Does the Physical Environment of an Urban Neighborhood Affect the Social Well-Being of Children?
A Pilot Study in Nagpur, India

Vaishali Pedram[1]* and Dr. Ujwala Chakradeo[2]
[1]Research Scholar, Smt. Manoramabai Mundle College of Architecture
Nagpur-440006, Maharashtra, India
[2]Vice-chancellor, S.N.D.T. Women's University,
Mumbai-4000202, Maharashtra, India
E-Mail: vaishali.pedram@gmail.com
*Corresponding Author

Abstract—
Purpose: This paper investigates the influence of urban neighbourhood environments on the social well-being of Indian children, focusing on the social development domains. It seeks to understand the relationship between children's social connectedness **(SC)** and the outdoor physical environment **(OPE)** during middle childhood. **Methodology:** The conceptual framework of this pilot study was based on Bronfenbrenner's Person-Proximal Process-Context model of human development. The proximal process was operationalized as children's outdoor out-of-school physical activities **(OOPA)** as a means of interaction with the physical and social environment. Adopting the cross-sectional quantitative method approach investigation was conducted in three neighborhoods. The study included subjective measures collected through in-person surveys (N=70) of 8–12-year-old children and objective measures computed using GIS. A strong correlation was found between children's daily duration of OOPA and SC, validating the PPC model's proposition of proximal process. SC and its linked dimensions show the significant influence of objective variables like building density, street connectivity, traffic exposure, quality of recreation spaces in the neighbourhood and subjective perceptions like personal safety and neighbourhood physical activity environment. Children's gender, motivation for outdoor physical activities and license for independent mobility were also found to influence social connectedness. The study confirms that OOPA is the profound connector between the OPE and their social development as it facilitates children's interaction with the outdoor physical and social environment. Children's SC and its linked dimensions were directly associated with objective OPE and perceived characteristics of the neighbourhood. The study also shows a significant association between active and independent mobility and children's SC. Considering well-researched evidence of linkages between the built environment and children's active and independent mobility, this study suggests the additional indirect influence of OPE on children's SC through their travel behaviors.

Keywords: Middle childhood, Urban Neighbourhoods, Social Development, Social connectedness, Outdoor Physical Activities.

INTRODUCTION

CHILDREN OF URBAN INDIA
In the last couple of decades in India, the combined forces of urbanisation, liberalisation, and globalisation along with the spread of dominant cultures and impingement of ICT in people's everyday lives have resulted in accelerated transformations in physical, sociocultural and economic

domains of the urban population (Saith & Wazir, 2010) including its large population of urban children (35.9% share) (Census, 2011; Kundu, 2020) Alongside, in the wake of the demographic dividend and its promise for the young population to become a major contributor to the country's present and future economic growth as human capital, India's children become major stakeholders in the urban agenda. ((Harjani, CNBC, 2012, Oct 24). - Google Search, n.d.) Challenges, particularly related to the transforming urban environments and children's social well-being are highlighted here. (i) Uncontrolled urbanization led to undesirable physical transformations like a congested and near breakdown of services in the urban core, car-dependent and infrastructure-deficient fast-expanding urban fringes, diminishing open spaces and parks and playgrounds, vehicular dominance on urban streets; increased travel time to school, new housing typologies imposed on the conventional residential environments (Pedram *et al.*, 2024) are not only creating challenges for children to utilise outdoor spaces but also affecting the local social circumstances for them. (ii) The ingress of ITC technology in children's play and communication patterns, and commodification of play, are some of the interrelated processes that manifest themselves in the daily lives of children in the form of changes like sedentary lifestyle, increasing virtual communication patterns (Pedram *et al.*, 2024) diminishing social interaction and integration. (iii) Other changes influencing children's immediate social environment are changing parenting styles influenced by overprotectiveness and time shortage syndrome (Rudd, 2019) placing restrictions on children's independent exploration of outdoor environments and socialization (Pedram *et al.*, 2024).

HOW ARE OUR CHILDREN DOING?

The cumulative effect of the above-mentioned urban transformations poses complex challenges for children's physical and mental health and social lives. Some alarming recent trends in children's physical and mental health are discussed herein. Worldwide, up to 10–20% of children are affected by mental health problems (Kieling *et al.*, 2011) and as per WHO reports, self-harm and suicides are the most common causes of mortality after road accidents among the young population. In India also estimated suicide rates are as high as 35.5 per 100,000 population among young people which is the highest in south-east Asia (WHO, 2017). Global School-Based Student Health Surveys (GSHS, 2007) have highlighted the prevalence of mental health indicators

like depression (25%), distraction (11%), anxiety (8%), loneliness (8%) and having no close friends (10%) among Indian children (WHO, 2017). There are up to 20 million adolescents with a severe mental health disorder, which is a growing concern (Shastri, 2009). The NCD's contribution to the total disease burden in India rose to 61.8% in 2016, a concerning trend linked to the rise in levels of urbanization across Indian states as evidenced by current studies highlighting the growing prevalence of obesity, T2 diabetes and psychological distress among the Indian young population in recent years (ICMR & PHFI, 2017; Mehreen *et al.*, 2020; Ramadass *et al.*, 2017; Saikia *et al.*, 2016).

NEW EMERGING NEEDS

Several positive health approaches for children recommend community connectedness and several related social aspects like social relationships, social acceptance, social coherence and integration as protective factors for mental health and an essential component of healthy development and quality of life (Cummins & Lau, 2005; Keyes, 2002; W.H.O, 1996). Apart from being a priority as a future human capital, action is imperative to inform public health interventions to address mental health issues and create a liveable environment for children's healthy development. It implies that India's urban environments (Tiere-I and Tier-II cities) will play an influential role in fostering the health, development and well-being of the country's growing young population.

BEYOND PREVENTION, A DEVELOPMENTAL APPROACH TO CHILD WELL-BEING

International forums like UNCRC, upholding children's equal rights to development, protection, and participation have been instrumental in expanding the traditional poverty & survival-centric approaches to wider multi-dimensional approaches to include both material and non-material aspects of **child well-being (CWB)** (Camfield *et al.*, 2010; Saith & Wazir, 2010). Article 27 of CRC calls for a standard of living adequate for the child's physical, mental, spiritual, moral and social development' (Bartlett, 2002). India being a ratifying country for UNCRC, needs to take up a wider and holistic framework for CWB and development. Healthy child development involves mutually related aspects like physical, mental, psychological and social health and health-promoting behaviour, and to understand it holistically it needs to be contextualised (Bartlett, 2002; Ben-Arieh *et al.*, 2014; Pollard & Lee, 2003).

Convergence of Child Development and Urban Environment

Theory and research have recognised the neighbourhood, where children live and grow as an important ecological context (Physical and social environment factors) for understanding CWB and development (Bronfenbrenner, 1979; Leventhal & Brooks-Gunn, 2000). Previous studies have investigated the effect of a neighbourhood's structural/compositional factors (income, employment, racial composition) and social /organizational factors (disorder, safety, social cohesion) on children's developmental outcomes but the influence of fundamental facets like physical, & natural environment on child development is largely ignored (Leventhal & Dupéré, 2019; Vaden-Kiernan et al., 2010). The persistent epidemic of obesity and mental health issues among children in high-income countries has encouraged health research to extend from a person-centred approach to broader everyday environments to investigate factors influencing children's active living (Woolcock & Gleeson, 2007). Consistent with this trend extensive research has explored the relationship between the neighbourhood's PE and children's PA and health (Davison & Lawson, 2006). Yet the potential effect of neighbourhood PE on children's other domains of development particularly social well-being has been largely under-studied internationally and in India (Bhonsle & Adane, 2015; Khatavkar, 2018). Although extensively studied in developed countries, the research on exploring the neighbourhood BE effects on children's health and well-being is nascent in India. A few studies from India have investigated this association of urban BE with some aspects of children's health and well-being such as PA, (Bhonsle & Adane, 2015; Chatterjee, 2006; ICMR & PHFI, 2017; Khatavkar, 2018) independent mobility (Tyagi & Raheja, 2021) and active travel to school (Cooper et al., 2006; Eccles, 1999). There is a near absence of studies exploring the relationship between neighbourhood PE and children's other key developmental domains in India (Tyagi & Raheja, 2021).

Bridging the Gap: Research Goals and Objectives

India's urban areas are expected to continue as growth poles with a 600 million urban population and 75% share of GDP by 2030 (PwC India & Save the Children India (2015)). Alongside an absolute number of urban children, a limited-time window of demographic dividend (2005-6 to 2055-56), an evolving landscape of child development in urban India and the ambitious goals of the New Urban Agenda,

set to be achieved shortly present a crucial intersection that demands intensive investigation. Overwhelming urban expansion and large population of urban children along with India's unique other challenges like, financial constraints, and diverse socio-economic and cultural character, large-scale individual interventions for child development may prove impractical. Instead, it may be useful to take up a public health approach with a focus on the relationship between the physical environment and child development and investigate the linkages and implications to ensure that urban development in India may truly serve the best interests of its youngest citizens.

Addressing this research gap, this study aims to explore the association of the outdoor physical environment (OPE) with social development, measured as the social connectedness (SC) of children during middle childhood (8-12 years), at the neighbourhood scale in the city of Nagpur in India. This study is a part of an ongoing larger study focused on investigating the association between neighbourhood PE and key developmental aspects of middle childhood.

