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Disaggregated Mental Health Enhancing Features of the Urban Built Environment:
A Critical Interpretive Re-Consideration

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Abstract

A growing number of scientific research has linked the built environment to mental health and well-being, most use aggregated definitions of built environment measures that however do not lend themselves to comparison. The study conducted a critical interpretive synthesis of built environment constructs as used in studies that relate the built environment to mental health. The study focuses on street setting elements and relooks at these measures at the elemental level to present a disaggregated analysis of what is being measured within these constructs. The study presents a causal loop diagram to tease out the interactions between the elements to present an ecological perspective of the interaction between the elements and mental health. The objective of the study is through a critical interpretive synthesis to link the opportunities of enhancing mental health to the features of urban streets by generating a causal loop diagram. The study found that scale plays a key role in the conceptualization of constructs and recommends use of the most practical lowest scale to allow a multi scale analysis.

Keywords: Complete street, scale, modifiable areal unit problem, uncertain geographic context problem, parnachy

INTRODUCTION

Reviews that have been published addressing the mental health-urban built environment nexus reveal a mix of findings with some citing methodological and analytical differences in the studies. As the scope and depth of studies expands, so have the variables and constructs evolved in complexity and analytical frameworks. This study seeks to contribute to finding ways of clarifying these mixed findings by exploring the constructs of the built environment determinants of mental health that researchers have used in their studies. This study first explore the overarching frame works linking urban built environment to mental health, then consider the how the built environment has been conceptualized.

THEORY

Overarching Frame Works Linking Urban Built Environment to Mental Health

For David Halpern, the planned environment may affect mental health through four inter-related channels: 'by influencing social networks and support, being a source of stress, action of the planning process itself, and symbolic effects and social labelling played by architecture' (Halpern, 1995). He points out that 'to better predict health effects and mental health outcomes, more variance in the built environments being measured should be sought'. He also points out 'poor model specification (such as different aspects of the environment and context which may have opposing effects) being confused and compounded due to lack of guidance from theoretical models'.

Wandersman & Nation (1998) conceptual model at neighbourhood level which proposed the following: 'structural/ demographic characteristics (including percentage of residents living below the poverty line and ethnic distribution), neighbourhood disorder (presence of physical and social signs of neighbourhood decline) and environmental stress models that examine relationship between elements of the ambient and

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built environment'. They identified four classes of stressors: cataclysmic / catastrophic, stressful life events, daily hassles and ambient stressors, and socially toxic neighbourhoods. They propose neighbourhood interventions with a psychological orientation.

Marsella (1998) lists with examples four urban life determinants of mental health and social deviancy: 'Environmental (including air pollution, noise pollution, visual pollution, population density, traffic congestion, excessive stimulation etc.,); Sociological and economic (including: crime and violence, migration, poverty, unemployment, absence of community, marginalization etc.,), Psychosocial (including social structure, social drift, cultural confusion, social stress, acculturation / assimilation, rapid social change etc.,); and psychological (including quality of life, sense of coherence, powerlessness, alienation, fear, anxiety, isolation, loneliness etc.,)'. He further offers a five-level hierarchical system's model for urbanization-related stressors and interventions: the macro environmental, macrosocial, microsocial, psychosocial, and biopsychosocial. At the macro environmental level sampled dysfunctions included: population size, density, urban decay, crowding, excessive stimulation, and pollution; and possible interventions included: legislation, policy formation and urban planning (Marsella, 1998).

Evans (2003) dual direct and indirect pathways of the built environment effect on mental health is another framework captured in literature. In the direct domain characteristics such as housing (type & quality, neighbourhood quality), crowding, Institutional settings, lighting, indoor air quality, noise are correlated to mental health issues. The indirect pathways identify three psychosocial processes: personal control, social support and restoration. One of the methodological challenges he highlights is the inadequate exposure estimation which this study explores. He also highlights the embeddedness of built environment elements and highlights that the built environment may in this sense yield multiple adverse physical and social exposures that affect the mental health outcome more.

Wood & Giles-Corti (2008) framework focuses on the social domain to find how social capital, the built environment and mental health interact. They identify three relationship domains: between macro environmental trends (crime, violence, neighbourhood stability) and social capital; between aspects of the neighbourhood context or design (walkability, presence and adequacy of amenities/facilities) and social capital at the meso level, and neighbourhood attributes at the micro level (opportunities to: meet others, interact socially etc and neighbourhood quality: incivilities and disorder, access to nature and greenery, feeling of safety). McCay et al., (2017)mind the GAPS frame work has a positive outlook for mental health and seek opportunities to promote it. They propose: access to nature, prosocial places, safety and security, and physical activities in daily routines. GAPS is an acronym for Green, Active, Pro-social and Safe.

This study considered the overarching frameworks with which the urban built-environment-mental health research has been conducted. The study highlighted and unpacked the issues.

Perspective on the Definitions and Conceptualizations

Marsella (1998) notes that studies of the urban space - mental health nexus are multi-disciplinary which leads to multiplicity of definitions, concepts and methods. Some of the major issues highlighted in reviews include:

Objective and Subjective: Objective measures of the built environment directly measure the variables of interest, whereas subjective measures employ the perception of respondents towards variables of interest for measurement. Studies measure objective and subjective attributes of the built environment with the latter being called out for respondent bias Araya et al., (2006) , Gong et al., (2016). Objective measures may depend on standard instruments that have been validated and shown to be reliable. Where possible the employment of both measures is preferred because the experience of the built environment is subjective and nuanced to the individual.

Aggregated and Disaggregated: Research strategies may depend on measurements that may directly pick the built environment features as disaggregated attributes that are then used to develop constructs for analysis while other studies have relied on already aggregated data as a starting point for their analysis. For research to however

inform design practice the disaggregated features that are the elements used in urban design and architecture should be explicated to leverage the research outcome.

Compositional vs Contextual: the understanding that health is patterned by individual characteristics as well as area characteristics presents another methodological challenge faced by researchers, the reconciliation between compositional and contextual constructs. Compositional effects are those that are as a result of the different individual (disaggregated) level observations of the observed group. Contextual effect constructs are those collected at a higher level (aggregated) and considered to influence a lower level of observation after controlling for relevant confounders, for instance the effect of neighbourhood density on individual health.

Scale: The scale of the build environment is vast and poses significant measurement challenges. In attempting to make sense of this Oshan et al., (2022) captures three conceptualizations of spatial scale that can be leveraged in research: 'geographic scale representing the entire geographic area of interest, observation (measurement) scale that is the resolution of spatial units across an area of interest and process (operation) scale that is the scale at which a particular process operates'. Liu et al., (2020)a contends the reasons for which the urban health issues seem unsolvable include: 'the specialization of urban systems into superorganisms with preferred sustenance at the higher scale at the expense of the lower scales'; like Fleckney & Bentley (2021), they note 'the needs of capital being elevated above the citizens right to the city resulting in a shrinking, privatised and increasingly contested public realm'. They also note the difference in scaling effects between biological and the social networks resulting in mismatched adaptation and growth; and finally, they note institutional specialization which self-reinforces and dominates the urban agenda while reducing resilience. These observations highlight the significance of scale and resolution of studies of urban systems and the need to be conscious of how scale affects our interpretation of urban phenomena. Kwan (2012) highlights two scale related methodological problems affecting environment – health research nexus: the modifiable areal unit problem (MAUP) which is the different results that disaggregated measures lead to when using different aggregations units (areal units: such as administrative units or census tracts); and the Uncertain Geographic Context Problem (UGCoP) the truly causally relevant scale and resolution of the built environment and its attributes being unknown; this usually being the aim of research, can be mismatched resulting in misleading findings.

The process of interaction between the built environment and mental health: To enable an assessment of the constructs, this study adapt Bratman et al., (2019) four-step procedure from their nature experience conceptual model by which urban phenomena can be considered to affect mental health: first a definition and characterization of the urban features including diversity, spatial configuration, composition, size and type; second, a characterization of the amount of contact or exposure through an estimation of proximity usually through access/ availability metrics, frequency and /or duration of exposure; third, the exposure is then further specified through interaction patterns and/or dosage; finally, a characterization of the specific potential mental health benefit or dis benefit. Three beneficial pathways have been identified by Roberts et al., (2021): 'instoration by building capacities such as encouraging physical activity or social interaction, mitigation by reducing the harmful effects of the environment such as reducing noise or air pollution, and restoration by restoring capacities such as cognition'. The disbenefit pathway has been linked to the built environment through stressors, and as a barrier to social and physical activity benefits that lead to the onset or acceleration of mental health issues. The study leverage this procedure in our analysis of the psychometric properties of the built environment constructs and their measures.

