living	137 (47%)	
Circulation	154 (53%)	
Apartment mean depth	2.01 (0.26)	1.50–2.76
Depressive symptomology		
CES-D ≥ 10	116 (40%)	
CES-D < 10	174 (60%)	
Demographics		
Age (years)	46.6 (14.7)	18.6–85.6
Male	71 (24%)	
Female	220 (76%)	
< High School	136 (47%)	
High School	94 (32%)	
> High School	61 (21%)	
Employed	88 (30%)	
Unemployed	49 (17%)	
Out of labor force	149 (51%)	
Health		
Comorbidity	1.17 (1.15)	0–6
Housing and neighborhood characteristics		
Public housing	97 (33%)	
Section 8	84 (29%)	
Private market	110 (38%)	
Perceived crowding	2.04 (0.65)	1–4
No. of maintenance deficiencies	2.68 (1.74)	0–7
Social cohesion	2.74 (0.99)	1–5
Physical disorder	1.57 (0.58)	1–3

^a N s may not total 291 due to missing data for select variables

$p = 0.04$) (Fig. 2). Among male residents, the pattern was reversed, with a lower proportion screening positive for depressive symptomology in circulation-centered apartments (26%) than living-centered apartments (36%); but the association was not statistically significant ($\chi^2 = 0.48$, $df = 1$, $p = 0.49$).

In sub-group analysis by gender (Table 2), odds for female residents in living-centered apartments were significantly lower than those for female residents in circulation-centered apartments (OR = 0.44, 95% CI = 0.22–0.86) adjusting for covariates. Odds for male residents reporting depression were higher in living-centered apartments than in circulation-centered

apartments (OR = 3.59, 95% CI = 0.73–21.78), but this difference was not statistically significant. There was no evidence of multi-collinearity between the variables, and only one of the variables included in the models had VIF greater than 2 (housing type; $vif = 2.5$). A sensitivity analysis was done comparing participants that lived alone and participants living with others. Female residents living alone had higher rates of depression if they lived in circulation-centered apartments (74% of 19 women in our sample) than female residents in living-centered apartments (22% of 18 women in our sample). A model, including covariates, with an interaction between circulation-centered apartment type and a binary variable indicating whether the woman lives alone or with others showed neither a significant main effect for the “living alone” category (OR = 2.06, 95% CI = 0.57–8.28) or for the interaction effect (OR = 0.71, 95% CI = 0.12–3.84).

Discussion

Female residents in living-centered apartments had less than half the rate of depression than female residents in circulation-centered apartments. However, male residents in living-centered apartments were no less likely to have depressive symptomology than male residents in circulation-centered apartments. It could be that female residents are more likely than male residents to rely on social support to counteract depression [42]. If so, our results are consistent in that the communal living rooms in circulation-centered apartments would be more isolating and these apartments would offer fewer opportunities for unplanned social interaction. Our data, however, do not give us enough information to examine this hypothesis.

An unexpected observation in this study was that even female residents living alone had higher rates of depression if they lived in circulation-centered apartments than female residents in living-centered apartments. Although not statistically significant, it suggests that isolation due to depth may be experienced not only in the form of reduced social interaction, but also as a subjectively perceived quality. This point is supported by recent work on social isolation and health [28, 29]. Cornwell and Waite in a set of recent papers [43, 44] proposed that the sense of isolation experienced by individuals can be expressed as a combination of two distinct constructs, social disconnectedness and

Fig. 2 Mosaic plots showing the association of apartment centrality on prevalence of depression (areas of rectangles are proportional to observed frequencies). In the two-way mosaic plot on the left, gender (x -axis) is plotted against prevalence of depression illustrating the slightly greater rates of depression among women. In the three-way plot on the right, the same data are split along the vertical axis by apartment centrality before being further split by depression.

perceived isolation, the latter being considered a subjectively registered affect. The idea that perceived isolation may be generated by the environment by itself, even in the context of a person living alone is also supported by work on environment preferences by Rachel and Stephen Kaplan. They found that people responded affectively to the way a given setting revealed information about itself from particular vantage points within it and proposed that this affective reaction could be explained by two opposed cognitive motivations—“understanding” (a tendency to feel satisfied by a completely known environment) and “exploration” (a tendency to find interest in the unknown) [45–47]. It may be that views from communal rooms of circulation-centered apartments were perceived as not providing information that could satisfy the need for understanding and so generate affective feelings of isolation.

