RESEARCH REPORT

Urban built environment and depression: a multilevel analysis

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Study objective: To assess the relations between characteristics of the neighbourhood internal and external built environment and past six month and lifetime depression.

Design and setting: Depression and sociodemographic information were assessed in a cross sectional survey of residents of New York City (NYC). All respondents were geocoded to neighbourhood of residence. Data on the quality of the built environment in 59 NYC neighbourhoods were collected from the United Status census, the New York City housing and vacancy survey, and the fiscal 2002 New York City mayor's management report.

Main results: Among 1355 respondents, residence in neighbourhoods characterised by a poor quality built environment was associated with greater individual likelihood of past six month and lifetime depression in multilevel models adjusting for individual age, race/ethnicity, sex, and income and for neighbourhood level income. In adjusted models, persons living in neighbourhoods characterised by poorer features of the built environment were 29%–58% more likely to report past six month depression and 36%–64% more likely to report lifetime depression than respondents living in neighbourhoods characterised by better features of the built environment.

Conclusions: Living in neighbourhoods characterised by a poor quality built environment is associated with a greater likelihood of depression. Future prospective work designed to assess potential mechanisms underlying these associations may guide public health and urban planning efforts aimed at improving population mental health.

Cities have long been the subject of interest as a potentially powerful force in shaping the health of populations.[1–9] Early research that laid the groundwork for much of the current thinking on the relation between particular aspects of urban living and mental health includes the work of Farris and Dunham, who found a high degree of association between different types of psychoses and certain conditions of communities,[10] and the Midtown Manhattan study that suggested that sociocultural features of urban living such as disorganisation may influence mental health.[11]

However, despite this early work and a flourishing of empirical literature on the relation between characteristics of the urban environment and health, most of the recent multilevel literature has focused on physical health. A systematic review of neighbourhood characteristics and health outcomes only identified one study that considered mental disorders.[12 13] Recent studies have shown that neighbourhood social disorganisation is associated with depressive symptoms[14] and that living in socioeconomically deprived areas is associated with depression,[15 16] with higher levels of child problem behaviour,[17] with a higher incidence of non-psychotic disorders.[18] A randomised controlled trial that moved families from high poverty neighbourhoods to non-poor neighbourhoods showed that both parents and children who moved reported fewer psychological distress symptoms than did control families who did not move.[19]

To our knowledge, only one other study has explored the association between characteristics of the urban built environment and mental health. Weich *et al* found that persons living in neighbourhoods characterised by a poor quality physical environment were more likely to report symptoms consistent with depression after accounting for individual characteristics.[20] Building on this work we were interested in the association between qualities of the urban neighbourhood built environment and the likelihood of depression. In particular we were interested in assessing characteristics both of the internal (characteristics of indoor environments) and the external (outside features of buildings and streets) physical built environment and their potential relation to depression. Given a concern with the relation between the urban environment and mental health, it is plausible that there are different relations between characteristics of the internal and external environment, to which persons may be exposed for different lengths of time and in different ways, and the likelihood of depression.

METHODS

We conducted a random digit dial telephone survey of residents of the New York City (NYC) metropolitan area between 25 March and 25 June 2002. The study was designed to report population mental health in the aftermath of the September 11, 2001 terrorist attacks. The study included non-institutionalised adults at least 18 years of age and over-sampled residents living in the area closest to the World Trade Center site.[21] For this analysis of NYC neighbourhoods we limited the sample to residents of NYC. This work was reviewed and approved by the Institutional Review Board of the New York Academy of Medicine.

Respondents were interviewed using a structured questionnaire that assessed background and demographic characteristics including age, race and ethnicity, sex, and income. For this analysis we focused on past six month and lifetime depression as primary independent variables of interest. Depression was measured with the national women's study (NWS) depression module, a validated measure that captures symptoms of major depression consistent with DSM-IV criteria.[22 23] To meet the criteria for depression, respondents

Abbreviations: NYC, New York City; NWS, national women's study; NYCHVS, New York City housing and vacancy survey

Table 1 Baseline demographics of the study sample; residents of New York City in 2002