Nordbø et al., (2018) has conducted a similar study with a bias for geographic information systems (GISs) measurable data that affects the adolescent age group. They identify seven main categories and 18 sub categories including measures of: 'population, built form, land use, road and street environment, facility and amenity, topography, neighbourhood green and open space, and composite measures. Another similar study is Fleckney & Bentley (2021) which also focuses on the adolescent age group but limits the functional scope of the built environment to the public

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realm. They identify four scales: city structure (national/ reginal/city scale), urban form (city neighbourhood scale), public realm (street scale) and private realm (home, work, private property). In this study our bias is toward the disaggregated elements and attributes of the built environment constructs, how and at what scale they have been measured and operationalised. The study also considered the face validity of the measures by employing Bratman et al. (2019) four part process of linking the physical environment to mental health. More specifically the aim of this review was to within the context of built environment -mental health nexus research: first identify the constructs of the external urban built environment, their measurements and instruments used; second explore the resolution of measurement i.e., scale at which the element or attributes are being measured; thirdly to describe their psychometric properties and evaluate their applicability and feasibility for use in practice and research.

RESEARCH METHODS

Search Strategy

The study searched databases whose coverage would collectively present peer reviewed articles with a wide spectrum of interdisciplinary topics that are accessible and hence platforms that offer open-access articles. The search was conducted between December 2022- March 2023 on websites: MEDLINE, PsycINFO, PubMed, emerald insight, frontiers, BMC, MDPI. More references were also sourced from bibliographic reference sections of retrieved papers. The search strategy was the snow balling effect. Keywords used for the search were identified from an initial review of relevant articles and included the following combination of key words: "urban design" OR "street*" OR "neighbourhood" OR "neighbourhood" OR "urban*" OR "precinct" AND "mental health" OR "positive mental health" OR "mental wellbeing" OR "flourishing". Initially the search was restricted to articles that have positively conceptualized mental health, but this criterion was removed as most studies relevant to the subject had the negative conceptualization of mental health.

Inclusion and Exclusion Criteria

Studies included in the review were those that measured a construct of the urban built environment (natural systems by the virtue of being managed by humans are included in the built environment) and associated to an outcome of a construct of mental health in both its positive and negative conceptualizations. The article should have used empirical data to report analysis of mental health outcomes in relation to an urban built environment characteristic; articles have been included even if this relationship was not the primary aim of the study. The language of publication had to be in English, while the publication was in a peer reviewed journal. Articles that were accessed and reviewed were published between 2002 -2022. Some articles that may have been included in the review were left out due to limitation in access.

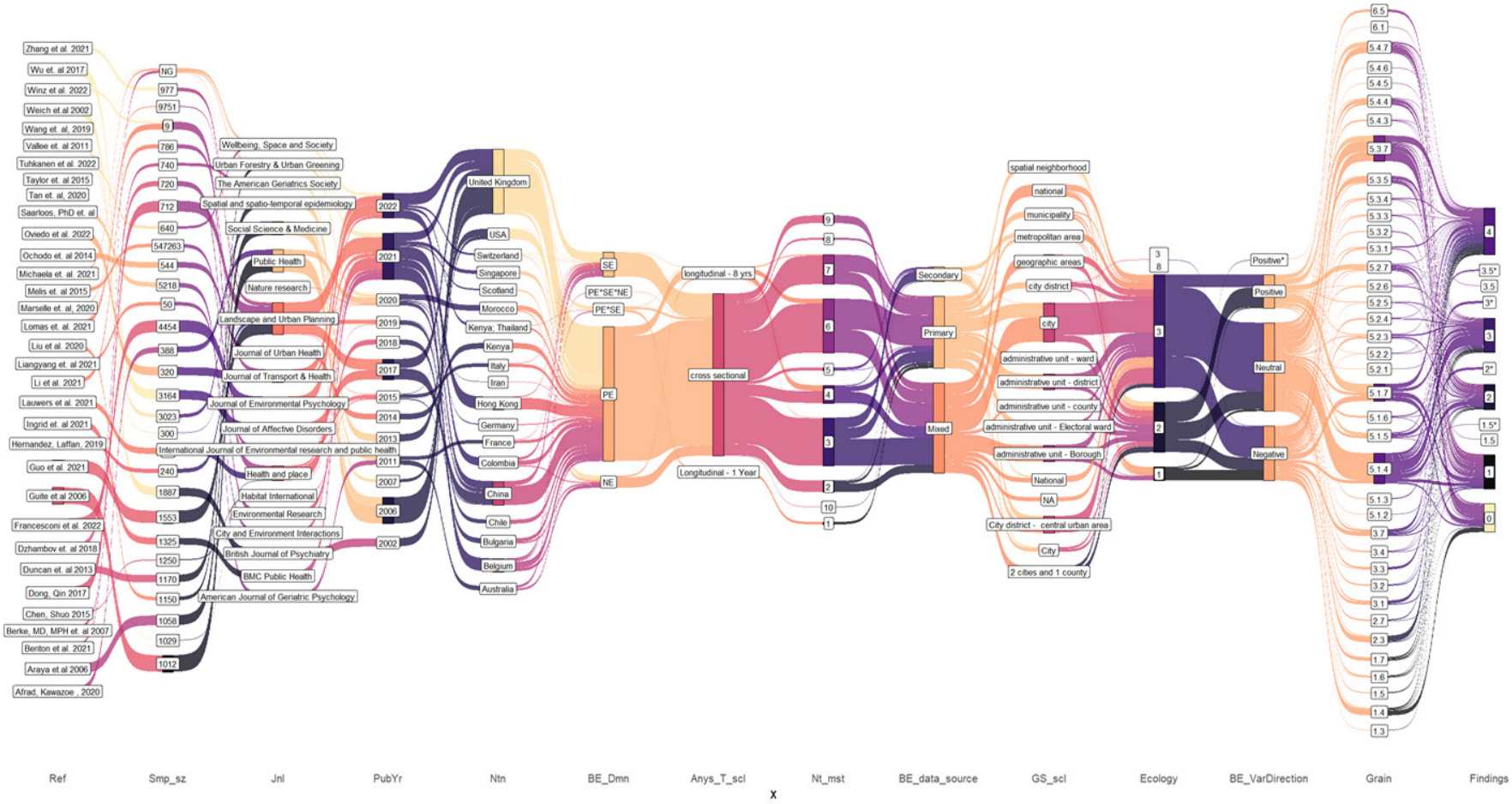
Data Extraction and Quality Assessment

Clarity of the built environment constructs used in these studies is sought and their face validity (whether they accurately and completely capture the concept being measured) is considered. Validity is checked by assessing the tools used to measure the constructs, the scale at which it is observed and operationalized to associate it with a mental health construct. The study considered the scales adapted for measuring the urban built environment, whether it was measured as an objective or subjective variable, whether it was employed in its aggregated or dis aggregated form and whether its effect had been considered as a compositional or contextual variable.

