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First-mile walking, neighbourhood walkability and physical activity in Bangkok, Thailand

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Introduction: First-mile walking (FMW) supports sustainable mobility and public health by enabling utilitarian and recreational walking. However, its relationship with neighbourhood walkability and physical activity remains underexplored in tropical, high-density cities like Bangkok. This study examines these associations.

Methods: A cross-sectional survey of 881 Bangkok residents from 50 districts assessed neighbourhood walkability (NEWS-A) and physical activity (GPAQ). Multivariable logistic regression models examined associations between walkability, FMW, and sufficient physical activity (≥150 min/week).

Results: Higher neighbourhood walkability significantly increased both utilitarian and recreational FMW. High-rise residents were more likely to engage in utilitarian walking, while planned and high-rise neighbourhoods supported recreational walking. Utilitarian walking strongly correlated with achieving sufficient physical activity.

Conclusion: Neighbourhood design plays a critical role in promoting walking and physical activity. Policy efforts should prioritise pedestrian infrastructure, green spaces, and transport connectivity to encourage active lifestyles.

KEYWORDS

first-mile walking, neighbourhood walkability, physical activity, Bangkok, landscape architecture, urban health

1 Introduction

Walking, a fundamental human activity, offers immense benefits to public health and urban sustainability (Liu et al., 2020; Zhao et al., 2022). As a mode of transportation, walking reduces air pollution, mitigates traffic congestion, and fosters physical and mental wellbeing (Garg and Sharma, 2022; Grant, et al., 2017; Bryan and Katzmarzyk, 2009). It is particularly critical in urban areas, where promoting walkability is essential to achieve sustainable urban development. First-mile walking (FMW), which encompasses the initial segment of any journey typically originating from home, plays a significant role in enabling active transportation and recreational activities. In literature, FMW is commonly classified into two categories: utilitarian and recreational walking. First-mile utilitarian walking involves purposeful trips from home to specific destinations, such as

workplaces, schools, or public transport hubs (Watson et al., 2021; Fonseca et al., 2021). In contrast, first-mile recreational walking encompasses activities undertaken for leisure, health, or relaxation (Hekler et al., 2012; D'Hooghe et al., 2022).

The theoretical foundation of FMW is rooted in fields of transportation studies, urban planning, and public health. FMW has its origins in transportation research, where it is recognised as a crucial element in promoting non-motorised travel and improving access to public transport systems in urban areas (Kåresdotter et al., 2022). In urban planning, FMW is grounded in the compact city and garden city models, which advocate for high-density, mixed-use developments where urban facilities and amenities are designed to be accessible within a short walking distance from home (Ha et al., 2023). In public health, FMW is widely recognised as a key component of active travel, offering numerous health benefits. For example, studies have shown that FMW can lead to a reduction in the risk of cardiovascular diseases, obesity, hypertension, and type 2 diabetes (Omura et al., 2019; Oja et al., 2018). FMW is also associated with higher overall physical activity, which is crucial for maintaining a healthy weight and reducing chronic disease risk (Laeremans et al., 2017). Furthermore, the World Health Organization recommends that adults engage in at least 150 min of moderate-intensity aerobic activity per week, a goal that can be effectively supported through FMW (WHO, 2020). Additionally, FMW is recognised in the World Health Organization's Global Action Plan for Physical Activity as a key strategy for promoting physical activity and enhancing mental wellbeing (WHO, 2018). In other words, investing in FMW is one of the most effective strategies for promoting physical activity and a healthy lifestyle among urban populations.

The significance of FMW has grown in recent years, particularly since the COVID-19 pandemic, which reinforced the importance of local mobility and walkable neighbourhoods (Abusaada and Elshater, 2024). As social distancing measures and reduced motorised travel became the norm, walking emerged as a vital and safe activity near homes. This shift in mobility patterns created an opportunity to integrate first-mile walking into urban planning, notably through the '15-minute city' model (Tan et al., 2024; Wolański, 2023). This model emphasises the development of neighbourhoods where residents can conveniently access essential services—such as parks, schools, and workplaces—within a short walking distance. This model underscored the necessity of reimagining urban design to prioritise pedestrian-friendly environments, highlighting FMW as a fundamental component of sustainable, health-promoting cities (Rojas-Rueda and Morales-Zamora, 2021).

In both urban planning and public health literature, one of the important determinants of FMW is the neighbourhood walkability. Extensive research in Western countries has established that neighbourhood walkability characteristics play a crucial role in promoting FMW (Melnikov et al., 2022; Bedra et al., 2023; Tarek et al., 2021). Studies have consistently shown that people exposed to neighbourhood walkability factors such as pedestrian infrastructure, street connectivity, and access to green spaces, significantly influences FMW (Stefanidis and Bartzokas-Tsiompras, 2024; Elfituri and Hassan, 2021; Hussein, 2018). Moreover, walkable neighbourhood environments have been linked to increased physical activity levels and improved mental health outcomes among urban residents (Xu et al., 2024; Arifwidodo, and Chandrasiri, 2024). This growing body of evidence has led many cities to prioritise neighbourhood-level interventions for promoting walking as an urban planning and public health strategy.

However, the relationship between walkable neighbourhood environments and first-mile walking is more complex in cities like Bangkok. Previous studies identify four primary factors that make walking in Bangkok particularly challenging (Arifwidodo et al., 2021; Arifwidodo et al., 2019). First, the city's tropical climate presents significant challenges, including extreme heat and seasonal rainfall, which discourage outdoor activities and necessitate the creation of shaded and weather-resistant pathways. Second, its diverse urban fabric, characterised by mixed-use development, unplanned settlements, and high-rise apartments alongside planned housing projects in the outskirts, creates fragmented walking networks that often lack connectivity. Third, informal street markets and motorised traffic frequently dominate pedestrian spaces, further complicating efforts to establish walkable neighbourhoods. Fourth, the cultural and social norms favour car usage, as cars are often seen as symbols of status and convenience. This preference is reinforced by urban planning decisions prioritising road expansion and vehicle infrastructure over pedestrian pathways. Additionally, the lack of incentives for walking and the dominance of motorised traffic contribute to an environment where walking is perceived as impractical or unsafe. As a result, FMW in Bangkok predominantly occurs within residential complexes such as apartments, condominiums, and gated housing estates. These environments offer better-designed amenities that support walking, in contrast to many public spaces that lack pedestrian-friendly infrastructure (Arifwidodo and Chandrasiri, 2023).

