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Interactions between Urban Form and Mobility: Comprehensive Meta-analysis of the Brazilian Context

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Interseção entre Forma Urbana e Mobilidade: Meta-análise abrangente do contexto brasileiro

RESUMO

Este estudo analisa a relação entre a forma urbana e a mobilidade no Brasil, considerando sua diversidade regional. O estudo envolveu metanálise e revisão estruturada de literatura examinando estudos publicados entre 2013 e 2023. Os resultados destacam a importância da caminhabilidade e infraestrutura adequada para a melhoria da mobilidade urbana, influenciando a qualidade de vida e a sustentabilidade. Políticas públicas adaptadas às particularidades locais são necessárias para promover uma mobilidade urbana sustentável. O estudo contribui com uma abordagem interdisciplinar e quantitativa na análise das complexas relações entre forma urbana e mobilidade, utilizando análises bibliométricas para oferecer uma nova perspectiva sobre o tema.

PALAVRAS-CHAVE: Forma Urbana. Mobilidade. Caminhabilidade.

Interactions between Urban Form and Mobility: Comprehensive Meta-analysis of the Brazilian Context

ABSTRACTS

This study analyzes the relationship between urban form and mobility in Brazil, considering its regional diversity. The study involved meta-analysis and structured literature review examining studies published between 2013 and 2023. The results highlight the importance of walkability and adequate infrastructure for the improvement of urban mobility, influencing quality of life and sustainability. Public policies adapted to local particularities are necessary to promote sustainable urban mobility. The study contributes with an interdisciplinary and quantitative approach in the analysis of the complex relationships between urban form and mobility, using bibliometric analysis to offer a new perspective on the subject.

KEYWORDS: Urban form. Mobility. Walkability.

Intersección entre forma urbana y movilidad: metaanálisis integral del contexto brasileño

RESUMEN

Este estudio analiza la relación entre la forma urbana y la movilidad en Brasil, considerando su diversidad regional. El estudio implicó un metaanálisis y una revisión estructurada de la literatura que examinó los estudios publicados entre 2013 y 2023. Los resultados ponen de manifiesto la importancia de la caminabilidad y de las infraestructuras adecuadas para la mejora de la movilidad urbana, influyendo en la calidad de vida y la sostenibilidad. Son necesarias políticas públicas adaptadas a las particularidades locales para promover la movilidad urbana sostenible. El estudio aporta un enfoque interdisciplinario y cuantitativo en el análisis de las complejas relaciones entre la forma urbana y la movilidad, utilizando el análisis bibliométrico para ofrecer una nueva perspectiva sobre el tema.

PALABRAS CLAVE: Forma urbana. Movilidad. Caminabilidad.

ISSN 2318-8472, v. 12, n. 87, 2024

1 INTRODUCTION

The relationship between urban form and mobility in Brazil is crucial to understand the dynamics of displacement and the quality of urban life. Influenced by variables such as planning, population density, and transport infrastructure, this interaction addresses urban challenges, promoting sustainable solutions (Brazil, 2012; Pereira *et al*., 2022). The country's geographic diversity requires contextualized analyses to adapt urban planning to the specific needs of each region, considering everything from metropolises to less dense areas (Carvalho *et. al*, 2021; Pereira et al., 2022).

This urban form, which involves the physical and functional arrangement of the urban space, has a direct impact on the mobility patterns and the experience of residents, requiring planning that harmonizes functional, aesthetic, and sustainability aspects (Pereira *et al*., 2022; Rossi, 2001). The National Urban Mobility Policy (PNMU) reinforces the importance of urban quality for the efficiency of travel and accessibility, significantly influencing people's daily experience and quality of life (Brazil, 2012; Pereira *et al*., 2022). The interdependence between urban form and mobility underlines the importance of inclusive, accessible and sustainable urban strategies. Analysis focused on regional diversity and the specific variables that affect mobility is essential to identify and implement effective planning practices that respond to local demands, promoting urban environments better adapted to the needs of the population (Canali; Neckel; Piccinato Júnior, 2021; Pereira *et al*., 2022).