RESULTS

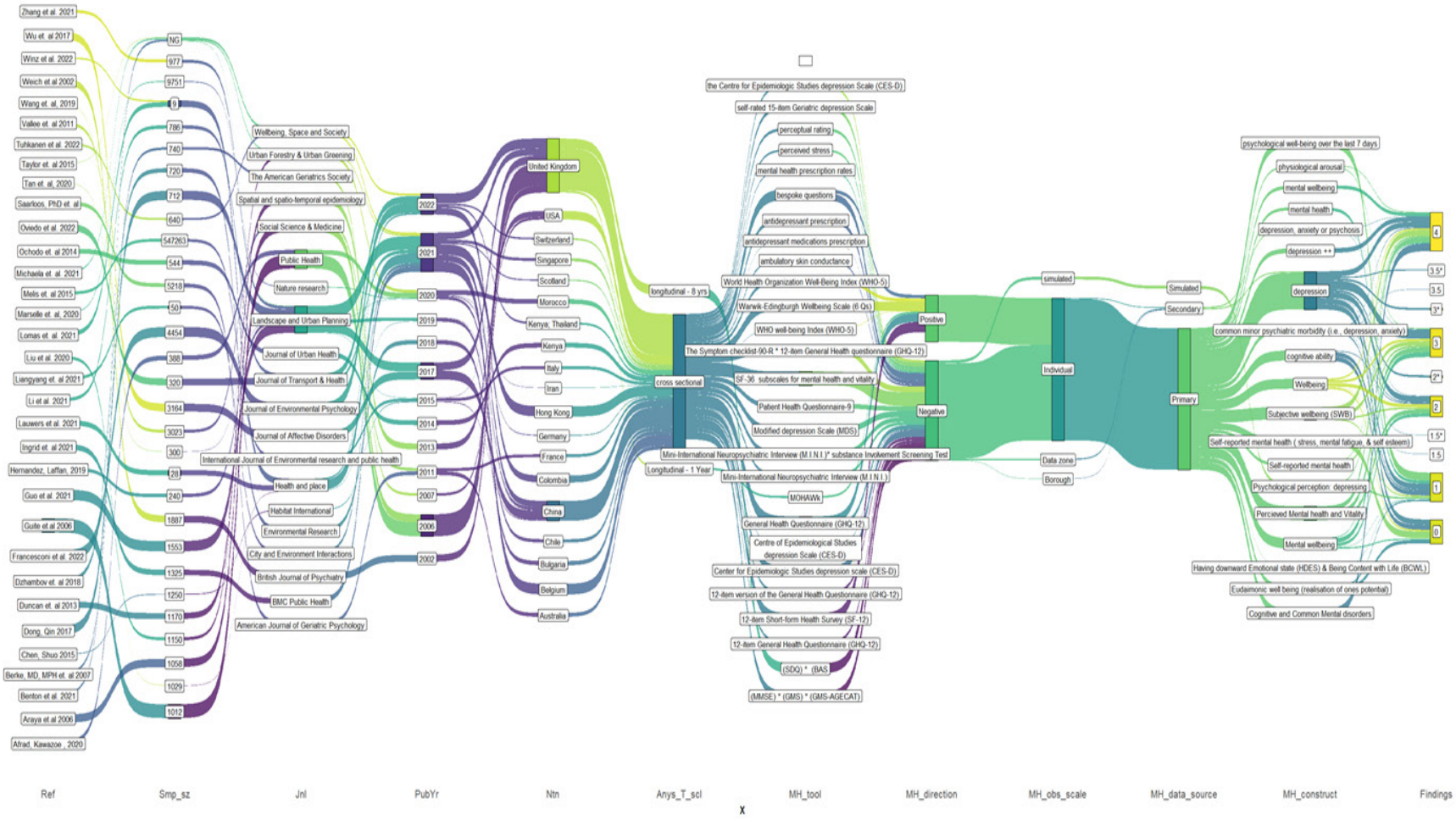
Summary of Included Studies

Screening was first done at title and abstract level, then full text review of those that met the inclusion criteria. Those found to be relevant were fully reviewed extracting their list of variables on a spread sheet). A total of 33 met the inclusion criteria after being reviewed fully, **Figure 1** and **Figure 2** . Relevant articles were published across 21 journals with the most from Landscape and Urban Planning (6), followed by Health and Place (5), then Wellbeing, Space and Society had 3, while Urban Forestry & Urban Greening, Social Science and Medicine, Public Health, Journal of Urban Health, Journal of Transport & Health, and International Journal of Environmental research and public health had 2, the rest had one publication each. Most studies in the review were conducted in the United Kingdom (8), China (6), USA (3), Belgium (2), Australia, Brazil, Bulgaria, Canada, Chile, Columbia, France, Germany,



Key: (Ref – Reference; Smp_sz -Sample size; Jnl – Journal; Ntn – Nation of study; BE_Dmn – Built Environment Domain; Anys_T_scl – Analysis time scale; Nt_mst – Nature of measurement (Table II), BE_data_source – Built environment Data Source; GS_scl – Geographic scale, Ecology- Brofenbreiners ecological scale; BE_VarDirection - Built Environment direction of measurement; Grain – Built environment grain (Table III); Findings – for (Findings Table IV),

FIGURE 1
Sankey diagram showing the flow of the independent variables
Source: Field survey, 2024



Key: (Ref – (Ref – Reference; Smp_sz -Sample size; Jnl – Journal; Ntn – Nation of study; PubYr – Year of publication; Anys_T_scl – Analysis time scale; MH_tool – tool for measuring mental health, MH_direction – direction of mental health construct; MH_obs_scl – Mental health observation scale, MH_data_source – Mental Health data source; MH_construct – Mental Health construct; Findings – (for Findings Table IV)

FIGURE 2
Sankey diagram showing the flow of the independent variables
Source: Field survey, 2024

Hong Kong, Iran, Italy, Kenya, Morocco, Scotland, Singapore, Switzerland had 1 each, one study was conducted across nations in Thailand and Kenya. Number of respondents is wide ranging from over 500,000 respondents, Melis et al., (2015) where n=547,263) to as low as 9, Lomas et al., (2021)); this is countered with the depth of detail being covered in the studies with higher number of respondents having less items to respond to. 6 studies are not clear about the sample size, use of machine learning blurs the sample for instance: Dai et al., (2021)uses a fully convolutional network to capture six psychological perceptions with 50 human volunteers and a computer algorithm using human-machine adversarial method, and used street view images blurring the notion of sample. Only two studies were longitudinal all others were cross-sectional studies.

Study Design

Two studies Lomas et al., (2021) and Lauwers et al., (2021) used a qualitative approach to their research, the rest used a quantitative approach. Numerous statistical approaches were used to confirm the association between the variables including: least square regression, binary logistic regression, multi variable logistic regression, structural model analysis, structural equation modelling among others. Confounders adjusted for included individual level (age, gender, education, marital status) and contextual area level features (level of crime, level of deprivation etc).

The built environment data collection methods adopted in the included studies

A variety of data collection methods were used to collect data related to the urban built environment constructs in the studies, **Figure 1** shows a Sankey diagram of the flow of the independent variables: from capturing the data first hand by spatial audits through consolidation and cleaning of secondary data sources to employing machine-human adversarial networks to parse through online sourced data. Following Collins et al., (2020), the study first coded the nature of the measurement into 10 categories, which considered the approach to the exposure to the built environment elements (**Table 1**).

Definition and characterization of the urban built environment features (psychometric properties)

To unpack the built environment constructs the study first adapted a spatial unit based scaling system as developed by Fleischmann et al., (2020) by taking the grain as the extent; indices were conceptualized as measurements of sub elements within the grain which allowed for comparison between the studies based on scale. **Table 2** shows the granular extents adapted, the metric categories and example indices of this extent; the last two columns report on review findings. Spatial elements that can be meaningfully defined within these extents are considered to be of appropriate resolution. The study also distinguished between the physical environment (PE) as artifacts in urban space (trees and vegetation cover were included here because they were conceptualised as land use); the natural environment (NE) including ambient conditions of air, soundscape, water and earth; and the social environment (SE) human behaviours which studies have shown to be related to the built environment such as incivilities, crime social interactions etc.

A variety of strategies were used to quantify the urban built environment constructs, **Table I** summarizes the nature of measurements identified in the review.

Appraisals generally generate subjective data when users are the source of data, while standardized instruments generate objective data from appraisals. This review captured 4 number standardized instruments: Built Environment Site Survey Checklist (BESSC), Residential Environment Assessment Tool (REAT), Method for Observing pHysical Activity and Wellbeing (MOHAWk), Neighbourhood Environment Walkability Scale-Abbreviated (NEWS-A).