Obj-1: To identify the difference in children's social connectedness across the three neighbourhoods and gender.

Obj-2: To investigate the association between children's social connectedness and OPE characteristics of the neighbourhood.

Obj-3: To get preliminary insight into the potential pathways through which OPE characteristics and other related factors influence SD during middle childhood.

This literature review explored the multifaceted relationship between child development and the physical urban environment specifically focusing on social development and social well-being during the middle childhood development stage and on the outdoor physical environment of the urban neighbourhood. The literature was reviewed to address specific research questions such as, How does child development contribute to children's well-being?; What are the developmental goals during middle childhood?; What are the key activities, interactions and resources through which the outdoor physical environment might influence the social development of social connectedness during middle childhood?; What are the appropriate theoretical frameworks to study the relationship of outdoor PE with the social development and well-being of children? A systematic search of relevant scholarly literature was conducted utilizing prominent databases such as Google Scholar, ResearchGate, PubMed, CINAHL Plus, and PsycINFO. Key search terms included domains of child development,

middle childhood development, social connectedness and wellbeing, urban and neighbourhood environment, and outdoor physical environment, Peer friendships, physical activities. The literature referred to included peer-reviewed articles, dissertations, and reports published in the last decade that investigate the impact of the built environment on children's physical and social development, particularly during middle childhood (ages 8-12).

DEVELOPMENT DURING MIDDLE CHILDHOOD

Childhood development is a continuous process of transformations across physical, cognitive, emotional, and social, dimensions but children develop in specific domains during specific development stages, provided they get requisite environmental stimuli and opportunities (Cherry, 2023). *Middle childhood (MCD)* (6-12 years) is also a distinct development stage with a particular set of tasks and needs (Cooper *et al.*, 2006; Eccles, 1999). During this stage, children undergo important changes in the developmental domains which manifest in the form of personality traits, behaviour patterns and incipient competencies which even affect development in adolescence and adulthood (DelGiudice, 2018; Moore & Theokas, 2008; Schonert-Reichl, 2011). During MCD, there is the intrinsic bio-psychological drive to achieve competency, independence and relatedness, due to which children naturally seek opportunities for acquiring and exhibiting new skills, assert their choices, even learn to control their behaviour and want to form relationships with peers and other adults (Eccles, 1999; Schonert-Reichl *et al.*, 2013). The decision to focus on MCD for this investigation is supported by several studies studying neighbourhood effects on children's several social development (SD) outcomes like peer friendships, (Rogers, 2012) place attachment, **physical activities (PA) and active travel (AT)** (Kyttä *et al.*, 2012). National studies of the same genre have also focused on the same age group and have investigated children's **independent mobility (IM)** (Tyagi & Raheja, 2021) travel to school (Tetali *et al.*, 2016) daily activities, and play provisions (Bhonsle & Adane, 2016).

FRIENDSHIPS AND SOCIAL DEVELOPMENT DURING MIDDLE CHILDHOOD

SD refers to the acquisition of personal and social skills, attitudes and behaviour that enable an individual to function in society and it is called socialization. (Seefeldt, 1986), At the onset of MCD, when children begin venturing outside into the physical and social environment, peers, play, and **physical activities (PA)** become powerful agents of their

socialization leading to SD. During MCD, friendships take a prominent role and peer interactions become instrumental in fostering companionship, a sense of belonging and motivation for participation in social activities. (Morrow, 2001) Organized sports, informal play, team games and active travel all have different dimensions of social experience. (Sage, 1986, p.346 as cited in Seefeldt, 1986) Outdoor play, exploration, and co-occurring social interactions nurture cognitive abilities that promote communication skills and greater social awareness and facilitate more complex interactions. Hartup, (1996) provides a frame of dimensions to understand the developmental significance of friendships. (i) Having friends: It's an indicator of being socially liked and is a developmental predictor. Children who have friends are more socially competent, less troubled, sociable, and cooperative. (ii) Friendship Quality: High-quality friendship is characterized by prosocial behaviour, intimacy, social adjustment, and the ability to cope with stress and affects other aspects of SD. (Berndt & Keefe, 1995)

Concludingly, good friendships (both quantity and quality) provide benefits such as companionship, sociability, feelings of self-worth, emotional security, affection, and well-being (Berndt, 2004) and lack of friendship is associated with conflicts, low self-esteem, and confidence, social withdrawal, poor self-regulation and impulsive risk-taking behaviour. (Mitic *et al.,* 2021) Developing, maintaining and being functional in a stable group, and interacting with peers and members outside the family is a crucial SD task during MCD. (Berndt, 2002, 2004)

RESEARCH INSIGHTS INTO THE NEIGHBOURHOOD AND CHILDREN'S SOCIAL DEVELOPMENT

Research exploring PE effects on a child's development has majorly focused on physical health, PA, obesity and mental health. (Biddle *et al.*, 2004; Transportation Research Board & Institute of Medicine, 2005) However, some evidence suggests that neighbourhood provide important exposure, resources and opportunities to explore the surroundings, learn and interact with people. (Hazen, 1982) MCD is a period when children often in collaboration with their friends, 'colonize' and extensively explore the outdoors. (Hartup, 1996; Moore & Theokas, 2008) Certain neighbourhood OPE characteristics have been identified as supportive of children's use and exploration. Walkable neighbourhood, characterized as having higher density, land-use mix, connected street networks, and highly accessible destinations have been associated with increased social

interactions, as people are more likely to walk, cycle, and linger locally (Goldfeld *et al.,* 2015). Unsafe neighbourhood may force children to be isolated in their homes, restricting their opportunities for peer play and social interactions (Morris & Kalil, 2006, p.237). Neighbourhood recreation facilities, and other utility destinations like libraries, schools, and hobby centers provide opportunities for social interactions, forming relationships and fostering meaningful social connectedness (Jago *et al.,* 2009). Although there is indicative research evidence and a theoretical platform for expecting neighbourhood PE to influence children's SD, there is a lack of studies examining this relationship (Villanueva *et al.*, 2016).

THEORETICAL PERSPECTIVES

Ecological frameworks are often employed in to examine the neighbourhood PE influence on children's physical and mental health and health behaviour in urban planning disciplines (Giles-Corti *et al.,* 2005). Bronfenbrenner in his bioecological model, puts relationships in the context of ecological systems and stipulates the environmental context as a powerful determinant of human development. The reciprocal interactions between different systems connected via social interactions are considered effective processes through which human development is brought about (Bronfenbrenner & Morris, 2006; Mitic *et al.*, 2021). Sampson *et al.,* (2002) has also outlined four classes of neighbourhood mechanisms related to children's health and behaviour problems. (i) Social Ties/Interaction: Works through social relationships and builds social capital (Leventhal & Brooks-Gunn, 2000) (ii) Norms and collective efficacy: Operates through informal social control, and social cohesion (iii) Institutional resources: catering to the needs of the children (iv) Routine activities: The availability and access to everyday activities and places like schools, mixed land-use, recreation spaces, transportation options, activity vibrancy on the streets and at POS are relevant to understand patterns of children's social encounters with peers, adults, and their social activities (Sampson *et al.*, 2002). Considering the complex relationship between OPE and children's SD, an integrated framework that would consider the interconnectedness of social processes (peer friendships, social capital), resources and physical features (natural and BE features), spatial dynamics (diversity, variability and complex interaction within PE components) and individual differences (age, gender, income) would provide a suitable conceptual framework for the study (Leventhal & Dupéré, 2019).

METHOD
CONCEPTUAL FRAMEWORK OF THE STUDY

The conceptual framework of the study is based on Bronfenbrenner's bioecological theory of human development. The essence of this theory is the 'Process-Person-Context'-Time' (PPCT for short) model which is particularly relevant for this study (See Figure 1) (Bronfenbrenner & Morris, 2006; Tudge, 2009; Xia *et al.*, 2020). The primary propositions of the PPCT model considered for the study are stated herein. (Ashiabi & O'Neal, 2015) (i) Human development takes place through the process of reciprocal interaction between an active, evolving biopsychological human organism and the persons, objects, and symbols in its immediate external environment. (ii) To be effective, interaction must occur regularly over extended periods. Such enduring forms of interaction in the immediate environment are referred to as proximal processes and these are the mechanisms through which developmental potentials are actualized (Bronfenbrenner, 1999; Högman *et al.*, 2020). (iii) The proximal processes are interpersonal interactions, as well as interaction with objects and symbols (Bronfenbrenner, 1999). (iv) Given the pilot study's limitations, (exploratory nature and cross-sectional data) a limited version of 'Process-Person-Context (PPC)' excluding the 'Time' component of the bioecological model was adopted in the conceptual framework (See Figure 1) (Ashiabi & O'Neal, 2015; Tudge *et al.,* 2009).

CONSTRUCTS, VARIABLES, AND MEASURES

The operationalization of constructs, variables, and measures within the 'Process-Person-Context (PPC)' model as applied in the study is described below (see Figure1).