Therefore, understanding the influence of urban form on mobility is essential for the development of sustainable urban solutions, facing contemporary challenges and improving the quality of life in Brazilian cities. The research seeks an in-depth understanding of this relationship, aiming at the formulation of urban planning strategies that are more informed and contextualized to the particularities of each region of Brazil (Pereira *et al*., 2022).

2 OBJECTIVES

This study aims to analyze the complex interaction between urban form and mobility in the Brazilian context, understanding how urban form influences people's transportation choices, travel behavior, and quality of life. This analysis aims to highlight the relevance of these aspects beyond the efficiency of transport systems, considering the country's regional diversity.

3 METHODS

The present research employed a meta-analysis approach to investigate the relationship between urban form and mobility in the Brazilian context. To this end, a structured literature review was carried out, following inclusion and exclusion criteria inspired by the work of Naess (2012), who analyzed the interaction of these concepts in Nordic contexts. The study covered a period of one decade (2013-2023) and a national geographic diversity. The objective was to discern how urban configuration influenced transportation choices and quality of life, using a wide range of databases and scientific journals, such as CAPES, *SciELO,* and *Google*

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Scholar, with specific keywords to ensure comprehensive and relevant data collection (Pereira *et al*., 2022; Naess, 2012).

The analysis of the 30 selected articles was carried out using the *VOS viewer software*, a bibliometric mapping tool that facilitates the visualization of trends and patterns in the scientific literature (Luiz, Henning, and Kalbusch, 2023). The meta-analysis allowed the synthesis of the results of independent studies, providing a detailed quantitative view of the interaction between urban form and mobility, highlighting the importance of this statistical technique in identifying common patterns and variations between studies (Guzzo, Jackson and Katzell, 1987; Lovatto *et al*., 2007). This robust method ensured a deep understanding of the relationship between the variables studied, contributing significantly to urban planning and sustainable mobility.

4 RESULTS

In this section, we present the results from the analysis of academic studies conducted over the last decade, which investigate the relationship between urban form and mobility in Brazil. The purpose of this section is to highlight key findings, elucidating trends and patterns identified during the research.

4.1 The Brazilian studies reviewed

Chart 1 provides a broad view of research related to the intersection between urban form and mobility in several cities in Brazil. The analysis of these studies reveals central themes, and a wide variety of topics explored in urban mobility research. Most of the articles investigate the interaction between walkability, urban mobility and urban form. However, the inclusion of variables such as population density, land use and infrastructure is also highlighted, indicating an integrated approach to understanding urban challenges. The concern with environmental and sustainability issues is evident, especially in the analysis of the impact of urban structure on air quality and the efficiency of public transport.

GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

ISSN 2318-8472, v. 12, n. 87, 2024

Chart 1 - Synthesis of the 30 Brazilian scientific articles included in the literature review