Bangkok encountered two significant challenges in promoting FMW. The first challenge is an infrastructure and policy misalignment, as the Bangkok Metropolitan Administration (BMA) has historically prioritised pedestrian infrastructure in tourist areas, recognising its importance for economic development, resulting in inadequate provisions for first-mile walking in residential neighbourhoods. This approach fails to address the daily mobility needs of residents, restricting opportunities for regular physical activity and active lifestyle. The second is a knowledge gap in understanding how Bangkok's unique urban context affects FMW. While extensive research has been conducted on FMW and neighbourhood walkability in United States and European cities, there is limited empirical evidence on how these relationships manifest in Bangkok. Specifically, the impact of walkability factors on first-mile utilitarian and recreational walking in Bangkok remains poorly understood.

To address these gaps, this study examines the relationship between first-mile walking, neighbourhood walkability, and physical activity by answering two key research questions: (1) To what extent is the neighbourhood walkability associated with first-mile utilitarian and recreational walking in Bangkok's urban context? And (2) Does engaging in first-mile utilitarian and recreational walking in the neighbourhood correlate with achieving sufficient physical activity among Bangkok residents? This study employed a cross-sectional survey design with 881 residents from 50 districts in Bangkok, using the Neighbourhood Environment Walkability Scale-Abbreviated (NEWS-A) to assess walkability and the Global Physical Activity Questionnaire (GPAQ) to measure physical activity levels. The analysis used multivariable logistic regression models to

examine the relationships between neighbourhood environment, first-mile walking, and physical activity.

Two contributions of the study were identified. First, it enriched the understanding of the link between FMW, neighbourhood walkability, and physical activity in Bangkok, contributing to the broader literature on FMW and neighbourhood walkability in rapidly developing cities facing similar challenges. Second, it provided practical recommendations to the Bangkok Metropolitan Administration (BMA) to inform policies and interventions aimed at promoting walkable neighbourhood environments in Bangkok.

2 Materials and methods

2.1 Study area

Bangkok, the capital of Thailand, is inhabited by more than 8 million people in an area of 1,569 sq. Km (Bangkok Metropolitan Administration, 2018). The city's complex environment significantly influences utilitarian and recreational first-mile walking activities. Bangkok's urban infrastructure vary considerably across different areas, impacting pedestrian behaviours. The Bangkok Metropolitan Administration (BMA) divides the city into 50 districts and three distinct zones, representing the zoning policies that differentiated the levels of urban density, public infrastructure and amenities distribution (Arifwidodo et al., 2019; Arifwidodo et al., 2021). The first is the inner Bangkok, the city's historical, tourism, and economic centre, characterised by vertical development due to space constraints. This zone has the highest built-up area density and the most comprehensive public infrastructure and amenities, including walking infrastructure and public transportation options. The second zone is the Outer Bangkok, which includes residential, commercial, and industrial areas connected by public transportation systems. This zone has moderate density and a mix of high-rise and low-rise buildings with varying levels of public infrastructure and amenities availability. The third zone, the urban fringe, mostly consists of residential development zones that blend urban and rural elements. This zone has the lowest density, fewer high-rise buildings, and less availability of public infrastructure and amenities, including parks and public transportation options. Figure 1 summarises the boundaries of the zones and land use in Bangkok.

2.2 Survey design

This study was based on two key premises supported by existing literature: that neighbourhood environments played a significant role in shaping urban walking behaviours and that engaging in first-mile walking, whether for utilitarian or recreational purposes, contributes to achieving sufficient physical activity. Figure 2 summarises the conceptual framework of this study.

A cross-sectional study design was employed to examine the relationship between neighbourhood environment, first-mile utilitarian and recreational walking, and physical activity levels among Bangkok residents using a self-reported survey questionnaire. This approach was selected for its ability to provide a snapshot of these associations at a specific point in time. It was particularly suited for exploratory research aimed at identifying patterns and relationships within a rapidly urbanising context such as Bangkok. Additionally, cross-sectional studies are commonly used in public health and urban planning research, offering valuable insights for policy development and intervention planning (Arifwidodo, 2014; Audrey and Batista, 2017). Given the limited research on first-mile walking in Bangkok, this study allows for a comprehensive exploration of the factors influencing walking behaviours across diverse neighbourhood settings.

The self-reported survey questionnaire was employed to capture subjective perceptions of neighbourhood walkability and FMW, which are challenging to measure objectively. Such data offer valuable insights into residents' experiences, highlighting social and environmental influences on walking (Rosso et al., 2024; Frehlich et al., 2024). Despite inherent limitations, self-reported surveys remain a practical and cost-effective means of gathering data from a large, diverse sample, making them particularly suitable for this study. The rationale for selecting variables in this study is detailed in Section 2.3.

To ensure a comprehensive representation of Bangkok's diverse neighbourhood environments, we employed a quota sampling approach with a target of 900 respondents. Given that our unit of analysis was Bangkok as a whole rather than individual districts, we adopted a district-based clustering strategy to capture variations in urban environments. The city was divided into 50 administrative districts, reflecting its urban zoning policies and variations in walkability. All 50 districts served as clusters, providing comprehensive citywide coverage. Within each cluster, 18 respondents were randomly selected using the Bangkok Metropolitan Administration's (BMA) official household registry, allowing for equitable representation across different neighbourhood types (unplanned, high-rise, and planned neighbourhoods) and zoning classifications (inner, outer, and suburban Bangkok). A random number generator was employed for respondent selection within each district, ensuring an unbiased sampling process. To enhance representation, we applied additional criteria: (1) geographic distribution–ensuring balanced representation across all neighbourhood and zoning types; (2) demographic representation–capturing respondents across different age groups, income levels, and education backgrounds to reflect Bangkok's socioeconomic diversity; and (3) first-mile walking variation–including participants with varying levels of physical activity and residential environments to ensure broad representation of first-mile walking. This sampling strategy ensured methodological rigour by systematically reflecting Bangkok's socio-spatial diversity while mitigating selection bias. Previous studies support this methodology as an effective way to enhance the reliability and generalizability of findings (Arifwidodo and Chandrasiri, 2020; Arifwidodo et al., 2022).