1) Social Development Outcome: Social Connectedness (SC):

The construct of (SC) is defined as an emergent property of SD and it assesses social networks and a sense of belonging and support from the neighbourhood peers and community (Moore & Theokas, 2008). Following the Middle Years Development Instrument (MDI, 2021 developed by HELP, UBC), (Schonert *et al.,* 2013; Thomson , 2018) the construct of social connectedness was operationalised as a composite variable including (a) Peer friendships: Measured as a count of the number of friends in the neighbourhood. (b) Quality of peer friendship: Measured with a five-item subscale of peer belonging and friendship intimacy covering aspects like kinship, sharing, and intimacy. The responses were
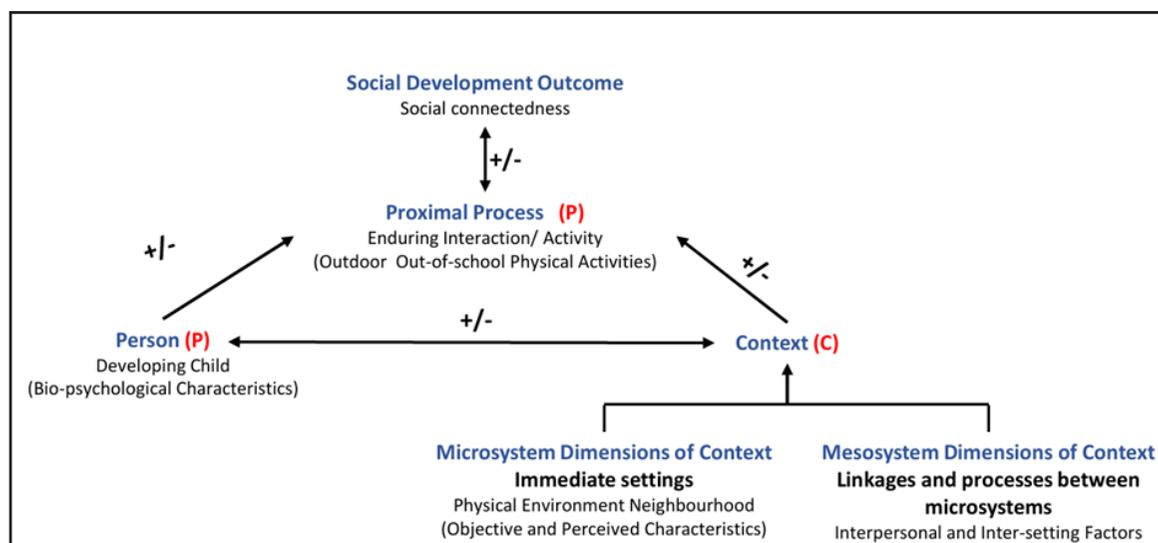
Fig. 1: Conceptual Framework to Identify variables
Reference: (Hayes et al., 2022; Schaerz, 2021)

scored with a 5-point Likert scale (Disagree a lot=5 and Agree a lot=1) (Berndt, 2002; Gadermann *et al.,* 2016; Thomson *et al.,* 2018) (c) Number of known adults in the neighbourhood: Measured as a count of number of known adults in the neighbourhood who are caring, helpful to children and important. (Islam, 2008) For the composite variable of SC a combined weighted score was also calculated for the correlation analysis.

2) The Proximal Process – Outdoor out-of-school physical activities (OOPA):

As mentioned earlier the proximal process of the (Process-Person-Context) model is operationalised as children's daily duration of OOPA in the neighbourhood. Out-of-school activities provide a venue for interacting and "networking" with other peers. (Ripke *et al.,* 2006) The spatial distribution of these daily activities in a way organises when and how children come in contact with neighbourhood peers and other community members. Regular OOPA promotes SC through their friendship experiences and greater social awareness. (Hagger & Chatzisarantis, 2005)

The OOPA was measured using three items adapted from existing PA questionnaires, Childre's Leisure Activities Study Survey (CLASS) (Huang *et al.,* 2009; Telford *et al.*, 2004) Other international and national PA study protocols were also referred to make the survey item suitable for local situations. (Health Behaviour in School-Aged Children (HBSC) Study Protocol, 2014; Mehreen *et al.,*

2020; Rosenberg *et al.,* 2009) Children reported categorical responses to items of frequency several days per week (Never/ Rarely; Once/2-3 days/ 4-5days, 6-7days) ((HBSC) Study Protocol, 2014) and duration in minutes over weekdays and weekends in a usual week. (<=30; up to 60; up to 90; up to 120 and >120) To obtain the overall estimate of the OOPA in a usual week the categorised time intervals over weekdays and weekends were first transformed into a continuous score per week and then the duration of OOPA per day in a week was calculated as adopted by the other studies. (Bringolf-Isler *et al.*, 2012)

3) The Context – Neighbourhood Outdoor Physical Environment (OPE)

Focusing on the neighbourhood OPE as a microsystem dimension of the context (See Fig 1), as postulated in the 'Process-Person-Context (PPC)' model, we further anchor on relevant pathways of neighbourhood influence on child development as outlined by Sampson, (i) Physical characteristics (ii) Resources, (iii) Disorder and safety (children's perceptions) (iv) Children's routine activities. (Sampson *et al.,* 2002) Further tapping the operational research frameworks from health-promoting and child-friendly environment research like, 'Ecological models of PA determinants' (Bauman *et al.,* 2012) and 'Ecological model of active living' (Sallis *et al.,* 2006). to identify relevant features of OPE that influence child development. Considering the many overlaps among these frameworks we adopt an integrated approach to identify OPE attributes

that comprehensively capture the objective and perceived characteristics of OPE that may influence children's OOPA, which is hypothesised as the interface between OPE and the socially developing child. Referencing to the previous discussion presented in the literature section of this paper, we have identified six OPE attributes along with ten objective and three perceived OPE variables as described in (Table 2).

Assuming that ease of movement in the neighbourhood unfolds opportunities for social activities along with physical exploration, mode of travel to school (Inter-setting) and licence for independent mobility (Interpersonal) are the two mesosystem dimensions of the context included in the framework. (See Fig 1) (Babb *et al.,* 2011; Högman *et al.,* 2020; Loebach & Gilliland, 2022; Tetali *et al.,* 2016)

4) The Person: Gender

The 'Person' in the Process-Person-Context' model (Bronfenbrenner & Ceci, 1994) is postulated as personal characteristics (biopsychological) that either initiate or inhibit the proximal process of interaction. (Högman *et al.*, 2020) The study includes variables of (i) Gender (biological) and (ii) Motivation for PA as personal characteristics of the child, which is hypothesised to influence children's PA and SC. (Biddle & Mutrie, 2001; Frank *et al.*, 2005)

5) Socio-demographic Factors

Age and Monthly household income are the two variables that were included in the study as demographic information to ensure the recruitment of children within the target age range (8-12 years) and socio-economic category (MIG-I & II). (Davison & Lawson, 2006; Ding *et al.*, 2011)

Study Settings

This study was conducted in Nagpur, the second capital of Maharashtra has 24.48 lakhs population (Census, 2011). It's central India's regional centre for commerce, industries, services, health and education. In the last two decades, there have been progressive changes in Nagpur's industrial, and economic profile leading to real estate growth especially induced by the MIHAN project (Comprehensive Mobility Plan for Nagpu - Google Search, n.d.). Coupled with significant in-migration is transforming the city physically, socially, and culturally. Rapid changes in the urban landscape are putting the city's infrastructure under stress resulting in urban sprawl, increased densities, higher crime rates, increase in traffic volume, and lack/ shortage of open spaces, leisure and amenities are affecting liveability for children. Nagpur,

a tier-II city is significant as a representative case of transforming the urban living environment in India, hence a suitable context for exploring the relationship between OPE characteristics and child social development.

NEIGHBOURHOOD SELECTION

A multiple case study approach was adopted as the study focused on examining the real-life context. As discussed before, OOPA is hypothesised as an interface between OPE and the socially developing child assumed to enhance children's opportunities for regular social interactions and experiences. We identified four OPE factors (proportions of intersection & commercial use streets, heavy traffic roads, and amount of recreation open spaces) known to support children's daily duration of OOPA, forming the selection criteria for identifying the study neighbourhoods. (Biddle & Mutrie, 2001; Frank *et al.*, 2005) Three neighbourhoods from Nagpur namely, Trimurti Nagar (TN), Jaripatka (JP) and Besa (BS) were carefully selected based on the preliminary cluster analysis of four OPE factors (selection criteria) and were computed using GIS within tentatively delineated neighbourhood boundaries by direct site observation and consultation with the neighbourhood residents. The purposeful selection of three neighbourhoods was aimed to maximise variability in the level of PE supportiveness (high, medium and low) for OOPA and social interactions within the pilot study.   (See Table 1)

DATA COLLECTION
SUBJECTIVE DATA

The cross-sectional data for this pilot study was collected from the interviewer-administered survey of children (N=70) 8-12 years old belonging to middle-income households recruited from three neighbourhoods covering the whole spatial range. There were several reasons behind using this method for collecting subjective data on perceptions, certain PE characteristics and outcome variables like social connectedness as discussed here. (i) Limited awareness about the usefulness of academic surveys (ii) Parental apprehension regarding interacting with strangers particularly involving their children (iii) Technology and literacy barriers like discomfort with electronic surveys and varying literacy levels among participants (iv) Child-centric approach of one to one conversation in the presence of parents fostered a sense of security and comfort for children. (v) Comprehensive spatial coverage was important to ensure a representative sample across the neighbourhood's diverse physical environment. A door-to-door approach,

coupled with clear explanations about the study's purpose and data usage, a conversational way of interview, flexibility in language choice (Hindi, Marathi, or English), employing young adult interviewers (aged 20-25) allowed to build trust, put children at ease, established rapport with both children and parents helped more open and engaging data collection method. After the consent was secured from both the parent and the child, the interview surveys were conducted in the presence of parents in the language of choice and lasted 15-20 min. The questionnaire included 13 questions and 4 subscales, adapted from internationally and nationally recognised scales. (Adlakha *et al.,* 2016; Bringolf-Isler *et al.*, 2012; Cain *et al.*, 2021; Huang *et al.,* 2009; Islam, 2008; Kyttä *et al.,* 2012; Mehreen *et al.,* 2020; Rosenberg *et al.,* 2009; Telford *et al.,* 2004; Tetali *et al.,* 2015; Thomson *et al.,* 2018) The residential address provided by the parents was re-checked using Google Earth and Google Street View and confirmed by the parents or by direct observation.