The non-concordance between perceived and objective measures of the built environment are captured in literature Gebel et al., (2009) thus employing both objective and subjective data types is recommended. In this review only 5 studies used both data types in their measurement of the built environment. The new development of using supervised machine learning to classify potential perceptions creates another category that does not fit neatly in either category; the review identified two such studies. Other studies developed their own measures from previous studies to create a questionnaire relevant to their aims and objectives. Most studies approached the exposure to the built environment from a space consumption

TABLE 1
Codes for the nature of measurement of the built environment constructs

Code	Category	**Definition:** Studies that measure	Variables identified	%
1	Intervention studies	User appraisal before a change in the built environment, and/or the change itself and the appraisal of the change after intervention	5	1.5%
2	Exposure (proximity) studies	Distance to a specified built environment element(s)	22	6.4%
3	Exposure (quantity) studies	Available amount within a specified field of a specified built environment element(s) within defined areas	93	27.3%
4	Exposure(quality) studies	Relevant micro- features of a specified built environment element(s)	34	10%
5	Mediated and or moderated exposure: studies that measured second level exposure; the interactions between the effects of built environment elements on a phenomenon that affects the mental health outcome	a. Internal Mediated and or moderated exposure – interaction between the built environment and users' cognitive, affective and psychological states and process and thus affecting mental health: like way finding in cognition – environment interaction; tranquillity in affect-environment interaction	6	1.7%
		b. External Mediated and or moderated exposure (contextual factors) – interaction between the built environment and users' social, economic environment and thus affecting mental health – social mediation/moderation social support/ community cohesion/ social networks on mental health		
6	Qualitative appraisal	Users' perception of their experience of the built environment elements	104	30.5%
7	Outcome of interaction (user experience)	(objectively) user behaviour in the built environment element being studied e.g., amount of social interaction	57	16.7%
8	Real time exposure	Responses while physically located in the study spaces using instruments attached to capture respondent physiological responses or using a structured questionnaire to capture their responses	4	1.2%
9	Simulated affect	Through the virtual interface, human responses and /or use machine learning (with human supervision) to predict affective responses to existing representations or edited / prospective interventions of places	15	4.4%
10	Exposure (frequency) studies	Frequency of interaction with a specified built environment element(s)	1	0.3%

Source: Field survey, 2024

TABLE 2
Granular extent, category and indices used for analysis

Grain /scale as extent	Category	Indices	Variables identified	%
Building (1)	Amount/ level / Dimension (1.1)	Height, width	0	0%
	Shape (1.2)	Non-rectangular shaped buildings	0	0%
	Spatial distribution (1.3)	Number of openings, number of floors	1	0.29%
	Intensity /concentration (1.4)	Number of residential units per building	14	4.11%
	Connectivity (1.5)	Number of through paths, Visual permeability,	2	0.59%
	Typology &/ Diversity (1.6)	Land use type (mixed use developments)	4	1.17%
	State /duration / (1.7)	Age, Quality of materials	7	2.05%
Lot/plot (2)	Dimension (2.1)		0	0%
	Shape (2.2)		0	0%
	Spatial distribution (2.3)	Number of trees in front garden	13	3.81%
	Intensity (2.4)		0	0%
	Connectivity (2.5)		0	0%
	Typology &/Diversity (2.6)		0	0%
	State (2.7)	Nature of space immediately outside front door	3	0.88%
Street (3)	Dimension (3.1)	Width, number of lanes, width of pedestrian walkway	8	2.35%
	Shape (3.2)	Linearity /curvatiousness	3	0.88%
	Spatial distribution (3.3)	Linear street tree density	5	1.47%
	Intensity (3.4)	Vegetation Canopy Index	3	0.88%
	Connectivity (3.5)	Node presence and type	0	0%
	Diversity (3.6)	Front type	0	0%
	State (3.7)	Presence & working condition of traffic calming features	13	3.81%
Block (4)	Dimension (4.1)		0	0%
	Shape (4.2)		0	0%
	Spatial distribution (4.3)	Available Land use types, number of structured green spaces	0	0%
	Intensity (4.4)	Residential density, vegetation cover, Count of empty lots per block, Average storey height per block	0	0%
	Connectivity (4.5)	Number of accessible alleys	0	0%
	Diversity (4.6)		0	0%
	State (4.7)		0	0%

Grain /scale as extent	Category	Indices	Variables identified	%
Neighbourhood (spatial neighbourhood 5.1.*, functional neighbourhood 5.2.*, social neighbourhood 5.3.*, administrative unit 5.4.*, undefined 5.5.*)	Dimension (*.1) [5.1.1,5.2.1, 5.3.1, 5.4.1, 5.5.1]	Height of neighbourhood housing	0, 1, 5, 0, 0	0%, 0.29%, 1.47%, 0%, 0%
	Shape (*.2) [5.1.2,5.2.2, 5.3.2, 5.4.2, 5.5.2]		1, 2, 2, 0, 0	0.29%, 0.59%, 0.59%, 0%, 0%
	Spatial distribution *.3) [5.1.3,5.2.3, 5.3.3, 5.4.3, 5.5.3]	Number	2, 8, 3, 3, 0	0.59%, 2.35%, 0.88%, 0.88%, 0%
	Intensity (*.4) [5.1.4,5.2.4, 5.3.4, 5.4.4, 5.5.4]	Population density at block level (residents per block)	59, 3, 4, 13, 0	17.3%, 0.88%, 1.17%, 3.81%, 0%
	Connectivity (*.5) [5.1.5,5.2.5, 5.3.5, 5.4.5, 5.5.5]	Recreational facilities accessibility, Street network metrics: intersection density	11, 3, 14, 1, 0	3.23%, 0.88%, 4.11%, 0.29%, 0%
	Typology &/Diversity (*.6) [5.1.6, 5.2.6, 5.3.6, 5.4.6, 5.5.6]	Land use entropy / Land use mix	4, 3, 0, 1, 0	1.17%, 0.88%, 0%, 0.29%, 0%
	State (*.7) [5.1.7, 5.2.7, 5.3.7, 5.4.7, 5.5.7]		33, 13, 49, 21, 0	9.68%, 3.81%, 14.37%, 6.16%, 0%
Walkable distance (5/10 minutes) / District (6)	Dimension (6.1)		1	0.29%
	Shape (6.2)		0	0%
	Spatial distribution (6.3)		0	0%
	Intensity (6.4)		0	0%
	Connectivity (6.5)	Availability of urban service (public transport)	5	1.47%
	Diversity (6.6)		0	0%
	State (6.7)		0	0%
City (7)	Dimension (7.1)		0	0%
	Shape (7.2)		0	0%
	Spatial distribution (7.3)		0	0%
	Intensity (7.4)		0	0%
	Connectivity (7.5)		0	0%
	Diversity (7.6)		0	0%
	State (7.7)		0	0%
Urban area (8)	Dimension (8.1)		0	0%
	Shape (8.2)		0	0%
	Spatial distribution (8.3)		0	0%
	Intensity (8.4)		0	0%
	Connectivity (8.5)		0	0%
	Diversity (8.6)		0	0%
	State (8.7)		0	0%

Grain /scale as extent	Category	Indices	Variables identified	%
Metropolitan area (9)	Dimension (9.1)		0	0%
	Shape (9.2)		0	0%
	Spatial distribution (9.3)		0	0%
	Intensity (9.4)		0	0%
	Connectivity (9.5)		0	0%
	Diversity (9.6)		0	0%
	State (9.7)		0	0%

Source: Field survey, 2024

perspective, the space production perspective was rarely considered. One such exception is identified in this review where territoriality and stewardship have been explored by Afrad & Kawazoe (2020) and they sought to find the associated mental health outcome of producing this urban space. The unfortunate outcome is the association of this process with depression.

The review takes note of the variations in scale especially for the observation and operation scales. The geographic scale remained stable with most studies taking a city (13) or a city district or sub city area (10) as their geographic scope, 4 studies took the metropolitan region while 3 took the national scale. One study Tuhkanen et al., (2022), compares data across two second order cities in two nations. For the observation scale, most studies aimed to capture exposure to the built environment at the individual level, the extents adapted while egocentric were however diverse with different buffers being used from as low as 100m around the users geocoded residence to as far as 2km buffer around data zone border. In some cases, the observation scale could not be determined because the use of simulated affect does not readily lend itself to such analysis. In two studies Taylor et al. (2015) and Roberts et al. (2021) the resolution at which the secondary data for mental health was available dictated to scale at which the built environment had to be observed. For the operation scale we find a lot of cross scale analysis largely because of contextual variables. Some covariates had a contextual variable that is measured within a larger area to be meaningful (usually an administrative unit such as census collection district, or ward) making most of the analysis with such covariates cross scale. The study also found a similar mismatch between the built environment constructs whose measure can only be meaningful at a large spatial extent such a sanctuary and will be matched against the individually measured mental health.