Ten trained surveyors conducted face-to-face interviews with the participants. These surveyors were master's students from the Faculty of Architecture, Kasetsart University, specialising in landscape architecture, architecture, and urban planning. A 3-day training session and a pre-survey were implemented to ensure consistency in data collection. The survey took place between 1 December 2022, and 31 January 2023. As a token of appreciation, participants received a souvenir worth 30 THB (approximately 1

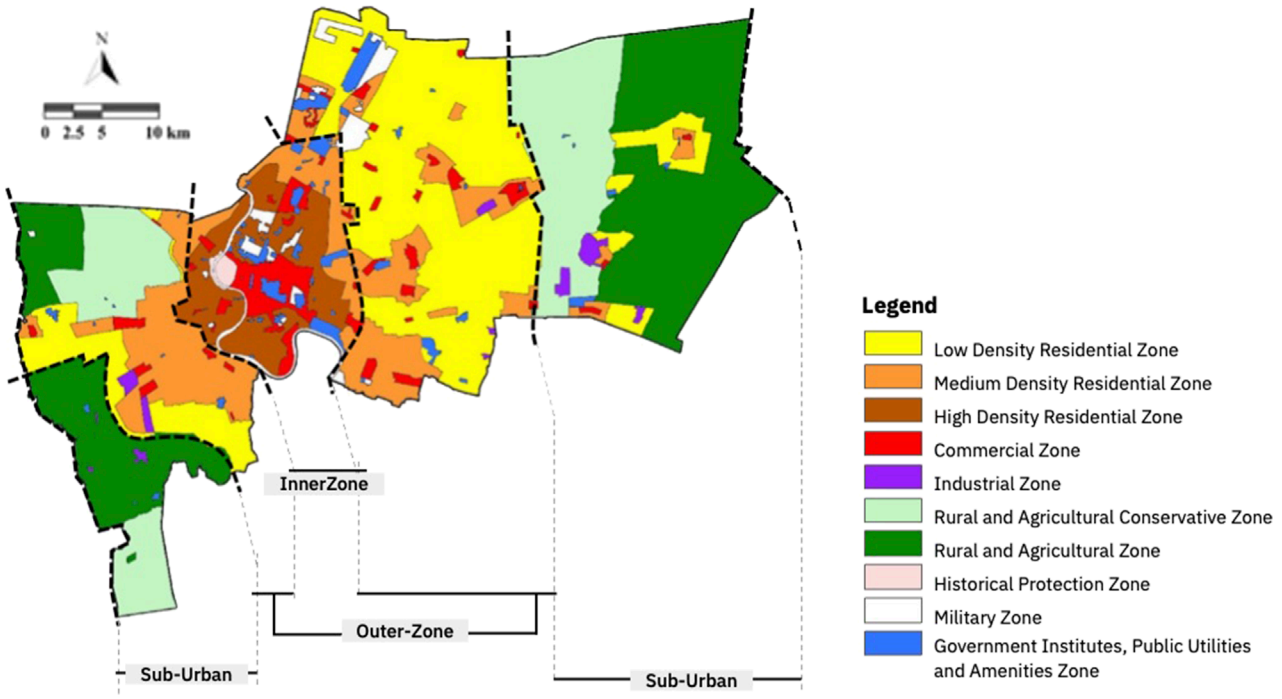

FIGURE 1
Bangkok zone and land use adapted from Bangkok Metropolitan Administration (2013).

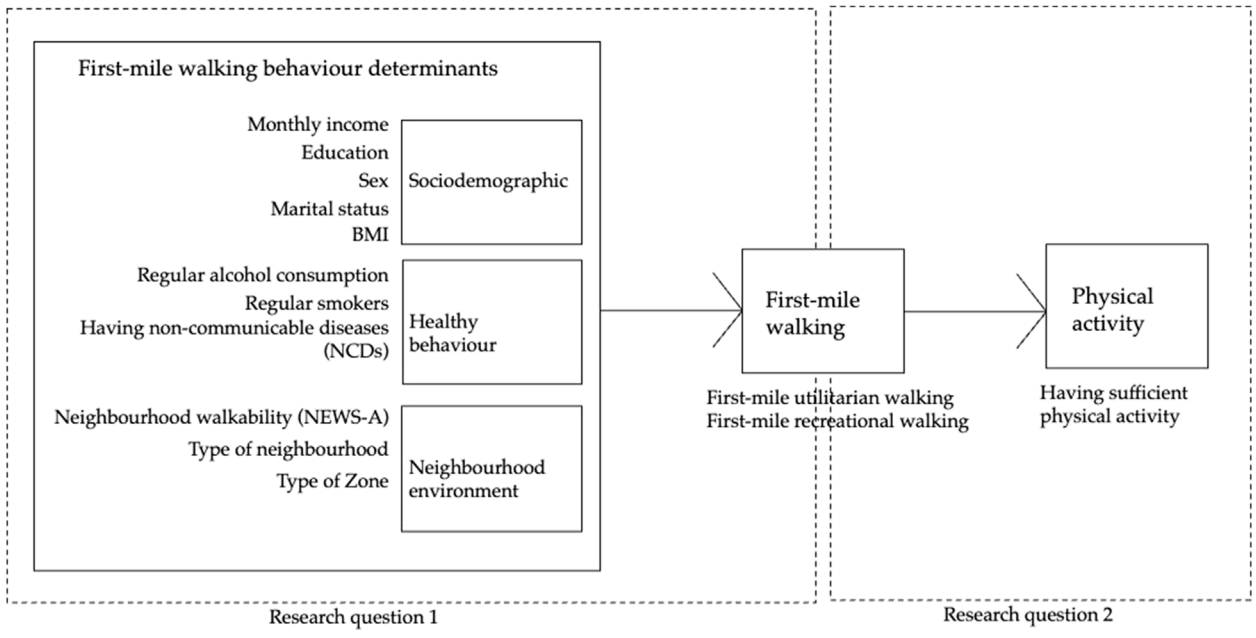

FIGURE 2
Conceptual framework of the study.