Objective data

For collecting the objective data of outdoor physical environment characteristics, a Geographic Information System (GIS) was employed due to its inherent capabilities in spatial data creation, management, integration of various datasets and analysis. GIS was instrumental in precise measurements and mapping of PE features like building footprints, areas of ROS, and linear measurements. It facilitated a comprehensive understanding of physical environment features. A circular neighbourhood buffer of a 400-meter radius was created around each child's (N=70) home location to compute GIS data of objective measures of OPE. This definition of individual neighbourhood buffer is similar to several international studies and national studies of the same genre. (Kyttä *et al.,* 2012; Tyagi & Raheja, 2021) GIS data extraction was a three-step process as explained herein.(Brisotto *et al.,* 2023; Pindarwati & Wijayanto, 2023)

(Step-1)-**Base data collection:** The building footprint was generated from Google satellite imagery using Mapflow AI (https://mapflow.ai/), a machine learning algorithm for automated feature extraction. OpenStreetMap, Google Street View and Google Maps /Earth were used to create vector data for locating the participant's home and buffering, identifying the road categories, marking the footpath, land use and recreation open spaces. (Step-2)- *Augmentation:* To enhance and refine the base data, Google Street View and Ground Truthing process (direct observation, photo documentation) were used for attribute addition like building type, number of stories, and quality audit of recreation open spaces. (Step-3)- *Analysis:* Spatial analysis and map creation were performed using QGIS (version 3.24) geographic information system software (QGIS Development Team, 2021). Intersection analysis was done to calculate road intersection density. Pivot tables were used for summarising and aggregating the data. Data output tables were used for further analysis.

RESULT AND DISCUSSION

Analysis

Statistical analysis was performed using IBM SPSS Statistics version 26. To confirm the difference in OPE characteristics across the three neighbourhoods analysis of variance was performed using a one-way ANOVA Test (for normally distributed variables) and Krukal-Wallis Test (for non-normally distributed variables). Bivariate correlation analysis and multiple linear regression were used to investigate the association between children's social connectedness and objective and perceived OPE characteristics, personal characteristics of gender), and other factors like mode of travel to school, and license for IM. Several studies from Asia have employed a similar approach to examine built environment influence on children's outdoor PA (Islam, 2008; Islam *et al.,* 2016), children's independent mobility (Tyagi & Raheja, 2021) and time spent outdoor (Islam *et al.,* 2016) Other international studies have also employed similar statistical strategies to examine the influence of OPE characteristics on children's various developmental outcomes like PA, AT and IM (Oliver *et al.,* 2015b; Timperio *et al.,* 2008; Tyagi & Raheja, 2021)

1) Children's Social Connectedness by Gender

This section presents the outcome of descriptive statistics analysis of subjectively measured variables (Mean, SD) for the overall sample (N=70) and separately for boys (N=35) and girls (N=35). The outcome of ANOVA (Independent sample t-test, Chi2 test) of social connectedness and other subjective variables by gender is also included. (See Table 3). Age and Monthly Household Income variables were considered only for recruitment purposes and not included in the correlation analysis as independent variables. Overall, children reported a moderate level of social connectedness (mean=7.68, Maxi score=20) and 4.4 number

of friends, 2.57 number of known adults and perceived their friendships as moderate quality (mean=5.2, Maxi score=10). Boys consistently report higher mean scores for social connectedness (8.61 vs 6.75) and its three dimensions (Ref. Table 2) as compared to girls. The difference in the social connectedness of boys and girls was significant (t = 2.92, p= 0.005) with medium to large effect size (Cohen's d=0.7). Overall children acquired 54.77 minutes of OOPA per day. Whereas boys were acquiring substantially higher amounts of OOPA per day in a week than girls. (72.94 minutes vs 36.6 minutes) and this difference is statistically significant (t = 4.57, p-values <0.05) with a large effect size. (Cohen's d =1.09). Children have similar perceptions about traffic (Mean:2.29) and personal (Mean: 2.0) safety in the neighbourhood.

The Gender differences found in perceptions of traffic and personal safety were statistically not significant. (p-values >0.05). Boys find their neighbourhoods significantly more favourable for outdoor physical activities as compared to girls (p-values <0.05) and large effect size (Cohen's d =0.7). Predominantly children used passive mode (78.57%) of travel to school as compared to active mode (21.43%). Mode of travel showed an insignificant but weak association with gender. (p-values >0.05 and Phi = 0.103). More than half the children report high levels of independent mobility (Mean:57.14) as compared to moderate or some mobility (Mean:25.71) or no mobility (Mean: 17.14). With the current sample size, there was not enough evidence found to associate licence for independent mobility with gender (p-values >0.05 and Phi=0.056).

Table 1: Physical Profile of Three Neighbourhoods

Character	TN (N=25)	JP (N=18)	BS (N=27)
Location	South –West	North	South –East
Age of locality in years	40-30	60-50	<15
	Low-rise upto (G+3)	Low-rise upto (G+3)	Mid Rise upto (G+4 to G+8)
Street pattern	Irregular grid partially disconnected	Regular grid connected	Fragmented grid
Stage of development	Developed	Redevelopment initiated	Developing
Socio-economic character	MIG-I-II, LIG Monoculture Maharashtrian community	MIG-I-II, LIG Mixed culture North Indians, Maharashtrian, Buddhist	MIG-I-II, Mixed culture North &South Indians, Maharashtrian

Table 2: Outdoor Physical Environment Variables[1]

Attributes	Variable	Measurement/Indicator (Formula/Scale)	Source/ Tool
1) Built Form	1) Built-up area density[2]	Built-up area ratio (Gross floor area of all buildings / Total land area in 400 M. buffer) Unit: Area in SQM	GIS analysis
	2) Land use mix [3]	Entropy index: (Ratio calculated for six land uses residential, commercial, mixed-use, institutional, recreation open spaces, and other open spaces)	GIS analysis
2) Vehicular network	3) Street connectivity[4]	Intersection density[3]: Count of 3 or more legged intersections in 400 M. buffer Unit: Count in numbers	GIS anaysis

(Table 2 Contd ....)

Footnotes:

[1] Outdoor physical environment variables: (Cain *et al.,* 2021; Davison & Lawson, 2006; Ding *et al.,* 2011; Loon & Frank, 2011; Sterdt *et al.,* 2014)

[2] Built-up area density is measured as the built-up area ratio. (Islam, 2008)

[3] Land-use mix is represented by the entropy index, which is the most commonly used and widely accepted index. It is an evenness distribution of the proportion of the estimated square footage/ floor space of different land uses within the buffers using the following formula known as the Entropy index. (Nordbø *et al.,* 2018; Tyagi & Raheja, 2021)

[4] Intersection density is a measure of connectivity of the street network. (Frank *et al.,* 2005; Oliver *et al.,* 2015a)

(.... Contd Table 2)

	4) Traffic exposure[5]	The ratio of high-speed roads: (Total length of high-speed roads / Total length of low-speed roads in 400 M. buffer)	GIS analysis
3) Pedestrian and cycling infrastructure	5) Footpath availability[6]	The ratio of roads with footpaths: (Total length of roads with a footpath / Total length of all the rods in the 400 meter buffer)	GIS analysis
	6) Utility of pedestrian and cycling infrastructure[7]	Sub-scale: (6 items) (1) Frequency of footpath use (1 item) (2) Barriers to use of footpath (4 items) (3) Barriers to cycling (1 item) Response: 4-point Likert scale (strongly disagree=1 and strongly agree=4)	Survey
4) Recreation open spaces(ROS)	7) Proximity to ROS[8]	Street network distance to nearest ROS from home Unit: Distance in Meters	GIS analysis
	8) Amount of ROS[9]	The total area of ROS within 400 M buffer in SQM Unit: Area in SQM	GIS analysis
	9) Number of ROS[10]	Count of ROS within 400 M buffer Unit: Count in numbers	GIS analysis
	10) Quality of ROS[11]	A quality audit was conducted for 5 ROS features. (1) Access and surrounding (2) Play facilities. (3) Amenities (4) Aesthetic features (5) Safety Unit: Sum of quality audit score of all the ROS in the 400 M buffer	Quality audit
5) Perception of safety in the neighbourhood	11) Traffic safety[12]	Subscale- 1 items Response: 4-point Likert scale (strongly disagree=1 and strongly agree=4)	Survey
	12) Personal safety[13]	Subscale- 1 items Response: 4-point Likert scale (strongly disagree=1 and strongly agree=4)	Survey
6) Perception of neighbourhood environment for PA	Presence of PA facilities and PA culture in the neighbourhood.[14]	Sub-scale (4 items) (1) Level of satisfaction with PA facilities in the neighbourhood (1 item) (2) Presence of PA culture and friendliness in the neighbourhood (3 items) Response: 4-point Likert scale (strongly disagree=1 and strongly agree=4)	Survey Survey

Reference: Author

Footnotes:

[5] Traffic exposure is measured as the ratio of high-speed road length to low-speed road length. In the absence of traffic volume data, the traffic function was used as a proxy and traffic speed exposure. The data on the design speed of four urban roads (arterial, sub-arterial, collector and local) were obtained from the Indian Road Congress manual IRC:86-1983. The arterial and sub-arterial roads formed the category of high-speed roads (>50 km/h) and collector and local rods formed the category of low-speed roads (<50km/h). (Adlakha *et al.*, 2016; Cerin *et al.*, 2019; Day *et al.*, 2015; Giles-Corti *et al.,* 2011) (Geometric design standard for urban roads in plains, IRC, 1983).