	Number	%	Mean	SD
Total	1355	100.00		
Age			40.36	12.85
18–24	144	15.95		
25–34	357	27.75		
35–44	279	18.33		
45–54	248	18.04		
55–64	148	10.95		
65+	134	8.98		
Sex				
Male	616	43.83		
Female	739	56.17		
Race/ethnicity				
White	682	35.65		
Asian	102	6.26		
African American	220	24.24		
Hispanic	291	29.69		
Other	40	4.15		
Income				
$100000 +	213	11.33		
$75000–$99999	102	9.76		
$50000–$74999	196	16.08		
$40000–$49999	93	6.68		
$30000–$39999	134	14.91		
$20000–$29999	142	16.54		
<$20000	265	24.71		

had to report four or more symptoms for a period of at least two weeks, one of which included depressed mood or loss of pleasure or interest. Past six month depression was based on reporting four or more symptoms within the same month during the past six months and lifetime depression was based on reporting the required symptoms at any time in the past. The depression scale, which can also be scored continuously, had a Cronbach's α of 0.79 in our sample[24] and 0.85 in the NWS.[25] The depression scale, which can also be scored continuously, had a Cronbach's α of 0.79 in our sample[24] and 0.85 in the NWS.[25] Overall, the brief symptom inventory-18 depression scale [26] had 73% sensitivity and 87% specificity in detecting depression as classified by our depression instrument.[23]

The neighbourhood units for this analysis were the 59 community districts in NYC, well defined units, each headed by an administrative community board that as such have political and social relevance for their residents. Community districts were initially defined by a resident consultative process organised by the Office of City Planning to reflect residents' own descriptions of neighbourhoods in the 1970s. Although the community districts are not demographically homogenous (as would be expected in a city as diverse as NYC), they represent neighbourhoods that have been shown to affect resident behaviour and health.[27–29]

Information on the characteristics of the built environment in each neighbourhood was collected from the 1999 NYC housing and vacancy survey (NYCHVS)[30] and the fiscal 2002 NYC mayor's management report.[31] The NYCHVS is sponsored by the NYC department of housing preservation and development and has been conducted about every three years since 1962. The information is collected by trained field representatives who visit a sample of housing units in each neighbourhood in NYC and complete a questionnaire via interview with one adult member of each unit. In 1999, about 15 500 occupied housing units were included in the NYCHVS; only occupied housing units were considered in these analyses to allow for comparison between the role of characteristics of the external and internal built environment. The median number of housing units sampled per neighbourhood was 245 with a range of 187–702.

The mayor's office of operations compiles data from a number of NYC agencies including the NYC fire department and the department of sanitation, in the biannual mayor's management report. Information from the fiscal year 2002 report, including data for each NYC neighbourhood, was collected from the interactive "My Neighbourhood Statistics" feature on the mayor's management report web site and used in this analysis.

Characteristics of the internal and external built environment used in these analyses are as described in table 2.

Statistical analyses

All analyses were weighted to adjust for the probability of selection for interview and for the oversample. We constructed multilevel hierarchical models that assessed the relation between each characteristic of the built environment and the likelihood of past six month depression and lifetime depression.[32] We used separate multilevel models for each characteristic of the built environment (total 14 unadjusted and 14 adjusted models). Using differences in the log likelihood, we assessed linearity of the relations between each of the key independent variables and the outcomes of interest and, with the exception of two associations (from a total of 28 associations of interest) where a quadratic form provided a better model fit, the relations of interest were all adequately represented by simple linear models. For simplicity we present all analyses using linear models. In an attempt to avoid possible confounding, median neighbourhood income in 2000[33] and demographic characteristics of all participants (age, sex, race/ethnicity, and income) were controlled for in the final analyses. Marital status and education were also considered as potential confounders but did not significantly change results and as such were not included in final models presented. For ease of interpretation we calculated odds ratios for the relation between each of the characteristics of the built environment and likelihood of depression; odds ratios describe the likelihood of depression if a respondent was living in a neighbourhood characterised by a one standard deviation difference in the characteristic of the built environment. Therefore, interpretation of these odds ratios must consider the standard deviation of each of the independent variables presented in table 2.