USD) upon completion of the interview. Following data cleaning procedures, 881 valid responses were included in the analysis.

Ethical approval for this study was granted by the Institutional Review Board of Silpakorn University, adhering to the ethical principles outlined in the Declaration of Helsinki. The questionnaire encompassed four main sections: socioeconomic characteristics, physical activity and health behaviours, neighbourhood environment features, and walking behaviours. The reliability

of questionnaire items was assessed using Cronbach's alpha, with values ranging from 0.78 to 0.91, indicating strong internal consistency.

2.3 Variables and measures

In this study, first-mile walking (FMW) was categorised into two types: utilitarian and recreational, following previous studies (Chaix et al., 2014; Sugiyama et al., 2015). Utilitarian walking refers to walking from home to reach a particular destination or to complete a task, such as commuting to school, visiting the market, or accessing nearby public transport stops. Recreational walking, on the other hand, is characterised as walking undertaken for enjoyment, relaxation, or physical activity without a defined destination within the neighbourhood. These behaviours were assessed through two survey questions: (1) whether respondents engaged in first-mile utilitarian walking within the past week, and (2) whether they participated in first-mile recreational walking during the same period. Both variables were recorded as binary responses (yes/no).

We used three proxy variables to measure neighbourhood environment determinants. The first variable was the Neighbourhood Environment Walkability Scale-Abbreviated (NEWS-A), a standardised tool that evaluates neighbourhood walkability. This tool and its various adaptations have been extensively validated and utilised across different contexts to measure neighbourhood walkability, particularly for first-mile utilitarian and recreational walking (Baobeid et al., 2021). The NEWS-A measures eight subscales using a five-point Likert scale, with lower scores representing lower walkability and higher scores representing higher walkability. In this study, the NEWS-A scores were dichotomised into "high walkability" and "low walkability" for analysis, following previous studies (Arifwidodo and Chandrasiri, 2023; Arifwidodo and Chandrasri, 2024). The NEWS-A variables in this study demonstrated acceptable internal consistency (Cronbach's $\alpha = 0.83$).

The second proxy variable was neighbourhood type, categorised as unplanned neighbourhood, high-rise neighbourhood, and planned neighbourhood, following previous studies (Boonjubun, 2019; Arifwidodo and Chandrasiri, 2013). The Bangkok Metropolitan Administration (BMA) categorised the neighbourhoods in Bangkok into three types (Bangkok Metropolitan Administration, 2018). The first type is the unplanned neighbourhoods, which formed organically without formal planning. These areas feature mixed land use in dense regions, including informal settlements, and are mostly located in the inner urban areas of Bangkok. The second type is the high-rise neighbourhoods, primarily located in both inner and outer Bangkok, catering to middle and upper-income residents. These neighbourhoods offer modern amenities and vertical living, significantly altering the city's skyline, and include vertical government housing. The third type is the planned neighbourhoods, typically residential areas, often gated, aiming to provide a higher quality of life with controlled environments. These neighbourhoods are commonly found on the urban fringe of Bangkok. In the literature, unplanned neighbourhoods, mostly located in the city centre, are likely to have better sidewalks and connectivity with other areas, especially when located near tourist destinations (Cao et al., 2006). High-rise neighbourhoods, interpreted as apartments or condominiums, can offer green spaces and facilities for recreational walking (Maleki et al., 2022). In the literature, planned neighbourhoods are often designed with infrastructure supporting recreational and transportation walking (Salvo et al., 2018). The third proxy was the zone of the respondent's home location. This proxy measured the context of city-wide zoning policies and the distribution of public infrastructure and amenities to support FMW in Bangkok, as summarised in Section 2.1. We categorised the location of the respondent's home into three zones: the inner Bangkok, the outer Bangkok, and the urban fringe.

Physical activity in this study was measured using the Global Physical Activity Questionnaire (GPAQ). This standardised questionnaire developed by the WHO quantified the amount of physical activity (in minutes per week) in the work, transportation, and recreation domains. This instrument was chosen for its numerous advantages: it is widely used, easily understood by participants, and has demonstrated good validity and reliability across diverse populations. While GPAQ is typically used to assess physical activity status or in epidemiological studies, we applied it to explore the relationship between neighbourhood environment and physical activity levels. Responses were categorized into sufficient physical activity (≥150 min/week) and insufficient physical activity (<150 min/week) based on the 2020 World Health Organization guidelines (WHO, 2020).

We also collected health behaviour variables, which have been acknowledged to have association with first-mile walking and physical activity such as presence of non-communicable diseases (NCDs), smoking and alcohol consumption habits, and body mass index. Previous studies have found that the presence of NCDs reduces the amount of first-mile utilitarian and recreational walking and is associated with a decrease in overall physical activity (Lee et al., 2012; Heine et al., 2020). Smoking and alcohol consumption habits have significant associations with first-mile walking and physical activity, as evidenced by multiple studies. Smoking is consistently linked to poorer physical function and reduced physical activity (Choudhury and Smith-Conway, 2020). Excessive alcohol consumption can lead to unfavourable metabolic characteristics, which can impair the ability to engage in walking and other physical activity (Niemelä, et al., 2022). The relationship between body mass index (BMI) and first-mile walking and physical activity, is multifaceted and supported by various studies. Research indicates that BMI is inversely associated with walking distance, suggesting that individuals with higher BMI tend to walk less (Mathijs et al., 2021; Shen et al., 2015). Several key health behaviour variables could not be included in the analysis. Although the survey included a question on chronic diseases requiring regular physical exercise, such as cardiac conditions, no respondents reported having such conditions, leading to its omission. Similarly, a question regarding physical disabilities affecting mobility, such as wheelchair use, was included, but no respondents indicated having a physical disability, resulting in the exclusion of this variable from the analysis.

We also collected sociodemographic variables (income, education, sex, marital status, and occupation). Individual sociodemographic characteristics such as age, gender, race/ethnicity, education, and income play crucial roles in determining first-mile walking and physical activity levels. For instance, adults and those

with higher educational attainment are more likely to engage in first-mile walking and to meet physical activity guidelines, while lower socioeconomic status (SES) is often linked to reduced utilitarian and recreational walking (Moreno-Llamas et al., 2023). For example, with women generally reporting weaker attitudes towards first-mile walking and physical activity compared to men, and these attitudes tend to weaken further with age (Adlakha and Parra, 2020).