[6] Footpath availability: (Brownson *et al.,* 2009)

[7] Utility of pedestrian and cycling infrastructure: (Adlakha *et al.,* 2016; Cerin *et al.*, 2019; Day *et al.*, 2015)

[8] Proximity to ROS; (Davison & Lawson, 2006; Koohsari *et al.,* 2015)

[9] Amount of ROS8; (Kaczynski *et al.*, 2020)

[10] No of ROS; (Kaczynski *et al.,* 2020)

[11] Quality of ROS (Kaczynski *et al.,* 2020; Saelens *et al.,* 2006)

[12] Traffic safety: (Rosenberg *et al.*, 2009; Timperio, 2004)

[13] Personal safety: (Rosenberg *et al.*, 2009; Timperio, 2004)

[14] PA environment in the neighbourhood : (Holt *et al.,* 2008; Wong *et al.,* 2010)

Table 3: Descriptive Information and Analysis of Variance by Gender for Subjective Measures. (Independent Sample t-test, Chi2 test)

Variable	Overall (N - 70) Mean (SD)	Independent sample t-test			
		Girls (N=35) Mean (SD)	Boys (N=35) Mean (SD)	t (df)	Chhen'sd
1. Social connectedness (SC)	7.68 (2.8)	6.75(2.56)	8.61 (2.76)	2.92** (68)	0.7
Number of friends in the neighbourhood	4.4 (2.22)	3.8(2.29)	5.0 (2.01)	2.33* (68)	0.56
Friendship quality	5.2 (2.23)	4.42 (1.91)	5.98 (2.28)	3.1** (68)	0.74
Number of known adults in the Neighbourhood	2.57 (1.48)	2.0 (1.06)	3.14 (1.63)	3.48**(68)	0.83
2. Outdoor out-of-school PA (OOPA	54.77(37.76)	36.6 (20.32)	72.94(42.44)	4.57**(68)	1.09
3. Children's Perception of safety in the neighbourhood					
Traffic safety	2.29 (0.93)	2.17 (1.01)	2.4 (0.85)	1.02 ns (68)	0.24
Personal safety	2(0.99)	2.0 (1.06)	2.0 (0.94)	0 ns (68)	0
4. Perception of the PA environment in neighbourhood	5.66(1.33)	5.22 (1.20)	6.1 (1.33)	2.93**(68)	0.7
Variable	Overall (N=70) (%)	Girls (N=35) (%)	Boys (N=35) (%)	Chi2 test	
				X^2 (df)	Phi
5. Mode of travel to school					
Active mode (%)	21.43	12.86	8.57	0.76ns(1)	0.103
Passive mode (%)	78.57	37.14	41.13		
6. License for independent mobility					
No IM (%)	17.14	10	7.14	3.93ns (2)	0.056
Some IM (%)	25.71	17.14	8.57		
High IM (%)	57.14	22.86	34.29		

*Reference: Author, Notes: (1) (*p<0.05, **p<0.01), (2) n.s. indicates non-significant correlations (p>0.05)*

Table 4: Descriptive Information and Analysis of Variance by Neighbourhoods (TN, JP and BS) for Subjective and Objective Measures. (One way ANOVA, Chi2 test).

Subjective Variable	One way ANOVA				
	TN (N=25) Mean (SD)	JP (N=18) Mean (SD)	BS (N=27) Mean (SD)	F (df1, df2)	Eta Squared (n²)
1. Social connectedness (SC)	8.86 (2.13)	9.2 (3.09)	5.57 (1.67)	19.13 ** (2,67)	0.36
Number of friends in the neighbourhood	4.84 (2.3)	5.5 (2.36)	3.26 (1.48)	7.41** (2,67)	0.18
Friendship quality	6.81 (1.77)	6.2 (1.55)	3.04 (0.85)	52.1** (2,67)	0.61
Number of known adults in the Neighbourhood	2.48 (0.92)	3.89 (1.45)	1.78 (1.34)	15.81* (2,67)	0.32
2. Outdoor out-of-school PA (OOPA)	56.16 (33.28)	75.4 (51.13)	39.7 (22.79)	5.5** (2,67)	0.14
4. Children's Perception of safety in the neighbourhood					
Traffic safety	2.52 (0.82)	2.44 (0.78)	1.96 (1.06)	2.79** (2,67)	0.08
Personal safety	2.52 (0.92)	2.06 (0.94)	1.48 (1.85)	8.74* (2,67)	0.21
5. Perception of the PA environment in neighbourhood	6.41 (0.94)	5.83 (1.18)	4.85 (1.32)	11.92* (2,67)	0.26
6. OPE characteristics					

(.... Contd Table 4)

Subjective Variable	One way ANOVA				
	TN (N=25) Mean (SD)	JP (N=18) Mean (SD)	BS (N=27) Mean (SD)	$F\ (df1, df^2)$	Eta Squared (n^2)
1. Built form					
Built-up area density	0.80, (0.07)	0.89, (0.19)	0.53, (0.13)	46.94** (2,67)	0.58
Land use mix	0.41,(0.09)	0.43, (0.06)	0.60, (0.14)	24.62** (2,67)	0.42
2. Vehicular network					
Street connectivity	284, (72.79)	263, (34.31)	59, (17)	168.29**(2,67)	0.83
Traffic exposure	0.16,(0.05)	0.06, (0.05)	0.02, (0.04)	62.89** (2,67)	0.65
3. Pedestrian and cycling infrastructure					
Footpath availability	0.41(0.05)	0.3 (0.06)	0.13 (0.07)	138.18* (2,67)	0.8
Utility of pedestrian and cycling infrastructure[1]	6.77 (0.77)	7.02 (1.81)	3.37 (1.62)	49.51* (2,67)	0.6
4. Recreation open spaces (ROS)					
Proximity to ROS	231 (86.24)	227 (113.46)	290 (189.1)	1.44[ns] (2,67)	0.04
Number of ROS	5.5 (2.04)	3.89 (1.28)	2.96 (1.09)	16.99* (2,67)	0.34
Quality of ROS	267.12, (75.15)	158.57 (86.28)	88.53, (31.91)	48.45** (2,67)	0.59
Area of ROS	33449.04 (10797.11)	19223.28, (13862.92)	9064.04 (7486.98)	34.52** (2,67)	0.51
Nominal/ Ordinal Variable	TN (N=25) (%)	JP (N=18) (%)	BS (N=27) (%)	Chi2 test	
				$X^2\ (df)$	Cramer's V
7. Mode of travel to school					
Active mode	10	10	1.43	8.94* (2)	0.357
Passive mode	25.71	15.71	37.14		
7. License for independent mobility					
No IM	10	1.43	5.71	15.58** (4)	0.33
Some IM	2.86	4.29	18.57		
High IM (%)	22.86	20	14.29		

Reference: Author, Notes: (1) (*p<0.05, **p<0.01), (2) n.s. indicates non-significant correlations (p>0.05)

The above results showed a potential gender difference in social connectedness and its linked dimensions. Mitic, (Mitic *et al.,* 2021 Wave higher-quality friendships than boys. Results have demonstrated gender differences also in OOPA (Anderssen & Wold, 1992; Sallis *et al.,* 2000) and perceptions of the supportiveness of the neighbourhood for physical activity (Mecredy *et al.,* 2011) This suggests that gender is an important factor to consider in the investigation of the relationship between neighbourhood PE and the social connectedness of children. (Ashiabi & O'Neal, 2015; Bronfenbrenner & Ceci, 1994)

2) Children's Social Connectedness Across Neighbourhoods

This section presents descriptive statistics analysis (mean, SD) and the results of ANOVA (one-way ANOVA, Chi2 test) of objective variables and subjective variables of OPE across three neighbourhoods (TN, JP and BS) (See Table 4)

Children from JP (8.61) reported the highest levels of social connectedness followed by TN (6.75) and BS (2.92). Significant difference exit in SC across neighbourhoods (F=10.13, p=<0.001, n2=0.36). Similar to SC, children from

Footnote:

[1] A survey questionnaire measured Outdoor physical environment variables subjectively

JP reported having the most friends (5.5) and know most adults (3.89) in the neighbourhood followed by TN (Friends: 4.84, Adults: 2.48) and BS (Friends: 3.26, Adults: 1.78). There was a statistically significant difference in number of friends (F=7.41, p=0.001, n2=0.18). and number of known adults (F=15.81, p=<0.001, n2=0.32). Children from TN (6.81) report the highest mean score of friendship quality followed by JP (6.2) and BS (3.04) and the difference is statistically significant across the neighbourhoods (F=52.1, p=<0.001, n2=0.61).