The spatial configuration of these built environment constructs has not been explored in any of the studies reviewed; thus, the contribution of the micro patterns of the built environment elements to mental health may be a gap that researchers could include in future studies. Most studies have assumed a homogenous spread of the built environment element in their observation scale; graffiti for instance may be on specific buildings within a postal address and users deliberately avoid these buildings taking longer routes to navigate the city.

Characterization of the amount of contact or exposure, interaction patterns and/or dosage (psychometric features)

Few studies are explicit about exposure and implicitly, proximity is proposed through access and availability. Only two studies make reference to frequency and duration of exposure: Afrad & Kawazoe (2020), explored frequency and duration of exposure in detail and Vallee et al., (2011) who creates a category for frequency of interaction within a specified area. The review suggests that this may be a gap that future studies may explore to further disentangle the effect of the built environment

Characterization of the specific potential mental health benefit or dis benefit.

Mental health has mainly been characterized in the negative perspective with depression as the most com-mon indicator (**Figure 2**). The sample suggest mainly objective measures including

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standardized instruments (General health questionnaire (GHQ-12)) and secondary records such as medical prescriptions. Two studies Lomas et al., (2021) and Oviedo et al., (2022) used bespoke instruments to measure negatively conceptualized mental health; the former used a qualitative research approach whereas the latter used a mixed approach. Gong et al., (2016) points to the importance of using objective measures to capture mental health measures given the risk of same source bias. On the positive conceptualization end, well-being was the most common construct with the WHO Well-Being Index (WHO-5) as the most common measuring instrument. 4 studies have measures for both mental illness and positive mental health: for instance Guo et al., (2021) used Mental Component Summary (MCS) scale of the 12-item Short-form Health Survey (SF-12) and also measured subjec-tive well-being with questions on life satisfaction and happiness. Studies may set out on a positive mental health perspective and end up capturing the negative for instance Lomas et al., (2021) takes the positive men-tal health construct of mental well-being but findings reveal a negative perspective that reveal the sense of lack of control , source of anxiety and stress and lack agency or autonomy in participating in urban processes that directly affect the users. Studies like Navarrete-Hernandez & Laffan (2019), are prospective in their ap-proach of engaging potential users to the planning options of potential interventions to real world locations. There is consistency in the observation scale of measuring mental health constructs as only one study, Taylor et al., (2015), used borough rates of antidepressant prescriptions per 1000 population. Operation scale reveal a cross-scale analysis in understanding the associations between the built environment and mental health.

DISCUSSION

This review examined the association between the built environment constructs and constructs of mental health. The study specifically considered the disaggregated built environment elements being measured, the scale and resolution at which they were measured and operationalised to consider their effect on constructs of mental health. This is occasioned by the mixed results researchers are reporting and this study sought to understand the contribution of scale and conceptualization to these results. The results suggest that indeed there are built environment effects on mental health, but they are specific to scale, age group and mental health construct, echoing Berke, MD, MPH et al., (2007)contention. This therefore suggests the need to adapt the most efficient and practical small scale that captures detail that can later be smoothed out when scales are escalated. This strategy has the cost implications with more detail requiring first hand audits Wu et al., (2017).

Constructs of the urban built environment, their measurement and instruments used

The study extracted a total of 341 built environment constructs from the 33 studies sampled. Of the 341 constructs, 156 had statistically significant correlations to mental health with 90 being positively correlated while 66 be-ing negatively correlated; **Figure 4** shows the distribution between the statically significant correlation, men-tal health construct direction and built environment grain. The study noted an even distribution between positive and negative mental health constructs. Neutral built environment construct represents the majority. **Figure 7** shows statically significance positive correlation, the study found that mental health has mainly been negatively con-structed, few variables have both positive constructs of mental health, built environment and a virtuous cor-relation. The PE domain had 75 constructs among positively correlated, and 47 among the negatively corre-lated; the SE had 17 constructs among the positively correlated and 7 among the negatively correlated. It is noteworthy that for the natural environment only states of the air and soundscape as built environment ef-fects on mental health were identified in the review, suggesting a gap in how the state of water and earth contribute to mental health. Whereas SE has been linked to mental health and studies in this review were able to echo this association, the connection between SE and the bult environment is only beginning to be explored; features of the built environment that contributed to the social environments' effects have not been fully explored only 10(2.9%) constructs were extracted of which 5 had statistically significant correlations.

The study explored the nature of measurements used for the constructs of which ten categories were identified (**Table 1**); qualitative appraisal (30.5%) was the most common nature of measurement employed among the studies sampled. The built environment was further partitioned to

granular extents (**Table 3**) to allow for res-olution considerations in the observation scale as metric categories to allow for comparison between studies. The grain used most was neighbourhood unit with category state having overall grain dominance at 34%; for specific category, the spatial neighbourhood unit grain with intensity category topped with 17%. **Table 2** shows the categories, and findings; **Figure 3, Figure 4, Figure 5, Figure 6** and **Figure 7** show the co-occurrence between findings, positive or negative constructs for both mental health and built environment and the grain, and category of constructs.

The resolution of measurement i.e., scale at which the element or attributes are being measured

Gong et al., (2016) note the ambiguity around the neighbourhood level scale; while used extensively this re-view notes that it is not clearly articulated across the studies. This study notes the continued multiplicity of neighbourhood bounds: while some studies use it as a perceived area within respondents perspective Guite et al., (2006), others define it as representing a housing cluster of an income group Ochodo et al. (2014) others leverage administrative or official data collection units like census blocks Saarloos et al., (2011), others create a bespoke neighbourhood or circular buffer centred on respondent residential house geocode. The block as a spatial grain did not have any constructs attached to it possibly because it may have been identified as a neighbourhood. Perhaps a characterization of the physical extent of each of these constructs will make the neighbourhood construct clearer; Dzhambov et al. (2018) for instance defines it as 10-15minute walking dis-tance around residential address, whereas Roberts et al., (2021) uses a data zone defined by census data col-lection unit. For clarity, the review generated 4 neighbourhood constructs: spatial neighbourhood, which re-fers to studies that define a distance from datum like the respondent home (5.1.*); functional neighbourhood which refers to the area within which services (cultural, financial, ecological etc) are gleaned by respondents in the urban built environment (5.2.*); social neighbourhood which refers to respondents perception of what they deem as their neighbourhood (5.3.*), neighbourhood as an administrative unit (5.4.*) and finally neigh-bourhoods that are not clearly defined (5.5.*). Scale is condensed when a variable is subjective for instance Yigitcanlar et al., (2020) in using respondent park experience to measure a park brings together all conceptu-alizable scales of the park into this response.

TABLE 3
Categories of findings identified in the review

Finding	Code
Statistically significant Positive correlation between dependent and independent variable	4
Statistically significant on some social groups (age, sex, social economic, ethnic) Positive correlation between dependent and independent **composite/latent** variable	3.5*
Statistically significant on some social groups (age, sex, social economic, ethnic) positive correlation between dependent and independent variable	3.5
Positive correlation between dependent and independent **composite/latent** variable	3*
Positive correlation between dependent and independent variable	3
Negative correlation between dependent and independent variable	2
Negative correlation between dependent and independent **composite/latent** variable	2*
Statistically significant on some social groups (age, sex, social economic, ethnic) **Negative** correlation between dependent and independent variable	1.5
Statistically significant on some social groups (age, sex, social economic, ethnic) **Negative** correlation between dependent and independent **composite/latent** variable	1.5*
Statistically significant Negative correlation between dependent and independent variable	1
Variable was indicated as measured but correlation not given	0