2.4 Data analysis

Descriptive statistics were used to summarise the sociodemographic characteristics of participants, the neighbourhood environment variables, physical activity and healthy behaviours and first-mile walking behaviours. For data analysis, three multivariable logistic regression models were employed to examine the relationships between first-mile walking (FMW), neighbourhood environment, and physical activity. The first model assessed first-mile utilitarian walking as the dependent variable, while the second model focused on first-mile recreational walking. Both models evaluated the association between FMW (utilitarian and recreational) and neighbourhood walkability to address the first research question. The third model examined the relationship between physical activity levels and FMW, considering both utilitarian and recreational walking as independent variables, to address the second research question. This model used physical activity levels (sufficient *versus* insufficient) as the dependent variable and included first-mile utilitarian and recreational walking as independent variables, adjusting for covariates such as age, sex, BMI, smoking status, alcohol consumption, and NCDs conditions. This binary logistic regression model was selected for this study because it was widely understood by public health officials, ensuring the findings are interpretable, actionable, and directly applicable to policy-making. Additionally, binary logistic regression offers robustness, flexibility in handling dichotomous outcomes, and ease of communicating results, making it more suitable for confirmatory studies using validated measurement tools like NEWS-A, GPAQ. Odds ratios (OR) and 95% confidence intervals (CI) were reported to quantify the strength of associations. A significance level of $p < 0.05$ was considered statistically significant. All analyses were conducted using JAMOVI version 2.5.1 (The Jamovi Project, 2024; R Core Team, 2023; Fox and Weisberg, 2023).

3 Result

Table 1 summarises the characteristics of the respondents. The distribution of monthly income among participants varied, with 44.8% earning between 10,001 and 30,000 THB, and only 10.6% earning more than 50,000 THB. In terms of educational attainment, 43.9% had more than a bachelor's degree, while 12% had a high school education or less. The sex distribution was relatively balanced, with 53.2% female and 46.8% male participants. Most of the participants (76.7%) lived with their partners. In terms of health behaviours, a significant majority did not regularly consume alcohol (86.7%) or smoke (88.9%), and 88.8% reported not having non-communicable diseases (NCDs). Walkability scores, measured using the Neighbourhood Environment Walkability Scale-Abbreviated (NEWS-A), revealed that only 27.7% of neighbourhoods were considered highly walkable. With regards to neighbourhood type, 44.3% of participants resided in planned neighbourhoods, 41.9% in unplanned neighbourhoods, and 13.8% in high-rise neighbourhoods. Physical activity levels were generally high, with 78.7% of the participants engaging in sufficient physical activity (≥150 min/week). First-mile walking patterns differed substantially between utilitarian and recreational purposes, with 11.4% of participants engaging in utilitarian walking while a larger proportion (42.2%) participated in recreational walking during the study period.

Table 2 presents the results of multivariable logistic regression analyses examining associations between neighbourhood environment variables and both utilitarian and recreational walking. For utilitarian walking, two key environmental factors showed significant associations: high neighbourhood walkability (OR = 1.991, 95% CI = 1.2653–3.134) and residence in high-rise neighbourhoods (OR = 1.328, 95% CI = 1.1484–2.163) compared to unplanned neighbourhoods. For recreational walking, the analysis revealed broader significant associations: high neighbourhood walkability showed a stronger relationship (OR = 2.945, 95% CI = 2.1308–4.07), while both planned neighbourhoods (OR = 2.083, 95% CI = 1.479–2.881) and high-rise neighbourhoods (OR = 1.884, 95% CI = 1.2047–2.95) were significantly associated with increased recreational walking compared to unplanned neighbourhoods. Among health behaviour variables, non-alcohol consumption (non-smoking and absence of NCDs were not associated with either utilitarian or recreational walking. Notably, sociodemographic variables showed no significant associations with either type of walking, and type of zoning location (inner, outer, or fringe Bangkok) did not demonstrate significant association with first-mile walking.

Table 3 presents the results of multivariable logistic regression analysis examining the associations between first-mile walking behaviours and achieving sufficient physical activity levels, while controlling for neighbourhood environment variables. The analysis revealed strong associations between both types of walking and physical activity. First-mile utilitarian walking showed the strongest relationship with sufficient physical activity (OR = 6.292, 95% CI = 3.769–10.503), while recreational walking also demonstrated a significant positive association (OR = 2.394, 95% CI = 1.584–3.617). Among neighbourhood environment variables, high walkability remained significantly associated with sufficient physical activity (OR = 1.8835, 95% CI = 1.233–2.876), while neighbourhood type (planned or high-rise compared to unplanned) and type of zoning location showed no significant associations after adjusting for FMW and other covariates. These results suggest that engaging in FMW, particularly utilitarian walking, is strongly linked to achieving recommended physical activity levels, independent of neighbourhood environmental characteristics.

4 Discussion

This study explored the relationship between first-mile walking (FMW), neighbourhood walkability, and physical activity in Bangkok, Thailand. Two primary findings emerged from the

10.3389/fbuil.2025.1470792

TABLE 1 Respondents' characteristics.

Category	Variable	Sample characteristics
Sociodemographic	Monthly income	
	Less than 5000 THB (less than 160 USD)	3.9%
	5,000–10,000 THB (160–300 USD)	18.7%
	10,001–30,000 THB (300–1000 USD)	44.8%
	30,001–50,000 THB (1,000–1600 USD)	22.0%
	More than 50,000 THB	10.6%
	Education	
	High school or less	12.0%
	High school to bachelor's degree	44.0%
	More than a bachelor's degree	43.9%
	Sex	
	Male	46.8%
	Female	53.2%
	Marital status	
	Single	23.3%
	Living with partner	76.7%
	BMI	
	25 or less	84%
	>25	16%
	Having children	
	Yes	69.4%
	No	30.6%
	Having Car	
	Yes	29.7%
	No	70.3%
Healthy behaviour	Regular alcohol consumption	
	Yes	13.3%
	No	86.7%
	Regular smokers	
	Yes	11.1%
	No	88.9%
	Having non-communicable diseases (NCDs)	

(Continued on the following page)

TABLE 1 (*Continued*) Respondents' characteristics.