SEARCH PLATFORM	TITLE	REFERENCE	FIELD OF STUDY	GEOGRAPHIC SCALE	URBAN FORM VARIABLE INVESTIGATED	MAIN METHODOLOGICAL APPROACHq	RESULTS
ResearchGate	Forma urbana e poluição atmosférica: impactos na cidade do Rio de Janeiro	Mayan; Net; Costa (2019)	Rio de Janeiro - RJ	The areas for analysis were defined in 500 x 500 meter cutouts around the weather stations	Relationship between urban form and air quality, seeking to identify possible impacts on the concentration of satmospheric pollutants.	The study used a quantitative approach, performing statistical analyses to identify relationships between urban form and air pollution. Correlation and multiple regression analyses were applied, contributing to the development of indicators and public policies.	The study highlights that the occupancy rate and verticalization in urban areas influence the concentration of air pollutants, including CO, SO2 and PI6. Results indicate the relevance of these aspects in the concentration of pollutants.
UFG Journal Portal	A INFLUÊNCIA DA FORMA URBANA E DAS DINÂMICAS SOCIOESPACIAIS NA MOBILIDADE URBANA EM GOIÂNIA	Resende; Machado (2016)	Goiânia - GO	City of Goiânia, capital of the state of Goiás, and its metropolitan region	The authors highlighted the importance of considering socio-spatial dynamics in the analysis of urban mobility, recognizing the interaction between urban form and people's travel behavior.	The article adopted a qualitative approach, analyzing the relationship between urban form and mobility in Goiânia. Segregation and peripheralization were highlighted as influencing elements in the production of less accessible spaces.	The article on Goiânia highlights problems of mobility centered on individual transport, congestion and lack of public spaces. It proposes to rethink urban form and consider socio-spatial dynamics to improve mobility.
ResearchGate	Mobilidade e adensamento urbano: aplicação de indicadores em estudo de caso no distrito da Barra Funda, São Paulo	Strong; Duarte (2014)	São Paulo - SP	Barra Funda District, São Paulo	Urban transport	The article adopted the qualitative and quantitative method, and the application of indicators.	In the study of Barra Funda, São Paulo, the improvement of bus lanes reduced travel time. The implementation of cycling and pedestrian routes has increased the use of non-motorized transport and reduced the use of individual transport.
ResearchGate	A caminhada por diferentes propósitos: um estudo na cidade de Cambé-PR	Costa (2022)	Cambé - PR	Local scale	Walkability and land use	The research in Cambé-PR used a quantitative and spatial approach, analyzing walking routes for different purposes. Data on distance, duration and land use were collected, allowing a correlational analysis and considering information from the Origin-Destination study.	The study in Cambé-PR reveals that different walking purposes are associated with specific distances. It highlights walking as an accessible and equitable option, emphasizing the importance of mixed uses in the surroundings.
Technical and Scientific Journal Green Cities	Caminhabilidade como elemento estruturador da vitalidade urbana: estudo de caso na Avenida Nuno de Assis, Bauru-SP	Pinho; Gulinelli (2020)	Avenida Nuno de Assis, Bauru-SP	Local scale	Walkability	The study in Bauru-SP used a qualitative method, aiming to understand the pedestrian experience and the quality of the built environment on Avenida Nuno de Assis. It used the Walkability Index (iCam) and critical analysis, based on bibliographic research.	The study highlights the importance of walkability for urban vitality on Avenida Nuno de Assis. It proposes that rethinking the built environment can transform streets into more pleasant and interesting places.
ResearchGate	A caminhabilidade em ruas de Florianópolis (SC)	Debatin Neto; - De Mello Zabot (2023)	Florianópolis - SC	Local scale	Walkability	The method used to calculate the Walkability Index (CI) is quantitative, involves data and information collection through the Field Research Worksheet (PPC). The method allows the verification of specific criteria that influence walkability,	The results emphasize that land-use diversity alone does not guarantee high pedestrian count. The analysis highlights that stretches without motor vehicle traffic concentrated commerce, attracting pedestrians.
Public Transport Magazine - ANTP	Caminhabilidade como instrumento de mobilidade urbana: reflexões sobre a realidade de Belo Horizonte	Cardoso; Oak; Nunes (2019)	Belo Horizonte - MG	Municipal scale, considering the city as a whole, as well as the local scale, focusing on specific segments and intersections within the city.	Walkability as an urban shape index, but does not specify a specific urban shape index	The methodology for developing the walkability index in Belo Horizonte is predominantly qualitative, but incorporates elements of quantitative analysis. The selection of indicators and the local analysis were qualitative, highlighting walkability attributes. However, the on-site analysis of specific segments may have involved the collection of quantitative data, such as pedestrian counting and measurement of unevenness on sidewalks.	The survey reveals that factors such as the quality of sidewalks, obstacles and connectivity affect walkability in Belo Horizonte. It proposes a walkability index considering several attributes relevant to mobility on foot.

GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

ISSN 2318-8472, v. 12, n. 87, 2024

ResearchGate	ENCADEAMENTO DE VIAGENS PEDONAIS NO TRANSPORTE PÚBLICO INTERMUNICIPAL: O CASO DA REGIÃO METROPOLITANA DE FLORIANÓPOLIS	Oak; Kraus; Kretzer; Teixeira; Souza; Otto, (2017)	Florianópolis - SC	Metropolitan Region of Florianópolis, which includes nine municipalities. Spanning urban, suburban, and rural areas	Public transport and walking	The research on intercity public transport in Florianópolis had a quantitative approach, collecting data on trips by public transport and walking. It used geocoding, shortest distance criteria, and exploratory analysis to identify patterns.	It highlights the importance of pedestrian travel in intercity public transport, with walks often seeking cost savings. It suggests a deeper understanding of walking distances in downtown Florianópolis.
ResearchGate	Por onde as crianças circulam na cidade? Estudoda relação entreforma urbana e mobilidade de crianças no trajetocasa-escola em Quixadá-CE	Martins (2020)	Quixadá - CE	Local scale	Walkability	The study in Quixadá-CE involved a case study method with a quantitative and spatial approach. It analyzed the children's home-school routes, using mind maps and syntactic measures to understand the role of urban form in the children's movement.	The urban form influences the mobility of children, highlighting the importance of integration and connectivity in the choices of home-school routes.
ResearchGate	Expansão urbana e mobilidade: estudo de caso em Patos - PB	Bezerra; Philip; Silva; Guedes; Andrade; Cambric (2022)	Patos - PB	Local scale, focusing especially on the characteristics of urban expansion and mobility	Urban form of the city and how it affects urban mobility.	The article on Patos-PB was characterized as applied, adopting a qualitative and quantitative approach. It used a case study and calculation of the Sustainable Urban Mobility Index, based on correlations existing in the literature.	The study addresses the urban expansion in Patos, highlighting the influence of highways, the classification as a sub-regional center A and the need for public attention to urban mobility.
SciELO	O Aglomerado Urbano de Jundiaí (SP) e os desafios para a mobilidade metropolitana paulista	Fanelli; Santos Junior (2013)	Urban Agglomeration of Jundiaí (AUJ) - SP	Regional scale	Relations of interdependence of cities, intra-metropolitan expansion, urban dispersion along highways and the expansion of socio-spatial segregation that accompanies the redistribution of the population in the regional context.	The research explored relationships between cities in the AUJ, vectors of urban expansion and dispersion, using demographic data. It investigated impacts on socio-spatial segregation, contributing to understand the regional organization.	It points out challenges in intrametropolitan mobility in Jundiaí, highlighting the need for integrated planning and coordinated action to deal with common problems.
SciELO	Variáveis da caminhabilidade: um estudo empírico em Rolândia – PR, Brasil	Lion; Abonizio; Kings; Kanashiro (2020)	Rolândia – PR	Local scale	Residential density, occupancy rate of commercial areas, mixed land use (entropy), spatial syntax - integration and choice, and land and real estate values.	In the study, using geocoding of data from the Urban Mobility Plan, the urban form variables were aggregated and tested in 1000-meter network buffers. The analysis involved a machine learning approach, specifically the Random Forest algorithm, related to self-reported walking (meters walked per unit area).	It identifies important variables for walkability in medium-sized Brazilian cities, including entropy, integration, and residential density.
Google Scholar / SciELO	Modelagem de fatores da expansão urbana e padrões de viagens aplicando equações estruturais	Medrano; Taco (2013)	Brazil - DF	Local scale	Population density, land use, accessibility, centrality, urban expansion, urban development patterns and spatial distribution of activities.	The study uses the statistical technique of Structural Equations (SEM) to analyze the relationship between factors of urban sprawl and activity-based travel patterns. This approach allows the consideration of endogenous, exogenous, and latent variables, as well as the use of cross-section and logistic regression models. The analysis of the results provides valuable insights to understand the complex interactions in this context.	It highlights the relationship between urban sprawl and travel patterns in Brasilia, developing a causal model (ABTUS) that relates spatial and socioeconomic factors.