Source: Field survey, 2024

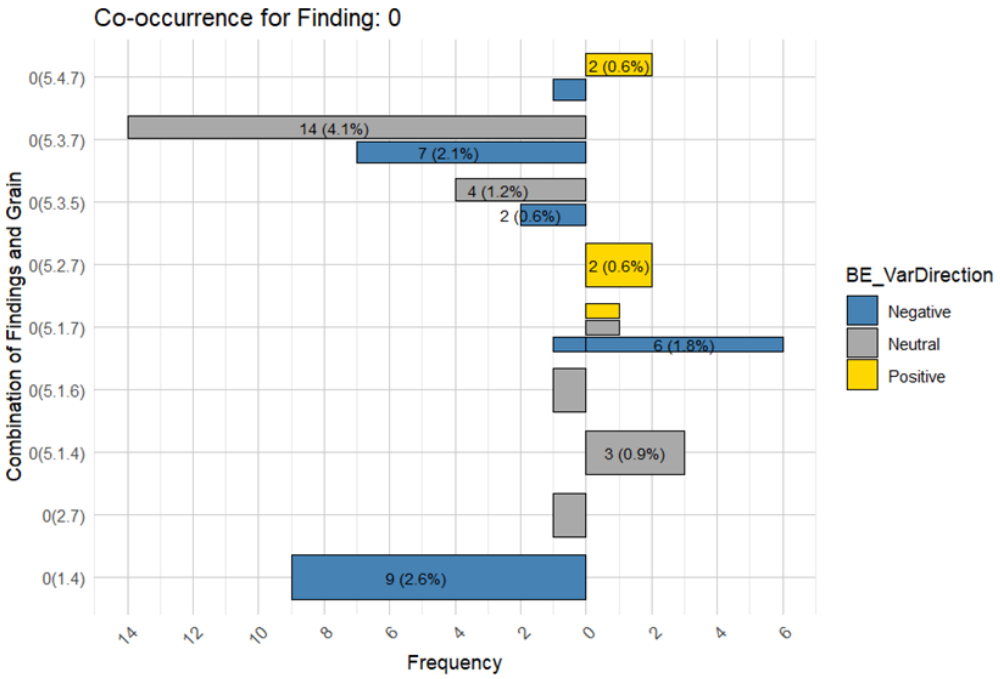

FIGURE 3
Co-occurrence between no report of findings, negative or positive conceptualization of mental health or built environment constructs and grain
Source: Field survey, 2024

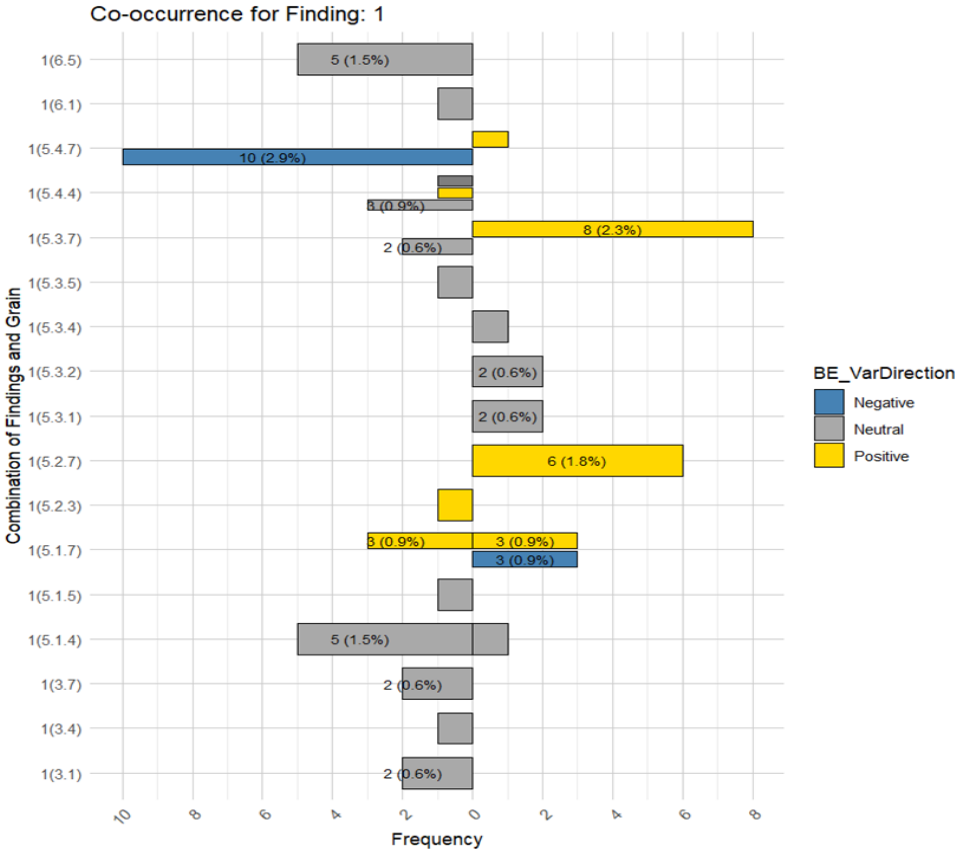

FIGURE 4
Co-occurrence between statistically significant negative correlation relationship, negative or positive conceptualization of mental health or built environment constructs and grain
Source: Field survey, 2024

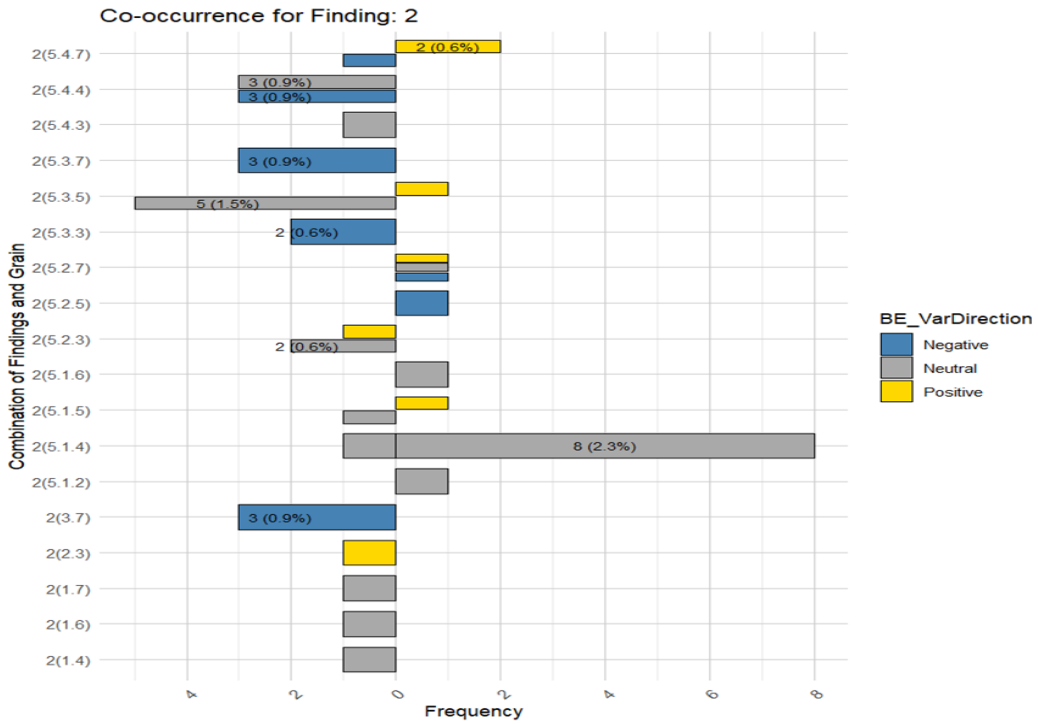

FIGURE 5
Co-occurrence between report of a non-significant negative correlation between, negative or positive conceptualization of mental health or built environment constructs and grain
Source: Field survey, 2024