Category	Variable	Sample characteristics
	Yes	11.2%
	No	88.8%
Neighbourhood environment	Neighbourhood walkability (NEWS-A score)	
	High	27.7%
	Low	72.3%
	Type of Neighbourhood	
	Unplanned neighbourhood	41.9%
	Planned Neighbourhood	44.3%
	High-rise neighbourhood	13.8%
	Type of zone	
	Inner Bangkok	49.1%
	Outer Bangkok	28.9%
	Urban fringe	22.0%
Physical activity	Physical activity level	
	Sufficient physical activity (more than 150 min/week)	78.7%
	Insufficient physical activity (150 min/week or less)	21.3%
First-mile walking	Conducting first-mile utilitarian walking in the last week	
	Yes	11.4%
	No	88.6%
	Conducting first-mile recreational walking in the last week	
	Yes	42.2%
	No	57.8%

analysis, corresponding to the study's research questions. The first key finding was that neighbourhood environmental factors significantly influenced both first-mile utilitarian and recreational walking, albeit in different ways. Neighbourhood walkability, as assessed using the NEWS-A, was strongly associated with both types of first-mile walking. This finding is consistent with research from Western urban contexts despite Bangkok's unique climate and urban characteristics. Previous studies have suggested that first-mile walking is predominantly influenced by immediate neighbourhood attributes, which may mitigate the impact of weather conditions on walking behaviours (Yuri et al., 2023; Chan et al., 2021). Infrastructure such as sidewalks, pedestrian-friendly amenities, and safe connections to public transport hubs, schools, and parks are critical in shaping first-mile walking behaviour. The strong association between NEWS-A walkability scores and first-mile utilitarian and recreational walking suggests that well-designed neighbourhood environments can effectively promote walking behaviour regardless of the urban context (Cerin et al., 2009; Buehler and Fuchler, 2023). However, the applicability of NEWS-A to Bangkok warrants further discussion, given the city's unique cultural and environmental characteristics. The relationship between neighbourhood walkability and first-mile walking remained strong even in Bangkok's urban environment, characterized by high density, varied urban forms, prominence of informal markets and the reliance on motorised transport. This resilience of the walkability-first-mile walking relationship across different urban contexts supports arguments for investing in neighbourhood-level walking infrastructure while highlighting the importance of developing context-specific urban design approaches tailored to Bangkok's unique needs.

10.3389/fbuil.2025.1470792

TABLE 2 Associations between utilitarian and recreational walking and neighbourhood environment variables.

Category	Variable	Utilitarian walking		Recreational walking	
		OR	95% CI	OR	95% CI
Sociodemographic	Monthly income				
	Less than 5000 THB (less than 160 USD)	ref		ref	
	5,000–10,000 THB (160–300 USD)	0.701	0.2255–2.182	0.634	0.289–1.390
	10,001–30,000 THB (300–1000 USD)	0.769	0.2684–2.205	1.001	0.4754–2.10
	30,001–50,000 THB (1,000–1600 USD)	0.7444	0.2462–2.245	0.749	0.3450–1.63
	More than 50,000 THB	0.775	0.2224–2.702	0.995	0.4159–2.38
	Education				
	High school or less	ref		ref	
	High school to bachelor's degree	0.881	0.5457–1.422	0.854	0.6235–1.17
	More than a bachelor's degree	0.837	0.4006–1.750	1.105	0.6835–1.22
	Gender				
	Male	ref		ref	
	Female	1.197	0.7652–1.872	0.912	0.685–1.218
	Marital status				
	Single	ref		ref	
	Living with partner	0.556	0.2850–1.086	1.016	0.6843–1.51
	BMI				
	25 or less	ref			
	>25	0.532*	0.3101–0.913	0.833	0.5582–1.24
	Having children				
	Yes	ref			
	No	0.886	0.0928–8.459	1.427	0.3153–6.46
	Having Car				
	Yes	ref			
	No	1.168	0.1227–11.125	1.291	0.2847–5.86
Healthy behaviour	Regular alcohol consumption				
	Yes	ref		ref	
	No	1.099	0.5147–1.934	1.338	0.8624–2.08
	Regular smokers				
	Yes	ref		ref	
	No	1.273	0.6728–2.410	1.056	0.670–1.67

(Continued on the following page)

TABLE 2 (*Continued*) Associations between utilitarian and recreational walking and neighbourhood environment variables.

Category	Variable	Utilitarian walking		Recreational walking	
		OR	95% CI	OR	95% CI
	Having non-communicable diseases (NCDs)				
	Yes	ref		ref	
	No	1.373	0.7115–2.648	1.105	0.6845–1.78
Neighbourhood environment	Neighbourhood walkability (NEWS-A score)				
	Low	ref		ref	
	High	1.991*	1.2653–3.134	2.945*	2.1308–4.07
	Type of neighbourhood				
	Unplanned neighbourhood	ref		ref	
	Planned neighbourhood	0.365	0.1364–1.057	2.083*	1.479–2.881
	High-rise neighbourhood	1.328*	1.1484–2.163	1.884*	1.2047–2.95
	Type of zone				
	Inner Bangkok	ref		ref	
	Outer Bangkok	1.225	0.7525–1.994	0.907	0.6455–1.27
	Urban fringe	0.518	0.2677–1.001	0.5237	0.6849–1.42

Note:*= $p < 0.005$. For Utilitarian walking model, the dependent variable was "did you engage in first-mile walking from home to reach a specific destination or accomplishing a task, such as going to school, the market or the nearest public transport stops in the last week?". For the recreational walking model, the dependent variable was "did you engage in walking for enjoyment, relaxation, or physical activity without a specific destination around home in the last week?"

The type of neighbourhood variable was also a significant determinant of both types of first-mile walking, revealing notable variations among high-rise, planned, and unplanned neighbourhoods. Residents of high-rise neighbourhoods, commonly comprising apartments and condominiums, were significantly more likely to engage in first-mile utilitarian walking. This trend can be attributed to the strategic placement of high-rise developments near public transit stations and their improved accessibility to green spaces, in line with transit-oriented development principles that have been shown to encourage active mobility globally (Gaxiola-Beltrán et al., 2021; Pereira et al., 2021). However, planned neighbourhood developments do not exhibit a significant association with first-mile recreational walking. This may be attributed to their typical location in urban fringe areas, where key destinations such as workplaces, schools, markets, and hospitals are farther away. Similar patterns have been observed in other large metropolitan areas (Cambra and Filipe, 2020; Zhu et al., 2023).