3) Preliminary Insight into OPE and other Pathways Influencing Children's Social Connectedness

Spearman's ranked-order correlation analysis was performed for the entire sample (N=70) to identify and examine the strength and direction of the relationship of OPE variables (both subjective and objective measures) with children's social connectedness (SC), The significant correlations identified from this analysis are presented in (Table 5). Taking into account the preliminary exploratory nature of this pilot study which was expected to inform further research, the correlation results are discussed here by integrating the outcome of descriptive, ANOVA (Table 3&4) and correlation analysis (Table 5) in an interpretive manner

1. OPE Profile Across the Neighbourhoods

The cluster analysis done for the neighbourhood selection was based on limited data. Understanding the detailed physical profile of the neighbourhood was important to interpret the descriptive, ANOVA and correlation analysis results comprehensively. Hence, the hierarchical cluster analysis was performed again using the GIS data of six OPE characters computed within a 400-meter buffer around each child's home. (N-70). The dendrogram based on mean, median and SD values of four OPE factors reveals the following neighbourhood clustering pattern. (See Figure-2) The OPE profile of the three neighbourhoods has been comprehensively interpreted with the help of cluster dendrogram (Figure 2), descriptive statistics (Table 4), and observed characteristics of the neighbourhood (Table 1) as follows.

Jaripatka (JP) is the oldest (60-50 years old) neighbourhood with a higher density(0.89)and land-use mix (0.49). It has marginally lower street connectivity (263 intersection / sqkm) and traffic exposure (0.06) compared to TN and

has a moderate amount of ROS (19233 sq.m/sqkm) of moderate quality (158.57). JP is also undergoing partial redevelopment, implying a transition in its built form potentially towards mixed land use.

Whereas, Trimurti Nagar (TN) (40-30 years old), with its marginally lower built-up area density (0.8) and land-use mix (0.41) than JP, has higher street connectivity (284 intersections / sqkm) and traffic exposure (0.06) than JP. TN has ample ROS (33,449 sqm/sqkm) of high-quality facilities and amenities. (262.12). TN has a well-established infrastructure, reflecting its developed stage.

Besa neighbourhood, (<15 years old) has a low density (0.53), less street connectivity (59 intersections / sqkm) and a meagre amount of ROS (9064 sqm/sqkm) of the lowest quality (88.53). BS has the highest land-use mix (0.6) among the three neighbourhoods, suggesting a wide variety of land uses. The low density and high land-use mix of the BS neighbourhood indicates large parcels of vacant land. Overall, it suggests that BS is a relatively new and still-developing neighbourhood.

In conclusion, JP and TN are more similar in their OPE character and clustered together first. (figure 2). Both have similar built forms (built density, land-use mix and street connectivity) but differ in terms of exposure to heavy traffic and characteristics of ROS. BS has the most distinct OPE character compared to the other two. The re-analysis served to confirm the stability of the initial clusters and strengthened the validity of the study findings

2. Oopa as a Potential Pathway Linking OPE and Children's Social Connectedness

OOPA has demonstrated a high-moderate correlation (0.03<r> 0.5, P<0.01) with SC and its three sub-variables. (Table-5) which was consistent with Bronfenbrenner's preposition that the reciprocally interactive proximal processes are the mechanisms through which developmental potentials are actualised. (Ashiabi & O'Neal, 2015; Bronfenbrenner & Ceci, 1994) Literature has ample evidence of friendships and social interactions positively contributing to children's PA, AT and well-being. (Jago *et al.,* 2011; Sharma *et al.,* 2009; Wray *et al.,* 2020) and conversely, PA benefits various aspects of children's social development such as peer friendships, social interaction and integration, and social skills. (Holt *et al.*, 2011; Howie *et al.*, 2010) Moreover, existing literature supports the positive association of children's participation in PA (recreational and travel PA) with various neighbourhood PE factors

and characteristics like density, land use mix, (Frank *et al.*, 2007), access to child-specific destinations like schools, recreation facilities (Giles-Corti *et al.,* 2011; Timperio *et al.*, 2008), street Connectivity (Roemmich *et al.*, 2007), traffic Exposure, (Davison & Lawson, 2006), pedestrian and cycling infrastructure (Smith *et al., 2*017), and perceptions of safety and neighbourhood PA facilities. (Sallis *et al.*, 2000; Timperio, 2004) The convergence of previous research and the present study's preliminary analysis findings emphasises the potential role of OOPA as a pathway linking OPE and SC and upholds the key proposition of this study that children's OOPA was a significant social activity through which various social developmental outcomes are actualised enabling social connectedness. (Abdollahi *et al.*, 2023; Rogers, 2012)

3. OPE Pthways to Children's Social Connectedness

(a) Built from: The correlation analysis has revealed several significant strong to moderate correlations between OPE characteristics and SC and its related three dimensions. (number of friends, friendship quality and, known adults) (0.3 < r >0.05, p<0.001) (Table 5). As hypothesised built area density and street connectivity were found to be positively correlated with SC. However, the negative correlation of land-use mix with SC is unexpected as per existing literature. (Abdollahi *et al.,* 2023)

Higher values of these core features of urban form variables are indicative of compact urban forms and concentrated urban activities. High density means closely clustered dwellings, higher concentration of people and more number of children to play with, increased physical proximity and social contacts enhancing the possibility of children having greater peer and intergenerational social networks. (Christian *et al.,* 2015; Mouratidis, 2018) A higher land-use mix indicates greater availability of neighbourhood destinations to visit (recreational and utilitarian), creating opportunities for children for social interactions and activities. (Abdollahi *et al.,* 2023; Loebach & Gilliland, 2022) A highly interconnected street network implies direct and more alternate routes improving proximity to various children's neighbourhood destinations. (Davison & Lawson, 2006; Oliver *et al.,* 2015a) In conclusion, the synergetic effect of compact built form enhances walkability, use of recreational spaces, and visits to other destinations and creates opportunities for children's social interaction, activities and independent mobility. Many previous

studies have recognised the potential of these three core built-form features. (Abdollahi *et al.,* 2023; Frank *et al.,* 2007) In the present study, 61% (N= 43) of the children reside in TN and JP neighbourhoods, which have distinctly higher built-density and street connectivity compared to BS. (Table 4) Children from JP demonstrate the highest levels of social connectedness, number of friends and known adults closely followed by TN with marginally lower levels. Children living in BS, which is a sparsely built neighbourhood, show a low level of SC and its related dimensions among children. These findings are supported by previous research. (Abdollahi *et al.,* 2023; Frank et al., 2007).

Several factors may account for the negative association found between land use mix and children's SC in all three neighbourhoods in this study. Nagpur's long-standing history of city planning has resulted in the prevalence of mixed land-use planning and it continues to present-day planning practices of transit-oriented development. This ubiquity makes it challenging to detect the specific influence of land-use mix in any single area. The urban fringe neighbourhoods like BS have sprawling built forms but have the highest level of land-use mix. However, children can not leverage the benefits of a high land-use mix because of lower levels of residential density, street connectivity and underdeveloped pedestrian infrastructure and recreation spaces. Moreover, BS land use is characterised by large parcels of vacant lands, large commercial establishments, service-oriented businesses and construction material retail does not create social opportunities for children.

The redevelopment and densification process is already underway in JP where ad-hoc integration of commercial and mixed-use within residential areas has resulted in traffic congestion and encroachment of commercial activities and parking on roads and side footpaths, creating major obstacles for children's outdoor play and active travel and indirectly influences their social connectedness. The TN neighbourhood which was developed during the period of expansion of institutional housing shows the more planned approach to implementing a land-use mix. The main commercial use is located along the peripheral roads. The overall street network is better designed. This configuration may be more conducive to children's social connectedness.

Our, analysis reveals that even though a mixed Land-use planning pattern is prevalent in Nagpur and India, its advantages can not be obtained for improving children's SC unless its planning, execution, maintenance, its relationship with other OPE features and spatial configuration are subject to ongoing appraisal.