Limitations

This study has a small sample size, relies on self-reported measures, and is limited to only one county within the USA. Also, the cross-sectional design of the AHOME study precludes any causal inferences that can be derived from the results. We hypothesized in this study that the apartment design can exacerbate or help mitigate depressive symptoms among residents.

The study design does not eliminate the possibility, however, that residents who are depressed may choose apartments of a particular kind. We believe this reverse relationship is less likely since residents are not typically conscious of how layout may influence their mental

health when choosing an apartment. The relationships observed among men should be interpreted with some caution. There were considerably fewer male residents participating in AHOME than female residents, and analyses are too underpowered to fully examine the desired relationships among male residents.

There are two distinct questions regarding the generalizability of the study results. The first has to do with the generalizability of the distinction between two types of layouts that we observed in our sample. The existence of two distinct patterns of layout in our sample is associated with two widely occurring patterns of organizing house layouts within the Western Hemisphere the living-centered type corresponds to a historically prevalent pattern identified as a matrix of rooms [23]. The circulation-centered type in most cases is associated with a new approach to layout design that began to be advocated in professional architectural publications in early twentieth century as a direct result of interest in the scientific study of home management and efficiency of circulation and interactions within the home [48, 49]. The result of this advocacy was that by the middle of the century, designing houses around a circulation core became almost standard architectural practice. Although our study itself does not offer specific confirmation of the causal mechanism between layout types and depression, given the limitations we have described above, we think that the existence of these two general patterns of organization within architecture gives our results added significance.

The second issue of generalizability has to do with how far the association between layout types and depression can be expected to hold in other communities.

Table 2 Logistic regression analysis (odds ratio (OR) and 95% confidence intervals (95%CI)) of spatial configuration and covariates on depressive symptomology by gender

		Female		Male	
		Odds ratio	95% CI	Odds ratio	95% CI
Spatial configuration					
Living		0.44	0.22–0.86	3.59	0.73–21.78
Circulation		Reference		Reference	
Apartment mean depth (steps)		1.75	0.49–6.45	0.35	0.02–5.28
Demographics					
Age (years)		1.02	1.00–10.05	0.97	0.91–1.02
> High School	0.74		0.30–1.79	1.74	0.22–14.79
< High School	0.78		0.38–1.58	1.17	0.21–7.11
High School		Reference		Reference	
Out of labor force		1.61	0.75–3.46	12.68	1.59–148.68
Unemployed		2.02	0.79–5.23	4.33	0.59–44.55
Employed		Reference		Reference	
Health					
Comorbidity		1.41	1.05–1.92	1.60	0.86–3.20
Housing and neighborhood characteristics					
Private Market		1.07	0.46–2.50	0.72	0.11–5.13
Section 8		1.13	0.50–2.57	1.62	0.25–10.70
Public housing		Reference		Reference	
Perceived Crowding		1.11	0.68–1.83	2.43	0.56–12.25
No. of maintenance deficiencies		1.23	1.02–1.48	1.09	0.67–1.81
Social cohesion		0.76	0.52–1.08	0.80	0.39–1.60
Physical disorder		1.16	0.63–2.13	1.43	0.37–5.55

^a One participant was removed due to missing CES-D score; analysis $n = 290$

The current study included low-income Hispanic/Latino adults. This research should be expanded to more communities to examine if the relationships hold. For example, there may be cultures that value individual privacy much more than the Latino community that we studied and thus circulation-centered types of home layouts in communities from such cultures may have less deleterious effects on mental health.

Conclusion

Beyond giving support to the idea that depth-related design elements of the apartment can be used to identify residents at risk for psychological distress, the results from our study are useful in pointing the direction to

future work that could further our understanding of the complex relationship between health and environment.

Future work should seek to explicitly specify and model the actual causal mechanisms suggested here using mediating variables that describe both behavioral and cognitive elements of the resident's use of space and why there may be gender-related differences. Women are at increased risk for depression and efforts are needed to better understand the contributing factors to this gender disparity [3]. The results of this study also suggest that, so long as our results are confirmed by further studies, policy aimed at changing architectural norms to be more aware of the effect that layouts can have on mental health among residents, may be one way to help address psychological distress among low-income populations.

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