RESULTS

Overall, 1570 NYC residents were interviewed, and of these, 1355 provided information allowing us to link them to their neighbourhood of residence. All analyses were necessarily restricted to this latter sample and there were no significant differences between the demographic characteristics of the included and excluded groups. The demographic characteristics of the sample are presented in table 1 and are consistent with demographic characteristics of NYC from the 2000 US census. Mean age was 40.4, 56.2% were female, 35.7% were white, 6.3% were Asian, 24.2% were African American, 29.7% were Hispanic, and 4.2% were of other race or ethnicity. The prevalence of current depression was 6.0% and 19.9% had a lifetime occurrence of depression. In the 59 neighbourhoods there was a mean of 23 respondents (median = 13, range = 4–291). Characteristics of the built environment relevant for this analysis for the 59 NYC neighbourhoods are presented in table 2.

Tables 3 and 4 show the multivariate relations between neighbourhood built environment characteristics and the likelihood of past six month and lifetime depression respectively. In separate multilevel logistic regression analyses adjusting for neighbourhood median household income and demographics (age, sex, race/ethnicity, individual income), the characteristics of the internal built environment that were significantly associated with past six month and

Table 2 Characteristics of the internal and external built environment in 59 New York City neighbourhoods

Built environment		Mean	SD	Median	Range
Internal built environment	*Percentage of housing units experiencing toilet breakdowns**				
	Percentage of housing units within a neighbourhood in which respondents experienced a time in the past three months when all toilets were not working for six consecutive hours.	9.6	3.9	9.0	16.0
	*Percentage of housing units with some non-functioning kitchen facilities**				
	Percentage of housing units within a neighbourhood in which respondents reported having one or more kitchen facilities that were not working at all.	2.4	1.5	2.4	6.3
	*Percentage of housing units experiencing over three heat breakdowns in winter**				
	Percentage of housing units within a neighbourhood in which respondents experienced more than three breakdowns in heating equipment during the winter before the interview, during which time, heating equipment was completely unusable for six consecutive hours or longer.	4.4	3.7	3.2	16.6
	*Percentage of housing units needing additional heating in winter**				
	Percentage of housing units within a neighbourhood in which respondents reported using additional sources of heat (for example, a kitchen stove) during the winter before the interview to supplement the regular system, because the regular system, though functioning, did not provide enough heat.	11.0	5.8	9.2	28.5
	*Percentage of housing units with a large area of peeling plaster or paint**				
	Percentage of housing units within a neighbourhood that displayed an area of broken plaster or peeling paint on the interior ceiling or walls of larger than 8.5 inches by 11 inches.	6.5	3.5	5.9	13.8
	*Percentage of housing units with internal water leakage**				
	Percentage of housing units within a neighbourhood in which respondents reported experiencing any water leaking into the unit in the past 12 months, not including leaks that resulted from the unit's own plumbing fixtures backing up or overflowing.	16.2	5.9	15.5	22.6
External built environment	*Percentage of buildings observed to be in dilapidated condition**				
	Percentage of buildings within each neighbourhood that displayed one or more critical defects such as major open holes in the outside walls, or intermediate defects, like missing stair railings, or poor original construction and thus incapable of providing safe and adequate shelter for occupants.	1.0	1.3	0.5	7.6
	*Percentage of buildings observed to be in deteriorating condition**				
	Percentage of buildings within a neighbourhood that displayed a lack of proper upkeep that could not be corrected by normal maintenance, demonstrated through one or more intermediate defects like rotted or loose window frames or broken or missing stair railings.	5.9	3.8	5.0	18.5
	*Percentage of buildings with any external wall problems**				
	Percentage of buildings within a neighbourhood that displayed one or more of the following characteristics: missing bricks, siding, or outside wall material, sloping or bulging outside walls, or major cracks in outside walls.	2.9	2.9	2.3	12.5
	*Percentage of buildings with any window problems**				
	Percentage of buildings within a neighbourhood that displayed one or more of the following characteristics: broken or missing windows, rotted or loose window frames or sashes, or boarded up windows.	3.1	2.8	2.4	11.5
	*Percentage of buildings with any exterior or interior stairway problems**				
	Percentage of buildings within a neighbourhood that was determined to have one or more of the following characteristics: loose, broken or missing stair railways, or loose, broken, or missing steps.	4.9	4.3	3.5	16.2
	Number of structural fire†				
	Number of fire emergency incidents in each neighbourhood to which the NYC fire department responded that were classified as structural fires, or fires that have spread throughout the structure of a building (in concealed spaces, between walls, along the roof, or outside of the building).	454.2	197.1	434.0	877.0
	Percentage of acceptably clean streets‡				
	Percentage of streets in each neighbourhood that met an acceptable standard of cleanliness based upon a seven point picture based rating scale designed to reflect the public perception of acceptable cleanliness levels. This value is an annual average of twice monthly ratings of the city-wide street sample.	80.0	8.4	78.7	33.4
	Percentage of acceptably clean sidewalks‡				
	As above, percentage of sidewalks in each neighbourhood that met an acceptable standard.	87.9	7.8	89.8	28.9