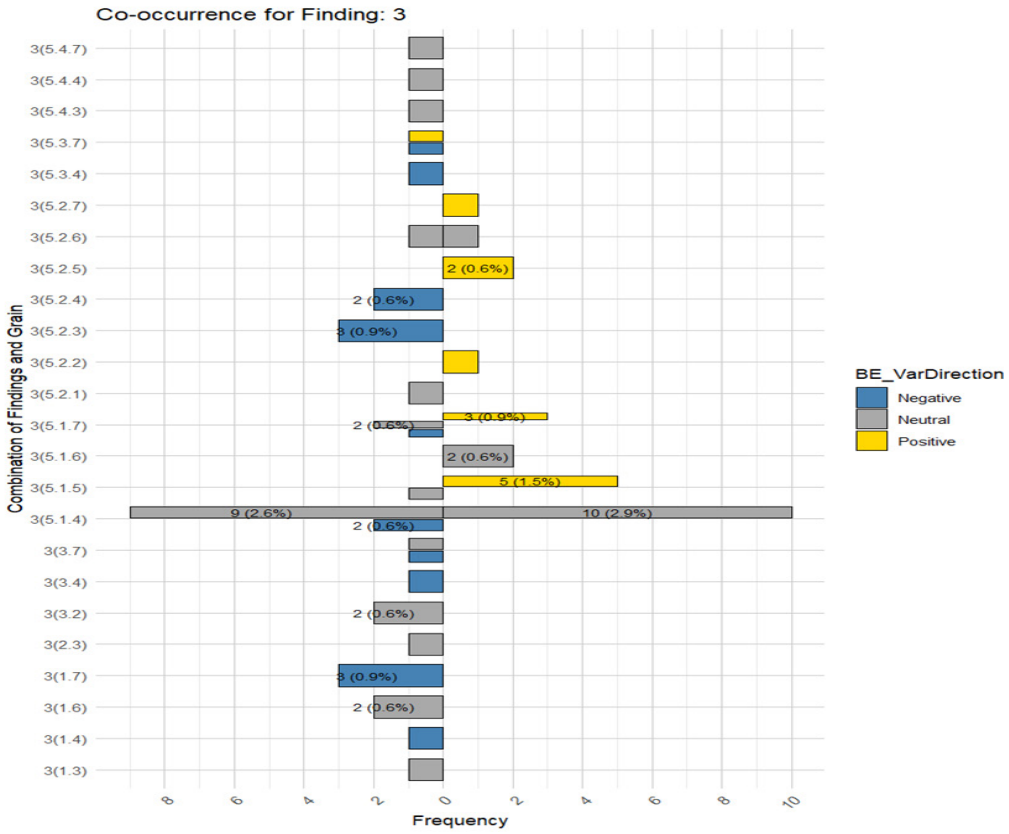

FIGURE 6
Co-occurrence between non-significant positive correlation between negative or positive conceptu-al-ization of mental health or built environment constructs and grain
Source: Field survey, 2024

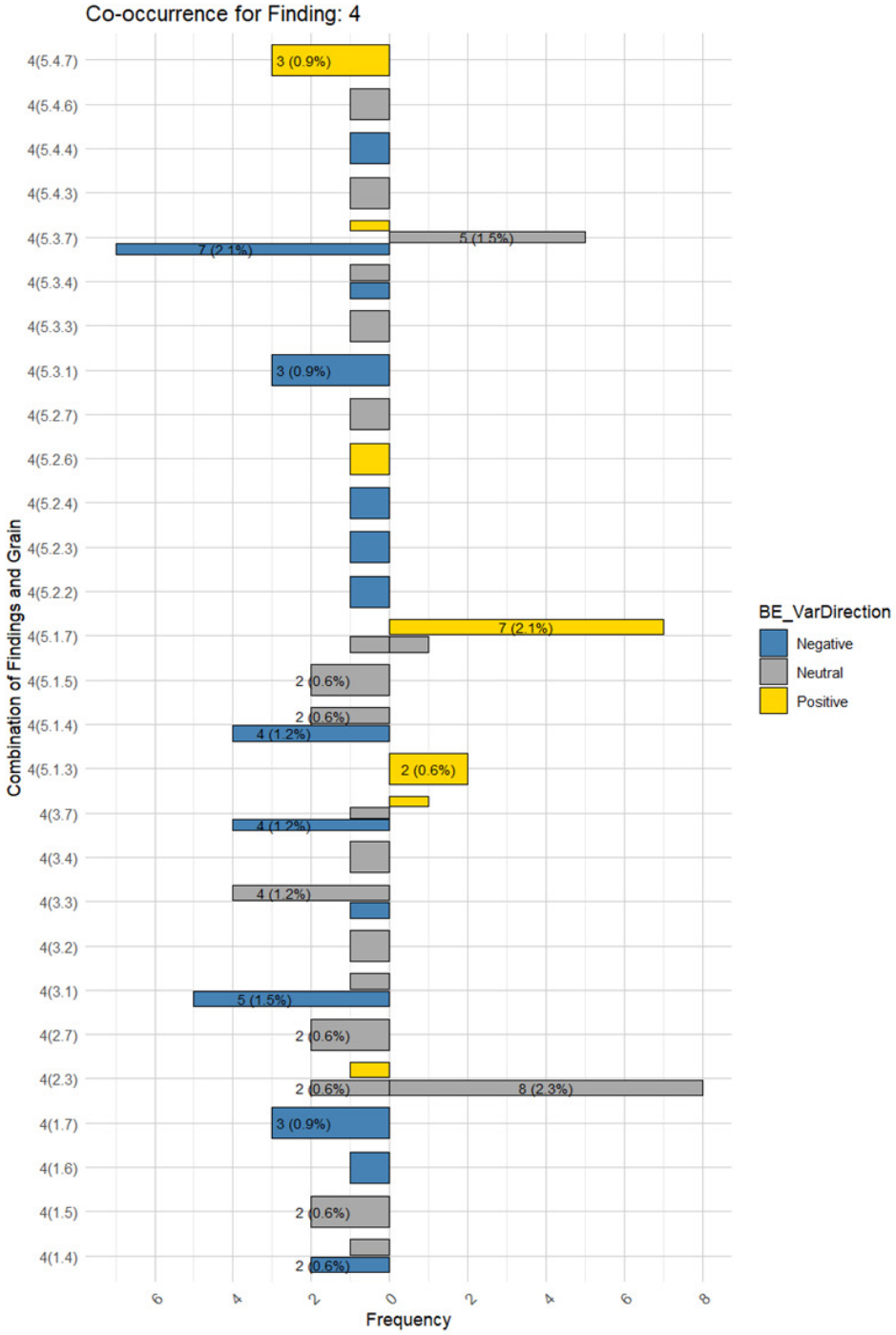

FIGURE 7
Co-occurrence between statistically significant positive correlation between negative or positive con-ceptualization of mental health or built environment constructs and grain
Source: Field survey, 2024

The study also notes the scale at which contextual variables have been employed, given that these are mostly cross scale variables the scale at which they are availed; for instance, crime rates only become meaningful at a certain scale. Studies could also explore configurations of these constructs to reveal occurrence patterns that may help clarify the effect of the phenomena and exposure. This study took note that very few constructs were identified at grain 10 and beyond (**Table 2**), this may be explained by the bias in the sample for individual level measurement of mental health

constructs.

Description of psychometric properties and evaluation of applicability and feasibility for use in practice and research: Smith, Crooks (2010) note the trade-offs between the level of detail achievable when the geograph-ic scale of study is expansive. Roberts et al., (2021)highlight the need to match scale of research to the differ-ent policy and funding decision making levels to be effective; the endeavour to improve policy decisions, may therefore cause a gravitation to a specific scale.

This, however, becomes problematic when MUAP and UGCoP are critical to study design and do not correlate to policy boundaries. The complexity of choice scale is further made evident by Berke et al. (2007) contention that the area effect is not universally singular but appears to be specific to some population groups, some area types and some health outcomes. Studies like Afrad & Kawazoe (2020)which take on a very high resolution pick micro details which include the dosage of exposure, but have geographic scale limits of extent considering the amount of work involved in gathering the data. On the other hand studies like Roberts et al., (2021) whose geographic scale is national and is using secondary data does not go into detail and captures the exposure quantitative category of measurement.