(b) **Transport:** Transport can influence children's PA and social health through two primary ways, exposure to traffic and mode of travel (Abdollahi *et al.,* 2023)

(c) **Traffic exposure:** Traffic exposure showed a significant positive association with SC and quality

of friendships which was not consistent with anticipated results (See Table 5). Acknowledging the data limitations of this pilot study a tentative explanation for this phenomenon can be given as follows. ANOVA indicates that TN and JP (61% of the total sample) have similar built-form characteristics which are distinctly different from BS (Post-hoc tests, all adj. p < 0.05) (See Table 4). The traffic exposure significantly differs among the three neighbourhoods. (Post-hoc tests, all adj. p <0.05). Notably, TN has a significantly higher proportion of high-speed roads. (Adj. p<0.001) compared to JP and BS, but the difference in children's perception of traffic safety is non-significant.
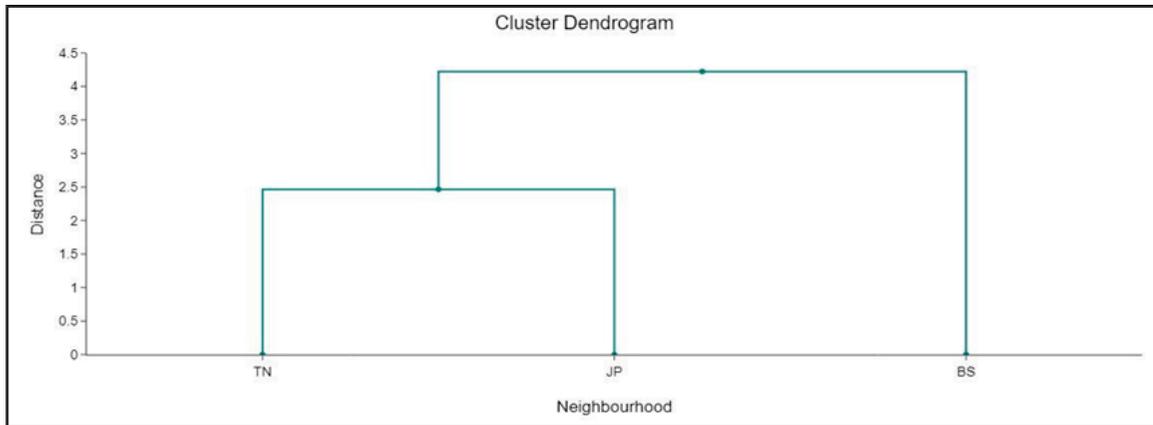

Fig. 2: Hierarchical cluster analysis: Dendrogram of three Neighbourhoods for OPE factors
Reference: (Statistical analysis using SPSS ver. 26.0.0); (Data visualization: DATAtab (DATAtab Team, 2024).

Table 5: Association between social connectedness and outdoor physical environment characteristics of the neighbourhood.

Variables	Social connectedness	No. of friends	Friendship quality	Number of known adults
OPE characteristics	Spearman's Rank-Order Correlations (r, p-value)			
1. Built-up-area-density	**0.55****	0.41**	**0.65****	0.38**
2. Land-use-mix	**-0.45****	-0.33**	-0.49 **	-0.29**
3. Street connectivity	**0.52****	0.35**	**0.61****	0.28*
4. Traffic Exposure	**0.36****	ns	**0.58****	ns
5. Footpath availability	**0.51****	0.34 **	**0.7*****	0.220*
6. Utility of pedestrian and cycling infrastructure	**0.53****	0.39 **	**0.65*****	0.37**
7. Proximity to ROS in buffer	ns	ns	ns	ns
8. Number of ROS in buffer	0.26 *	ns	0.35**	ns
9. Amount of ROS in buffer	0.34**	ns	0.41**	ns
10. Quality of ROS	0.42**	0.24*	0.49**	ns

(Table 5 Contd ....)

(.... Contd Table 5)

11. Perception of Traffic safety	0.24*	ns	0.33**	ns
12. Perception of Personal Safety	ns	ns	0.39**	ns
13. Perception of PA environment in the neighbourhood	**0.50****	0.44**	**0.50****	0.30*
Personal characteristics and other factors				
14. Outdoor out of school PA	**0.57****	**0.54 ****	0.42 **	0.47**
15. Motivation for PA	**0.65 ****	0.49 **	**0.72 ****	0.47 **
Point-biserial Correlation (rpb,p-value)				
16. Gender	0.33**	0.27*	0.35**	0.39**
17. Mode of travel to school	ns	0.31**	0.35**	ns
Eta Correlations (n, p-value)				
18. Licence for IM	0.41*	0.45*	0.38*	0.32*

In all three neighbourhoods, the high-speed roads are on the periphery and it did not appear to adversely influence children's perception of traffic safety implying it was positively contributing to children's SC. As noted previously, JP has a relatively more compact built form and mixed community character. Previous studies have suggested that that it favours more vibrancy of activities and supports social cohesion thus fostering a socially interactive environment and incidental community connections. (Kotharkar *et al.,* 2014; Waygood & Friman, 2015). However, we find that children from TN though exposed to high traffic have better SC and friendship quality than JP. This finding is similar to Waygood's *et al.,* (2017) study investigating the relationship between children's mode of travel and incidental social interactions which suggests that active travel regardless of traffic exposure increases incidental social interactions. Furthermore, we note that even though slow, the traffic congestion on the access roads might hinder children's mobility as in the case of JP, where densification and redevelopment are already emerging but not effectively managed.

(d) **Travel: Active travel to school and license for independent mobility:** The data of the present study demonstrated the insignificant difference in the active travel (AT) mode to school and licence for independent mobility (IM) by gender. However, there was a significant difference in AT to school (F=8.94, p<0.05) and in the licence for IM (F=15.58, p<0.05) across the neighbourhood. Given the

significant difference in the OPE characteristics across the neighbourhoods, the variation in AT and IM was expected and it is supported by existing literature.
(Frank *et al.,* 2007; Tyagi & Raheja, 2021)

Correlation analysis showed that AT to school has a moderate association with, the number of friends (r= 0.31, p=<0.05) and quality of friendships (r = 0.35, p=<0.05) and had no considerable association with overall SC and the number of known adults. (See Table5) Very few from TN and JP (10% each) and just a minuscule (1.46%) number of children use AT mode to school. The lack of significant association between AT to school and overall SC or the number of known adults may be because, in Nagpur, children commonly attend schools outside their neighbourhood and use passive modes of transport and clock in longer time commuting to schools. Potentially reducing their opportunities to interact with neighbourhood peers and neighbours. (Tyagi & Raheja, 2021) However, licenses for children's IM showed a consistently significant moderate correlation with overall SC (r= 0.41, p=<0.05), the number of friends (r= 0.45, p=<0.05), quality of friendships (r = 0.38, p=<0.05), the number of known adults (r = 0.32, p=<0.05). Even though TN has well well-developed infrastructure, the proportion of children having no IM is higher (10%) as compared to JP (1.43%) and BS (5.71%)

PE characteristics influence children's travel behaviour and collectively create various conditions

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that may be linked to various positive developmental outcomes. (Panter *et al.,* 2010; Schoeppe *et al.,* 2013) Active and independent travel naturally aligns with the children's developmental need for competence and independence and fosters deeper connections with the surrounding physical and social environment. (Eccles, 1999) Though children's active independent mobility is frequently linked with PA (Giles-Corti *et al.,* 2005; Panter *et al.,* 2010), its social developmental benefits are relatively less investigated. Some studies have associated AT with more intentional and incidental social interactions during the journey strengthing their peer friendships and community connections. (Waygood *et al.,* 2017; Waygood *et al.,* 2021). Studies investigating IM link it with increased peer activities, self-confidence, sense of community and safety, contributing to the feeling of connection with peers and community. (Pacilli *et al.,* 2013).

Given the neighbourhood profile discussed earlier in this paper, though TN has a relatively well-developed infrastructure, JP with its comparatively deficient infrastructure yet compact built form, and vibrant street life, is more socially engaged, with more eyes on the streets and seems to be more conducive for children to actively travelling to school. In the context of neighbourhoods in Nagpur, children's IM proved to be a potential pathway to enhance children's SC. Some other previous studies have reported similar findings. (Kyttä, 2004; Tyagi & Raheja, 2020; Waygood *et al.*, 2017)

(e) Pedestrian infrastructure: Neighbourhood-level infrastructure deprivation is widely prevalent in Indian urban neighbourhoods (Dutta *et al.,* 2017) A recent report on walkability research report in Nagpur, states that 73% of footpaths are not used by children which is a concerning indicator of infrastructure conditions. This report describes pedestrian infrastructure problems like incomplete, discontinuous design, narrow widths, encroachment, litter, and neglected maintenance. (ESAF & Health Bridge, 2015-2016) In a situation where walking on the footpaths becomes a task for the children, it is essential to understand how it influences children's PA and SC. The ANOVA results demonstrate a significant difference in footpath availability (F=139.18, p<0.05) and the utility of pedestrian and cycling infrastructure

(F=49.51, p<0.05) (See Table 5). The large effect size (n2= >0.35 for both) suggests both these OPE characteristics are distinguishing features among the three neighbourhoods. The consistency of moderate to strong correlations of availability and utility of the pedestrian and cycling infrastructure with SC and number of friends, known adults and quality of friendships (See Table 5) highlights the importance of the supportive role of pedestrian infrastructure in enhancing children's SC in all respects. OOPA is also demonstrating a significant moderate correlation with availability (r=0.28,p=<0.05) and utility (r=0.35, p=<0.05) of pedestrian infrastructure.

Similar to findings from the previous studies, these results also suggest that neighbourhoods with adequate, safe, well-mannered pedestrian infrastructure may encourage walking and cycling enhancing opportunities for social encounters and interaction fostering social connections and facilitating possibilities incidental and intentional OOPA. (Ortegon-Sanchez *et al.,* 2021; Waygood & Friman, 2015)

(f) Recreational open spaces (ROS): Building upon the earlier discussion on the PPC model and the role of OOPA as a conncetor between OPE and the social development of children, we now discuss the role of neighbourhood ROS in the interplay of OOPA and children's social lives. Though the presence of a greater number of ROS in the neighbourhood promotes non-school PA, (Timperio *et al.,* 2008) but some reviews have highlighted the mixed findings in the literature. (Koohsari *et al.,* 2015) Hence not only the presence of ROS but also the attributes like proximity, variety, quantity and quantity of ROS speculated to promote its actual use and playability are important to enhance children's physical and social activities. (Frank *et al.,* 2007)

There was no considerable neighbourhood difference in the proximity of ROS but a significant variation (p=<0.05) in the number, area and quality score of ROS within the 400-meter buffer from the child's home was demonstrated. The number (r=0.25 and r=0.35, p=<0.05) and amount of ROS (r=0.34 and r=0.41, p=<0.05) showed only minor to moderate correlations with children's overall SC and quality of friendships. However,

consistent significant positive correlations were observed in the quality score of ROS and children's overall social connectedness (r=0.42, p=<0.05), number of friends (r=0.24, p=<0.05), and quality of a friendship (r=0.49, p=<0.05). These findings suggested that the quality of ROS, measured as an audit assessment score of features like access and surroundings, play facilities, amenities, aesthetic features and safety are more effective in enhancing children's overall SC by contributing to the development of peer friendships.