*This information was obtained from the NYCHVS. †This information was obtained from the NYC fire department through the mayor's office of operations. ‡This information was obtained from the department of sanitation from the mayor's office of operations.

lifetime depression were percentage of housing units with non-functioning kitchen facilities ($\beta = 0.23$, $p = 0.02$ for past six month depression, $\beta = 0.22$, $p = 0.01$ for lifetime depression), heat breakdowns in winter ($\beta = 0.10$, $p = 0.03$ and $\beta = 0.10$, 0.01 respectively), needing additional heating in winter ($\beta = 0.09$, $p<0.001$ and $\beta = 0.08$, $p<0.001$ respectively), and large area of peeling plaster or paint ($\beta = 0.09$, $p = 0.05$ and $\beta = 0.10$, $p = 0.01$ respectively). The characteristics of the external built environment that were associated with past six month and lifetime depression were percentage of buildings in deteriorating condition ($\beta = 0.08$, $p = 0.02$ for past six month depression and $\beta = 0.07$, $p = 0.01$ for lifetime depression) and number of structural fires in a neighbourhood ($\beta = 0.002$, $p = 0.03$ and $\beta = 0.002$, 0.001 respectively).

Table 3 Multilevel logistic regression models predicting past six month depression*

Built environment		Estimate	p Value	OR†	Low CI	High CI
Internal	Percentage of housing units experiencing toilet breakdowns	0.0500	0.3603	1.2147	0.8008	1.8423
	Percentage of housing units with some non-functioning kitchen facilities	0.2244	0.0225	1.3851	1.0471	1.8325
	Percentage of housing units experiencing over three heat breakdowns in winter	0.0973	0.0258	1.4275	1.0441	1.9524
	Percentage of housing units needing additional heating in winter	0.0854	0.0004	1.6389	1.2495	2.1497
	Percentage of housing units with a large area of peeling plaster or paint	0.0890	0.0492	1.3600	1.0010	1.8470
	Percentage of housing units with internal water leakage	0.0278	0.2824	1.1794	0.8729	1.5935
External	Percentage of buildings observed to be in dilapidated condition	0.0670	0.4337	1.0937	0.8739	1.3687
	Percentage of buildings observed to be in deteriorating condition	0.0809	0.0215	1.3597	1.0462	1.7670
	Percentage of buildings with any external wall problems	0.0188	0.7778	1.0560	0.7237	1.5405
	Percentage of buildings with any window problems	0.0435	0.5171	1.1290	0.7821	1.6301
	Percentage of buildings with any exterior or interior stairway problems	0.0553	0.2035	1.2683	0.8794	1.8284
	Number of structural fires	0.0017	0.0332	1.3979	1.0199	1.8787
	Percentage of acceptably clean streets	0.0382	0.1092	1.3798	0.9309	2.0469
	Percentage of acceptably clean sidewalks	0.0078	0.7976	1.0627	0.6669	1.6933

*Model adjusted for neighbourhood income, individual income, age, sex, and race/ethnicity. †Odds ratio for a one standard deviation increase in the percentage of a particular characteristic of the built environment.