On the other hand, both high-rise and planned neighbourhoods were significantly associated with first-mile recreational walking. These findings are consistent with existing literature. Research indicates that planned and high-rise neighbourhoods are typically designed to provide greater access to green spaces, interconnected pedestrian pathways, and recreational facilities within residential complexes, fostering an environment supporting FMW (Song et al., 2020; Zhang et al., 2022). Their compact design enhances safety and security and fosters a sense of community, making them especially conducive to first-mile recreational walking, particularly for children, older adults and women (Gao et al., 2022; Herbolsheimer et al., 2020; Adlakha and Parra, 2020).

Interestingly, the type of zones (inner, outer, or fringe) did not significantly impact first-mile utilitarian and recreational walking, which contrasts with findings from the United States and Europe, where mixed-use land use is typically associated with higher walking rates (Chriqui et al., 2016; McCormack et al., 2023a; McCormack et al., 2023b; Freeman et al., 2012). This finding can be attributed to several interconnected factors. First, Bangkok's distinctive urban morphology differs fundamentally from Western cities' rigid land-use segregation. Mixed-use development permeates all urban zones in Bangkok, particularly in unplanned neighbourhoods distributed throughout the city. This characteristic creates a more homogeneous distribution of walking opportunities across inner, outer, and fringe zones, potentially diminishing the effect of broad zoning classifications on first-mile walking. Second, our analysis suggests that micro-level environmental characteristics exert stronger influences on FMW patterns than macro-scale zoning designations. The significant associations found with the NEWS-A walkability measure support this interpretation, indicating that features such as sidewalk availability, perceived

TABLE 3 Association between first-mile walking and having sufficient physical activity.

Category	Variable	OR	95% CI
Neighbourhood environment	Neighbourhood walkability (NEWS-A score)		
	Low	ref	
	High	1.8835*	1.233–2.876
	Type of Neighbourhood		
	Unplanned neighbourhood	ref	
	Planned Neighbourhood	0.664	0.332–1.334
	High-rise neighbourhood	0.930	0.586–1.476
	Type of zone		
	Inner Bangkok	ref	
	Outer Bangkok	0.756	0.124–2.74
	Urban fringe	0.893	0.519–1.5036
First-mile walking	First-mile utilitarian walking		
	No	ref	
	Yes	6.292*	3.769–10.503
	First-mile recreational walking		
	No	ref	
	Yes	2.394*	1.584–3.617

Note: *p < 0.005. For the physical activity model, the dependent variable was the physical activity level based on GPAQ, questionnaire, and dichotomised into "sufficient physical activity (more than 150 min/week) and insufficient physical activity (150 min/week or less)". The model was adjusted to for monthly income, education, gender, marital status, BMI, having children, having car, regular alcohol consumption, regular smoking, and having non-communicable diseases.

safety, and pedestrian-friendly infrastructure may be more decisive determinants of FMW than broader urban planning zoning classifications. Third, methodological considerations may also contribute to this finding. While our study encompassed 881 participants across 50 districts, the stratification of this sample across three urban zones may have limited statistical power to detect significant differences in first-mile utilitarian and recreational walking. Although the study achieved broad geographic coverage, the relatively smaller subgroup sizes within each zone could have masked subtle variations in first-mile walking patterns. Future research employing larger, more strategically stratified samples could better elucidate potential relationships between urban zoning and first-mile walking.

Additionally, sociodemographic characteristics did not exhibit significant associations with first-mile walking, diverging from prior studies that have linked socioeconomic status to walking behaviour (Kim and Woo, 2016; Villanueva et al., 2014; Ghimire and Bardaka, 2023). A plausible explanation for this discrepancy is that neighbourhood attributes exert a stronger influence on walking patterns in Bangkok than individual socioeconomic factors. Moreover, cultural attitudes towards walking in Bangkok may differ from those observed in Western contexts, underscoring the need for context-specific considerations in first-mile walking research.

The second key finding was that engaging in first-mile utilitarian and recreational walking was positively associated with achieving sufficient physical activity levels. This result aligns with previous studies that have identified walking as a primary mode of work-related and leisure physical activity, contributing to public health goals (Howell et al., 2017; Kang et al., 2017; Karolemeas et al., 2023). Even during the COVID-19 pandemic, while utilitarian walking declined due to movement restrictions, recreational walking increased, exceeding pre-pandemic levels (Arifwidodo and Chandrasiri, 2023; Topothai et al., 2023). These findings reinforce the argument that promoting first-mile walking—both for transportation and leisure—serves as an effective public health strategy to enhance physical activity among urban populations. In addition to that, the association between neighbourhood walkability and sufficient physical activity highlights the importance of neighbourhood design that integrates both walking infrastructure and accessible recreational amenities, such as green spaces, to support active lifestyles. Previous studies have reported similar findings (Chandrasiri and Arifwidodo, 2017;

Prins et al., 2019). Furthermore, during the COVID-19 pandemic, neighbourhood walkability was identified as a critical determinant of maintaining physical activity levels in Bangkok (Arifwidodo and Chandrasiri, 2024). Enhancing neighbourhood walkability through infrastructure improvements—such as maintaining sidewalks and increasing access to recreational spaces—can substantially encourage first-mile walking and contribute to higher physical activity levels (Arifwidodo et al., 2022; Molina-Garciá et al., 2019; Clarke et al., 2019).

This study has several limitations that should be acknowledged. Given its cross-sectional design, it cannot establish causal relationships between neighbourhood environments, first-mile walking, and physical activity. This highlights the need for caution when interpreting causal inferences and underscores the importance of longitudinal studies to examine temporal relationships and causality. Furthermore, the sample size of 881 respondents, while adequate within the constraints of a PhD research project, may limit the generalisability of findings. Future studies with larger samples could provide a more comprehensive understanding of first-mile walking across Bangkok's diverse urban landscape.