The scale at which decisions about urban life are made therefore play a role in deciding an exploratory scale; Lomas et al., (2021) highlight the distinction between autonomy and choice. Given that the planning process has been implicated in the mental health process, this review takes note of the continuation of the urban formation processes beyond the formal project phase. In highlighting the condition for those who attempt to create urban places Afrad & Kawazoe (2020) also showcases that everyday decisions are part of the urban process and have implications for health. Meaningfulness and sense of community are created through partic-ipation in these processes, how urban planners and designers allow for personalization by the users becomes an important built environment feature to be considered, territorial opportunities could be used to enhance a sense of control.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the study tease out a causal loop diagram (**Figure 8**) based on the review findings, while this attempts to summarize the structure of the human-built environment-mental health nexus it by no means exhausts the varied interactions and outcomes. The study proposes an interactive framework that reveals the interactions between PE, NE, SE, agency and human behaviour in relation to mental health (**Table 4**). It highlights the influence of the built environment on modal choice and therefore effect on the natural environment through air quality. The study also see the influence of the built environment on the social environment which impinges on place attachment. All loops relate to instoration, mitigation and restoration that have been shown to be the mechanisms through which mental health is positively af-fected by the built environment, negative effects of stress and mitigation are implied by the vicious feedback loops. In considering scale and resolution the study found modal choice decisions can only be mean-ingfully explored through a macro scale consideration proposing a panarchical perspective for under-standing these relationships. As the study moved toward mental health in causal lop diagram, micro features begun dominating the viable built environment measures largely because of the individual level consid-eration of mental health, this therefore concludes a panarchical relationship when the study operationalise the different scales. The study therefore recommends an understanding of scale, and a leveraging of the most practically measurable small scale to allow for building up and relating to larger scales. To further clarify the outcomes, multi group analysis be conducted to expose non-homogenous effects with respect to respondents' circumstances beyond physical exposure. The dosage proposed by Brat-man has scarcely been leveraged to reveal how frequency or level of interaction affects mental health outcomes.

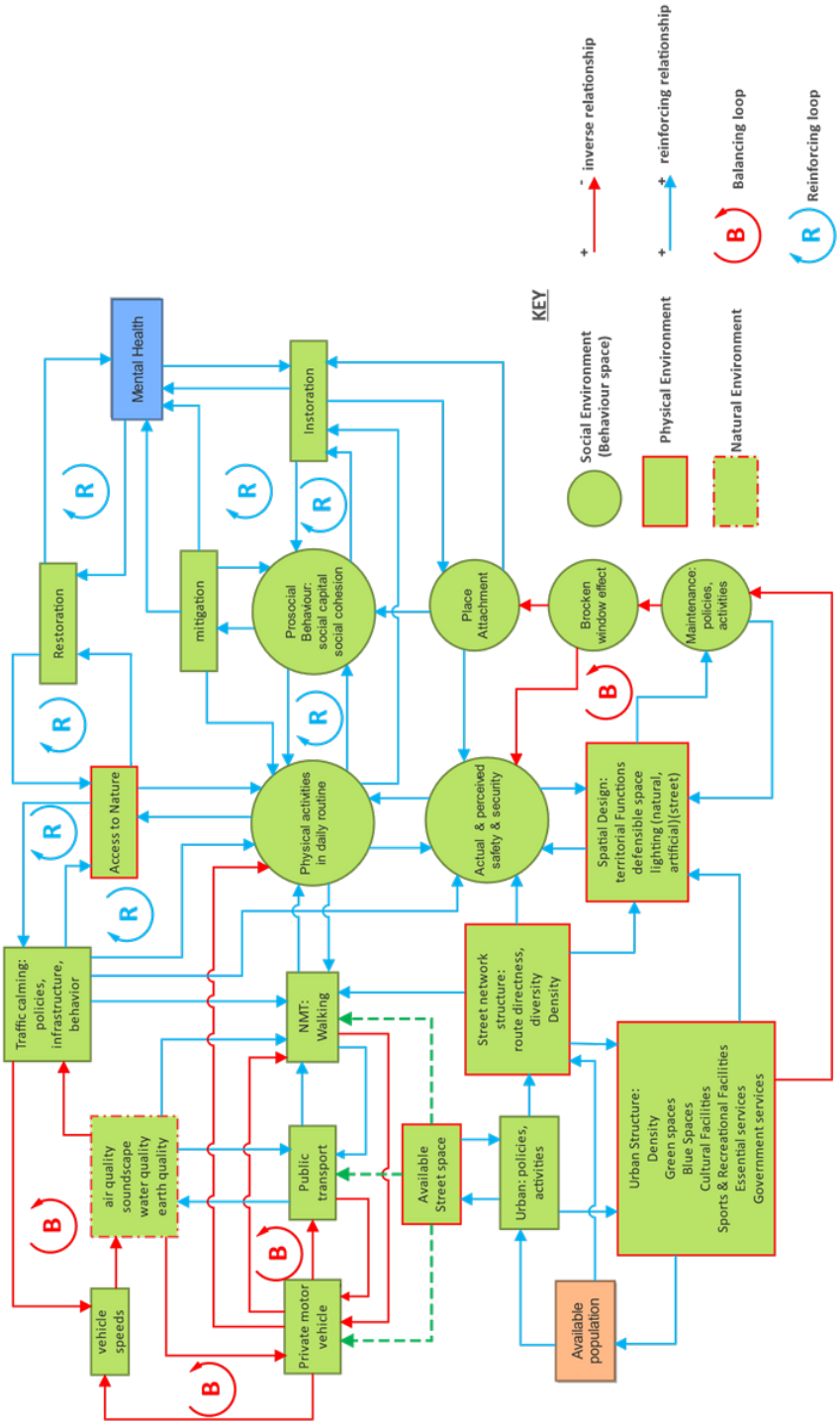

FIGURE 2
A Causal loop Diagram of the Built environment and mental health
Source: Field survey, 2024

TABLE 4
Proposed interactive framework for mental health enhancing features of the urban built environment

Reference	Proposed links	Proposed mechanisms	Proposed resolutions
Halpern (1995)	through four inter-related channels: 'by influencing social networks and support, being a source of stress, action of the planning process itself, and symbolic effects and social labelling played by architecture'		to better predict health effects and mental health outcomes, more variance in the built environments being measured should be sought 'poor model specification (such as different aspects of the environment and context which may have opposing effects) being confused and compounded due to lack of guidance from theoretical models'
Wandersman & Nation (1998)	at neighbourhood level which proposed the following: 'structural/ demographic characteristics (including percentage of residents living below the poverty line and ethnic distribution), neighbourhood disorder (presence of physical and social signs of neighbourhood decline) and environmental stress models that examine relationship between elements of the ambient and built environment'.	They identified four classes of stressors: cataclysmic / catastrophic, stressful life events, daily hassles and ambient stressors, and socially toxic neighbourhoods	They propose neighbourhood interventions with a psychological orientation
Marsella (1998)	examples four urban life determinants of mental health and social deviancy: 'Environmental (including air pollution, noise pollution, visual pollution, population density, traffic congestion, excessive stimulation etc.,); Sociological and economic (including: crime and violence, migration, poverty, unemployment, absence of community, marginalization etc.,), Psychosocial (including social structure, social drift, cultural confusion, social stress, acculturation / assimilation, rapid social change etc.,); and psychological (including quality of life, sense of coherence, powerlessness, alienation, fear, anxiety, isolation, loneliness etc.,)'	He further offers a five-level hierarchical system's model for urbanization-related stressors and interventions: the macro environmental, macrosocial, microsocial, psychosocial, and biopsychosocial. At the macro environmental level sampled dysfunctions included: population size, density, urban decay, crowding, excessive stimulation, and pollution	possible interventions included: legislation, policy formation and urban planning

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Reference	Proposed links	Proposed mechanisms	Proposed resolutions
Evans (2003)	dual direct and indirect pathways: In the direct domain characteristics such as housing (type & quality, neighbourhood quality), crowding, Institutional settings, lighting, indoor air quality, noise are correlated to mental health issues. The indirect pathways identify three psychosocial processes: personal control, social support and restoration.		methodological challenges he highlights is the inadequate exposure estimation which this study explores. He also highlights the embeddedness of built environment elements and highlights that the built environment may in this sense yield multiple adverse physical and social exposures that affect the mental health outcome more.
Wood & Giles-Corti (2008)	How social capital, the built environment and mental health interact. three relationship domains: between macro environmental trends (crime, violence, neighbourhood stability) and social capital; between aspects of the neighbourhood context or design (walkability, presence and adequacy of amenities/facilities) and social capital at the meso level, and neighbourhood attributes at the micro level (opportunities to: meet others, interact socially etc and neighbourhood quality: incivilities and disorder, access to nature and greenery, feeling of safety).		
McCay et al. (2017)	mind the GAPS frame work (GAPS is an acronym for Green, Active, Pro-social and Safe) this framework has a positive outlook for mental health and seeks opportunities to promote it. They propose: access to nature, prosocial places, safety and security, and physical activities in daily routines.		

Source: Field survey, 2024

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