Table 4 Multilevel logistic regression models predicting lifetime depression*

Built environment		Estimate	p Value	OR†	Low CI	High CI
Internal	Percentage of housing units experiencing toilet breakdowns	0.0255	0.5723	1.1043	0.7827	1.5580
	Percentage of housing units with some non-functioning kitchen facilities	0.2217	0.0126	1.3797	1.0712	1.7767
	Percentage of housing units experiencing over three heat breakdowns in winter	0.1001	0.0051	1.4422	1.1164	1.8637
	Percentage of housing units needing additional heating in winter	0.0786	0.0005	1.5757	1.2209	2.0336
	Percentage of housing units with a large area of peeling plaster or paint	0.0968	0.0048	1.3971	1.1077	1.7616
	Percentage of housing units with internal water leakage	0.0256	0.2546	1.1641	0.8965	1.5124
External	Percentage of buildings observed to be in dilapidated condition	0.1097	0.1709	1.1580	0.9387	1.4284
	Percentage of buildings observed to be in deteriorating condition	0.0669	0.0333	1.2893	1.0203	1.6285
	Percentage of buildings with any external wall problems	0.0071	0.8909	1.0208	0.7616	1.3682
	Percentage of buildings with any window problems	0.1013	0.0573	1.3265	0.9914	1.7748
	Percentage of buildings with any exterior or interior stairway problems	0.0528	0.1819	1.2547	0.8993	1.7507
	Number of structural fires	0.0020	0.0010	1.4831	1.1708	1.8421
	Percentage of acceptably clean streets	0.0013	0.9467	1.0110	0.7414	1.3775
	Percentage of acceptably clean sidewalks	−0.0272	0.2605	0.8090	0.5597	1.1695

*Model adjusted for neighbourhood income, individual income, age, sex, and race/ethnicity. †Odds ratio for a one standard deviation increase in the percentage of a particular characteristic of the built environment.

As an example of the magnitude of the associations, a respondent living in a neighbourhood characterised by non-functioning kitchen facilities had a 1.39 times greater odds of reported past six month depression than a similar respondent living in a neighbourhood characterised by one standard deviation fewer non-functioning kitchen facilities, when adjusting for individual characteristics and for neighbourhood level income. The comparable odds ratio for lifetime depression was 1.38.

DISCUSSION

We found that persons living in neighbourhoods characterised by poorer features of the built environment were 29%–58% more likely to report past six month depression and 36%–64% more likely to report lifetime depression than persons living in neighbourhoods characterised by a better built environment. There are three primary explanations that may account for why characteristics of the urban built environment are associated with mental health.

The psychosocial stress explanation suggests that living in areas characterised by a poor quality built environment is associated with psychosocial stress that in turn may place one at greater risk for depression. Psychosocial stress has been associated with mental health in general[34–37] and with depression in particular.[38] Although most of this work has considered stress processes at the individual level,[39 40] there is a growing appreciation of the fact that the environmental context may itself be an important determinant of mental health or may shape the impact of other stressors on individual mental health.[41] Urban neighbourhoods characterised by poor quality built environment may also involve substantial exposure to daily stressors and hassles that can result in greater social strain on their residents and greater likelihood of depression. Also, densely populated urban areas, may amplify social examples and stressors.[42–44] In the context of urban neighbourhoods, the concentrated proximity of persons within areas characterised by a deteriorating built environment may exacerbate both social strain and its mental health consequences.

The concentrated disadvantage explanation suggests that the association between qualities of the neighbourhood built environment and depression may be a reflection of concentration of other deleterious elements of the urban neighbourhood environment that, through various mechanisms, shape mental health. For example, the absence of green space has been associated with poor overall health and worse mental health functioning in several studies.[45 46] Noise exposure in urban neighbourhoods also may contribute to psychological distress and poor mental health.[47] Residents of neighbourhoods with poor built environments also may be more exposed to violence and trauma, which, in turn, is associated with greater likelihood of poor mental health.[48] However, our finding of an association between living in a neighbourhood with a poor quality built environment and individual depression even when accounting for neighbourhood median income (which is highly correlated with other forms of neighbourhood level disadvantage[49]) suggests that at least some of the association reported here may be attributable to explanations beyond the concentration of other elements of disadvantage in these neighbourhoods.

The social drift explanation suggests that persons with poor mental health are more likely to move to neighbourhoods with poor quality built environments. The study is cross sectional so any association between predictors and outcomes cannot establish a temporal relation. However, we show an association between quality of the built environment and likelihood of depression independent of neighbourhood socioeconomic status. It is unlikely that social drift would manifest as persons with mental disorder moving to neighbourhoods with poor built environment, within strata of overall neighbourhood socioeconomic status. Also, the observed associations were independent of individual income. This suggests that conditional on income levels, persons with depression are more likely to be living in neighbourhoods with poor quality built environments. Again, it seems unlikely to expect that within income strata persons with depressive symptoms will be more likely to move to or remain in poor quality urban areas. Reverse causation, however, may be an explanation for these findings; people with depression may be less likely to pay attention to their usual activities, including taking care of the built environment in which they live.