Additionally, the binary classification of recreational walking (yes/no) oversimplifies first-mile walking behaviour by not capturing its frequency, duration, or intensity. Future research should employ more nuanced measurement approaches to offer a detailed analysis of walking patterns. While the NEWS-A is a validated tool for assessing neighbourhood walkability, its applicability within Bangkok's unique socio-cultural and environmental context warrants further investigation. Local cultural norms, socio-economic diversity, and environmental conditions may influence walkability perceptions and impact the interpretation of scores. Moreover, while the NEWS-A has been effective in evaluating first-mile walking, its relevance to last-mile or trip-chained walking is less clear. Future research should assess whether this tool sufficiently captures walkability factors related to different types of walking in Bangkok's distinct urban setting.

The impact of Bangkok's seasonal hot and humid climate on FMW cannot be fully captured due to the cross-sectional nature of this study. Our survey was conducted during December–January, when temperatures and humidity levels are lower compared to the peak hot season (April–November). As a result, FMW activity observed in this study may reflect an upper bound, as FMW rates are likely to be lower during the hotter months when thermal discomfort is more pronounced. Additionally, while shading infrastructure, such as tree canopy and covered walkways, can help mitigate heat exposure, most pedestrian infrastructure in Bangkok lacks covered walkways. These covered walkways are primarily found in select tourist areas, while residential neighbourhoods in Bangkok have limited shading and shelter from rain. This lack of protective infrastructure exacerbates the challenge of FMW in extreme weather conditions and may discourage walking outside of the cooler months. This underscores the need for future research using longitudinal or seasonal studies to better understand how climate and urban design interact to influence FMW throughout the year. Additionally, the study's focus on adults limits its inclusivity. Expanding research to encompass diverse population groups, including children, older adults, and individuals with disabilities, would enhance the applicability and relevance of the findings. This inclusivity is essential for designing universally accessible walking environments.

Further research should also investigate specific neighbourhood design elements that encourage recreational walking in Bangkok, such as the availability and quality of pedestrian pathways and urban green spaces. Understanding these elements in greater detail could inform the development of targeted urban design guidelines. Moreover, the economic implications of investing in walkable neighbourhoods warrant further exploration. This includes assessing the cost-effectiveness and long-term public health benefits of such designs, particularly in relation to reduced healthcare costs due to increased physical activity and improved mental wellbeing. Additionally, studies should examine the economic viability of walkable urban environments by evaluating potential increases in property values, tourism, and local business activities. These insights would provide policymakers with robust evidence to support investment in pedestrian-friendly infrastructure as a means of promoting urban health.

Comparative studies with other major Asian cities could also offer valuable regional insights and inform urban planning strategies to encourage walking. Furthermore, the role of technology—such as smartphones and fitness trackers—in influencing walking behaviour was not considered in this study. Future research should explore how technological tools may encourage recreational walking and enhance data collection. Finally, a deeper investigation into Bangkok's social norms and cultural factors would provide additional context to the findings, facilitating a more nuanced understanding of walking behaviour in this setting.

Despite these limitations, this study enhances the understanding of first-mile walking, neighbourhood walkability, and physical activity in Bangkok. Its findings underscore the importance of micro-level neighbourhood design features in facilitating first-mile utilitarian and recreational walking. These findings provide valuable insights for urban planners and policymakers, indicating that targeted, neighbourhood-level interventions may be more effective in encouraging walking than broad city-wide zoning policies. The Bangkok Metropolitan Administration should prioritise walking policies by enhancing first-mile infrastructure near residential areas. Key policy measures to strengthen first-mile utilitarian walking should include well-maintained sidewalks, pedestrian-friendly amenities, and safe connections to public transport, schools, and parks to significantly encourage first-mile walking. Key policy measures to strengthen first-mile recreational walking should focus on establishing networks of green spaces in residential areas, particularly in high-density zones, to ensure equitable access to recreational spaces. Expanding green spaces and shaded pathways would increase accessibility and mitigate the effects of Bangkok's tropical climate on walking.

Furthermore, introducing traffic-calming measures in high-density neighbourhoods could enhance pedestrian safety. Strengthening connectivity between green spaces *via* well-maintained pedestrian pathways would further promote recreational walking. Policymakers should also explore repurposing underutilised urban spaces into community parks or recreational hubs to foster social cohesion while improving walkability. These tailored interventions, adapted to Bangkok's specific urban context, can potentially create walkable, health-promoting neighbourhoods.

5 Conclusion

This study examined the relationships between first-mile walking, neighbourhood walkability, and physical activity in Bangkok, Thailand. Our findings validate and extend existing theoretical frameworks across transportation studies, urban planning, and public health domains. From an active transportation perspective, our results demonstrate that neighbourhood-level infrastructure influences first-mile walking behaviour even in challenging urban environments. In urban planning theory, our findings challenge conventional city-wide approaches by showing that micro-level neighbourhood characteristics have greater impact on first-mile walking behaviour than macro-level interventions. From a public health standpoint, the strong correlation between first-mile walking and sufficient physical activity levels supports WHO's framework for physical activity promotion in rapidly urbanizing contexts. Several important limitations warrant consideration. The cross-sectional design limits causal inference, while the binary classification of walking behaviour oversimplifies complex walking patterns. Additionally, the application of NEWS-A in Bangkok's unique socio-cultural context requires further validation. Future research should employ longitudinal designs with more nuanced walking measurements and explore seasonal variations in walking behaviour, specific design elements that encourage walking in high-density Asian cities, and the economic implications of walkable neighbourhoods. Our findings suggest that targeted, neighbourhood-level interventions may be more effective than broad city-wide policies in promoting walking and physical activity, particularly in rapidly developing cities. These interventions should address both utilitarian needs through enhanced connectivity to public transport and essential services, and recreational opportunities through accessible green spaces and pedestrian-friendly zones. The integration of transportation, urban planning, and public health perspectives remains crucial for developing effective strategies to promote active, healthy urban communities.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Institutional Review Board of Silpakorn University in Thailand. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants'; legal guardians/next of kin in accordance with the national legislation and institutional requirements. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

PR: Conceptualization, Investigation, Project administration, Writing–original draft, Writing–review and editing. SA: Conceptualization, Formal Analysis, Methodology, Writing–original draft, Writing–review and editing. RA: Supervision, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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