In Indian urban neighbourhoods, a deficit in infrastructure provision and maintenance is a pervasive issue. The proximity, number and area requirements of neighbourhood ROS are partially met due to mandatory statutory regulations but the provision of age-appropriate play facilities, amenities, physical and personal safety features and general aesthetics and upkeep of ROS, which are crucial factors in stimulating children's interest and attracting them to visit ROS regularly, does not meet the required standards. (Loon & Frank, 2011) These findings are similar to previous studies drawing attention to the importance of well-maintained, safe neighbourhood ROS equipped with high-quality age-appropriate facilities to provide more diverse opportunities for peer activities like cooperative play, team sports, exploration and informal gatherings resulting in physical and social development outcomes like increased physical activeness (Cohen *et al.,* 2006; Dunton *et al.,* 2009) development of social skills, building relationships, and forming a sense of community synergetically enhancing children's social connectedness. (Loebach & Gilliland, 2022; Veitch *et al.,* 2008)

(g) **Perceptions of the neighbourhood:** Children's perceptions of the environment are shaped by their everyday experiences with the physical objects, social situations, obstacles and opportunities for their everyday activities in their living environment. Children's perceptions of the environment are also influenced by the child's characteristics like physical ability, social needs and motivations for PA. As per the bio-ecological model discussed earlier, it aligns with the reciprocal nature of interaction between the growing individual and their environment. (Ashiabi & O'Neal, 2015; Högman *et al.,* 2020) Perceptions of safety are often based on threats of physical harm, and incivilities, which denotes a negative appraisal of the environment which may be unfavourable for children's outdoor play and exploration, while perceptions of neighbourhood PA environment which is an assessment of satisfaction with the availability, usability of PA facilities and prevalence of the play culture in the community which stems from the positive appraisal of the environment as supportive to their outdoor physical and social activities.

(h) **Perceived Personal safety:** The descriptive and ANOVA analysis of children's perceptions of traffic safety demonstrated the highest mean score for TN (2.52), followed by JP (2.44) and the lowest score was achieved by BS (1.96) but this difference was not statistically significant. Perception of traffic safety was showing only weak to moderate correlations with overall SC and quality of friendships. (r = 0.24 and 0.33, P=<0.05). Perceived personal safety was highest in TN (2.52), followed by JP (2.06) and the lowest was in BS (1.48) and this difference was statistically significant. Perceived personal safety was found to correlate only with the quality of friendships (r=0.39, p=<0.05). Both the safety perceptions were found to have insignificant correlations with OOPA. These results differ from some previous studies that found a significant positive correlation between PA and traffic and the personal safety of children. (Carver *et al.,* 2008; Shortt & Ross, 2021; Timperio, 2004)

(i) **Perceived traffic safety:** The descriptive and ANOVA analysis of children's perceptions of traffic safety demonstrates the highest mean score for TN (2.52), followed by JP (2.44) and the lowest score was achieved by BS (1.96) but this difference was not statistically significant. Perception of traffic safety was showing only weak to moderate correlations with overall SC and quality of friendships. (r= 0.24 and 0.33, P=<0.05). Perceived personal safety was highest in TN (2.52), followed by JP (2.06) and the lowest was in BS (1.48) and this difference was statistically significant. Perceived personal safety was found to correlate only with the quality of friendships (r=0.39, p=<0.05). Both the safety perceptions were found to have insignificant correlations with OOPA. These results differ from some previous studies that found a significant positive correlation between PA and traffic and the personal safety of children. (Carver *et al.,* 2008; Shortt & Ross, 2021; Timperio, 2004)

The result was comprehensible as TN, and JP have relatively developed street and pedestrian infrastructure compared to BS and the peripheral location of high-speed roads across the neighbourhoods makes it feel safer for children to move around in the neighbourhood. Personal safety was the highest in a well-developed TN, followed by JP where there was more influx of people in the neighbourhood on account of an integrated and higher proportion of land-use mix resulting in heightened street activities. As the results suggest, neighbourhood safety perceptions do not show an effective influence on PA and SC. (Taylor *et al.,* 2018) Alton *et al.,* (2007) in a recent study exploring the effects of perceptions on children's PA, has found that though safety perceptions independently influence children's PA, it doesn't interfere with the relationship between OPE and PA. (Alton *et al.,* 2007) These research findings were similar to our findings suggesting neighbourhood safety perceptions might not be influencing children's PA and social interactions to the extent it can affect their SC. It is also widely acknowledged that children's feelings of safety are very important for their outdoor activities and neighbourhood mobility leading to more social engagement. (Carver *et al.,* 2008)

(j) Perceive neighbourhood physical activity environment: The descriptive and ANOVA analysis of children's perceptions of the neighbourhood PA environment demonstrated the highest mean score for TN (6.41), followed by JP (5.83) and the lowest score was achieved by BS (4.85) and this difference was statistically significant. (See Table 4) Correlation analysis reveals a significant moderate to strong relationship with overall social connectedness (r = 0.55), number of friends (r = 0.44), quality of friendships ((r = 0.50), and known adults (r = 0.30), (p =<0.05 for all). (See Table 5) These results were in line with the findings of the previous studies, suggesting availability and quality of neighbourhood recreation facilities positively influence children's activity levels. (Hayball *et al.,* 2018; Wong *et al.,* 2010) Neighbourhood parks and playgrounds equipped with age-appropriate play, and sports facilities are major neighbourhood attractions specifically for children in their middle childhood as they fulfil their developmental-stage specific needs of outdoor exploration and physical

and social peer activities like group play, and spending time with friends. (Loebach & Gilliland, 2022; Rogers, 2012) The preceding discussion on children's perceptions of safety and supportiveness of the neighbourhood environment suggests that neighbourhood perceptions form a feedback loop. Positive neighbourhood perceptions encourage outdoor activities and social interactions, further improving children's perceptions of the OPE as a safe, enjoyable and socially stimulating place. This reciprocal reinforcing relationship is significantly effective in improving children's SC. (Motl , 2007) Moreover, integrating both objective (spatial) and subjective (perceptions) measures can provide a complete assessment of complex neighbourhood physical environments (Villanueva *et al.,* 2016) and refine the pathways in which OPE influence a child's social development.

CONCLUSION

This study was among the first to examine the complex relationship of children's social well-being with OPE of urban neighbourhoods in India. Considering the lack of previous research of a similar kind, the research was framed as an exploratory pilot study with a limited sample. The notable contribution of this study is the comprehensive operationalisation of variables within the theoretical framework of Bronfenbrennr's Process-Person-Context (PPC) model of human development. The context-specific, field-based investigation of this relationship has identified both expected and unexpected patterns of association between OPE and personal characteristics, the proximal process of OOPA and the developmental outcome of social connectedness.

The study has included both objective and subjective measures to get a comprehensive understanding of the complex spatial, socio-economic and cultural profile of the Indian urban neighbourhoods. Recalling the results, OOPA as expected has emerged as a highly effective interface between OPE and children's social activities in the form proximal process. Enjoyable PA experiences in child-friendly, safe OPE, can lead to a more positive perception of the neighbourhood environment, further encouraging children to spend more time outside, increasing social interaction and activities, and developing more social connections and bonding.

The study has identified compact built-form characteristics like built density and street connectivity as having a

significant influence on children's SC. Unexpectedly, the relationship between SC and the land-sue mix was negative and drew attention to the need for context-specific implementation and appraisal of mixed-use development or it may negatively influence social interactions.

The micro-built environment features like pedestrian infrastructure availability and utility have proved to be important factors to consider to increase children's active independent travel leading to more social connectedness. Children opting for active modes of travel seem to be affected by exogenous factors like distant school locations rather than OPE characteristics of the neighbourhood. Well-developed and compact neighbourhoods, having usable pedestrian infrastructure proved to be favourable for children's independent travel further positively influencing their SC.

The variety, size and quality of neighbourhood ROS have been identified as more important features, contributing to children's SC than just the proximity of ROS from a child's home. Positive perceptions about personal safety and supportiveness of OPE for PA were found to be instrumental in enhancing children's social connectedness. Given the exploratory nature of the pilot study, it proved instrumental in identifying useful patterns of associations between OPE characteristics and children's social well-being in the context of urban neighbourhoods in India.

In conclusion, this paper presents a case of an initial foray into the field of neighbourhood PE effects on child social well-being. Considering the fast-transforming urban environments with vast diversity in the socio-cultural, and economic pressures on development which is unique to India, particularly with its large children population, this study initiates an intense discourse on the impact of urban physical environment on child development and well-being. This study conducted in Nagpur, a case of fast transforming and expanding typical tier-II cities of India, demonstrates high relevance and potential for transformative impact.

CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors

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