We suggest that psychosocial stress, concentrated disadvantage, and social drift may all play a part in the relations reported in this analysis. The operation of one mechanism does not preclude the importance of another. Future studies should address the different and concurrent pathways through which characteristics of the urban built environment may influence mental health.

We assessed differences between the role of the external physical built environment and the internal built environment by individually testing several characteristics of each. Most of the published peer reviewed literature about the relation between the built environment and health has focused on characteristics of the external built environment.[20 50] Although we found more consistent associations between characteristics of the internal environment and depression than between characteristics of the external environment and depression, work in this area is limited and further research needs to clarify which characteristics of

What this paper adds

- Although the part cities play in shaping individual mental health has long been a subject of interest, there is little empiric work on the features of the urban built environment that may be associated with mental disorders.
- This study examined the associations between characteristics of the urban internal and external built environment and the likelihood of past six month and lifetime depression.
- Persons living in neighbourhoods characterised by poorer features of the built environment were 29%–58% more likely to report past six month depression and 36%–64% more likely to report lifetime depression than respondents living in neighbourhoods characterised by better features of the built environment.

the built environment may be associated with specific morbidities including mental health.

There were a number of limitations in this study. NYC is a uniquely dense and diverse city even at the comparatively small neighbourhood level used in this analysis. Also, this study was conducted to assess mental health problems in the aftermath of the September 11, 2001 terrorist attacks and as such the findings may be particular to this context. The comparability of our past six month and lifetime depression prevalences to US national estimates in other contexts[51] is reassuring that these results may be more broadly applicable to other cities at other times. Some residents were certainly living in other areas when they last experienced an episode of depression. Any misclassification attributable to this limitation would probably be non-differential as there is no reason to expect that, accounting for income, an earlier experience of depression would make someone substantially more likely to move into a more or less deteriorated neighbourhood. We used lay interviews to assess symptoms consistent with DSM-IV criteria for depression; such assessments cannot replace clinical studies that can use clinicians to diagnose psychopathology. Features of the built environment reported here are ecological characteristics of neighbourhoods and as such we cannot draw inference about potential relations between individual exposure to deterioration in one's own home and likelihood of depression. It is possible that our finding of an association between ecological measures of the quality of the built environment and individual depression is an underestimate of a relation between individual exposure to poor quality of one's own residence and likelihood of depression. We did not assess major depressive disorder. We used a validated lay instrument to assess major depression episodes but did not assess either manic or psychotic symptoms. We are therefore not assessing major depressive disorder and not precluding potential bipolar affective disorders. Further work using in-person interviews may better illuminate the relation between features of the urban built environment and specific psychopathologies. Finally, this work was not designed to assess mechanisms but was a first step toward assessing elements of the built environment that may be associated with depression. As such, we present here results of several models each of which considers the contribution of specific characteristics of the neighbourhood internal and external built environment. This is not intended to imply that these variables are all related, through a separate aetiological process, to depression. Rather, these variables are highly interrelated and it is probable that multiple characteristics of the built environment jointly influence depression. Further work needs to assess the joint contribution of multiple characteristics of the built environment and mental health. Such work may fruitfully consider non-linear features of the possible relations between characteristics of the neighbourhood built environment and mental health and also consider this question both prospectively and in studies designed to assess potential mediators of the observed associations.

CONCLUSION

This study showed that characteristics of the built environment are associated with likelihood of depression. This study adds to the growing literature that suggests the importance of the built environment in shaping health and behaviour. We suggest that this work is still preliminary and it is too early to use this evidence to advocate for better quality built environments as part of an effort to improve public mental health. However, the rapid pace of urbanisation globally,[1] and the potential part that the built environment may play in shaping health and behaviour[52] both call for increased collaboration between urban planners and public health professionals to better assess the relations between urban characteristics and mental health and to identify potential avenues for improving the health of urban populations.

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