ISSN 2318-8472, v. 12, n. 87, 2024

Google Scholar	Buscando a caminhabilidade: fatores que influenciam nos hábitos de caminhada em Palmas-TO	Olive tree; Barbosa; Olive tree; Marques (2022)	Palmas - TO	Local scale	Population density, entropy index and road connectivity.	In the 1st stage, the research characterized the urban structure using indicators such as population density, entropy index and road connectivity. The density was calculated as the ratio between population and block area, the entropy index measured the diversity of land use, and the connectivity index evaluated the road network. In the 2nd stage, a quali-quantitative analysis of factors that affect walking was carried out, with responses from residents of 89 blocks in Palmas. Data were collected via online questionnaire, obtaining 387 non-probabilistic responses.	It shows that walking habits are influenced by socioeconomic factors and urban structure. It emphasizes the importance of land use diversity to promote walkability.
Google Scholar	MOBILIDADE E FORMA URBANA: FEIRA DE SANTANA-BA E A ESTRUTURA VIÁRIA	Britto; Saints; Freitas (2021)	Feira de Santana - BA	Local scale	Road structure, population density, delimitation of neighborhoods and functions assigned by urban zoning, as expressed in the Integrated Development Master Plan and the Urban Development Master Plan. In addition, it addresses the influence of roads on the city, the political and economic interests behind innovative projects and real estate speculation.	The study employed a methodology that consisted of the analysis of data from previous surveys, municipal urban development plans, urban mobility projects and relevant documents. In addition, the mapping of urban expansion between 1959 and 2017 was carried out using the ArcGIS software. The research also included a theoretical analysis of urban form and mobility from a geographical perspective, followed by the evaluation of the road network of Feira de Santana and its impact on the structuring of urban space.	It indicates that the highways influence the urban form of Feira de Santana, impacting population density and guiding urban expansion.
Google Scholar	INFLUENCIAS DO ESPAÇO PARA A MOBILIDADE URBANA – O JARDIM DAS ROSAS EM PRESIDENTE PRUDENTE-SP	Lopes; Silva; Merique; Bianchini; Matsutane ; Maria (2015)	Presidente Prudente - SP	Local stopover (Jardim das Rosas neighborhood)	The distribution of different uses in the city, the conditioning of human activities, accessibility to different areas of the city, afforestation, the presence of benches and sidewalks, the width of sidewalks, the potential for local mobility and the experience of space	The method involved on-site research for recognition, followed by bibliographic research. It combined direct observations with a theoretical basis, allowing an in-depth analysis of mobility in the region.	It identifies challenges in mobility, such as long blocks and commercial density. It highlights the need for interventions to promote less problematic mobility.
Google Scholar	A problemática da mobilidade urbana em Anápolis (GO) entre2011 e 2018	Rodrigues (2022)	Anápolis-GO	Local scale	The organization of urban space, the socio-spatial dynamics of space production, the morphology of the city, the arrival of the railroad, the influence of federal highways and the implementation of the Agroindustrial District of Anápolis (DAIA).	The methodology covered geographic data analysis, considering physical and spatial aspects and public policies of urban mobility. It provided a comprehensive and detailed analysis in Anápolis, in the period between 2011 and 2018.	It shows that urban mobility in Anápolis has been affected by decades of inadequate land occupation and lack of sustainable policies.
Google Scholar	MOBILIDADE URBANA EM ARARAQUARA/SP: DESAFIOS PARA UMA CIDADE DE PORTE MÉDIO	Orsi (2017)	Araraquara - SP	Local scale	The spatial distribution of the population in the city, the fleet of private vehicles, public transport services and urban infrastructure, such as sidewalks and bike lanes	The author's analysis focuses on data related to public transport services and the fleet of private vehicles in the city. In addition, the author likely used statistical information and observations about urban infrastructure, including sidewalks and bike lanes, to support his conclusions about the challenges faced by the city in terms of urban mobility.	It points to the lack of infrastructure for pedestrians and cyclists, concentration of private vehicles and insufficient public transport. It highlights the need to rethink practices for a more sustainable and inclusive city.

GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

ISSN 2318-8472, v. 12, n. 87, 2024

Google Scholar	ACESSIBILIDADE E O EFEITO BARREIRA NA PERIFERIA DE CIDADES MÉDIAS	Bernardes; Souza (2017)	Presidente Prudente - SP Marília - SP São José do Rio Preto - SP Ribeirão Preto - SP São Carlos - SPLondrina - PR	Peripheral region of the 6 cities	Urban form, land use, road system, bus routes, physical and social barriers, discontinuities in the urban structure, distribution of the transport network, road structuring, commuting movements from residential neighborhoods from the peripheries to central service areas, urban accessibility, and the relationship between peripheral neighborhoods and the central area of cities. In addition, the characteristics of urban morphology, socio-spatial inequalities and the production of urban space in cities were considered.	The authors adopted a methodology based on the analysis of the mobility of residents of peripheral and low-income neighborhoods in six medium-sized cities, including five in the State of São Paulo (Presidente Prudente, Marília, São José do Rio Preto, Ribeirão Preto and São Carlos) and one in the State of Paraná (Londrina). The fieldwork was carried out collectively, in collaboration with researchers linked to the Thematic Project "Economic logics and contemporary spatial practices: medium-sized cities and consumption". Data collection involved visits to public institutions, interviews with residents and informed agents, as well as organization and graphic and cartographic analysis work carried out later in an office environment.	It identifies the barrier effect in the peripheries of medium-sized cities, contributing to socio-spatial segregation.
CAPES Newspaper	A caminhabilidade como medida da mobilidade urbana: análise do centro de Brejo Santo, Ceará	Lima; Jeronymo (2022)	Brejo Santo - CE	Local scale	Width and paving of sidewalks, street typology, crossings, lighting, noise pollution, garbage collection and cleaning, physically permeable facades, visually active facades, day and night public use, and mixed uses.	It used the Walkability Index version 2.0 to measure characteristics of the urban environment that influence pedestrian circulation. It collected data, applied the index and analyzed the results to evaluate walkability in Brejo Santo-CE.	It presents a walkability score, highlights the need for improvements in road safety, and suggests the use of the iCam 2.0 tool for urban infrastructure analysis.
CAPES Newspaper	Mobilidade em centros urbanos por circuitos de caminhada utilizando o método multicritério PROMETHEE, estudo de caso de Campinas	Oak; Rodrigues; Pezzuto; Bike; Oliveira (2021)	Campinas - SP	Local scale, centered in the central region of Campinas - SP	Walkability, from urban bus terminals.	Using the PROMETHEE multicriteria method, the study aims to improve the walkability of urban bus terminals towards the central region of Campinas-SP, evaluating indicators of environment, comfort and safety. The method provides recommendations for improvements, aiming to create more pleasant and safer urban environments.	It proposes to encourage the integration of public transport with walking, highlighting the importance of public policies and the PROMETHEE II method to plan safe routes.
CAPES Newspaper	A mobilidade urbana e o crescimento da frota de veículos em Pirapora	Neves dos Santos (2017)	Pirapora - MG	Local scale	Increase in the fleet of vehicles, traffic accidents, lack of adequate road system, non-compliance with laws, and discordant policies.	The article adopts a qualitative and exploratory approach to analyze the challenges of urban mobility in Pirapora-MG, possibly including literature review, data collection on vehicle fleet and traffic accidents, qualitative analysis and solution proposals.	It reveals a significant increase in the vehicle fleet, challenges in road infrastructure and the need for effective public policies for urban mobility.
CAPES Newspaper	Perspectivas de mobilidade urbana sustentável e a adesão ao modo cicloviário	Diogenes; Araujo; Tassigny; Bizarria (2017)	Strength - CE	Local scale	Profile of users (age, gender, socio-environmental awareness), the formation of user clusters, urban infrastructure, obstacles to adherence (driver behavior, lack of infrastructure, urban violence) and socio-environmental awareness	The research adopts a triangulation approach, combining quantitative and qualitative methods to analyze obstacles to the use of bicycles as a means of transportation. Data collection includes an electronic questionnaire, quantitative analysis with the K-Means method, and qualitative analysis with Content Analysis.	It indicates a possible evolution in the use of bicycles in Fortaleza, with changes in profile and cultural challenges. It suggests segmented policies and highlights the importance of planning.
CAPES Newspaper	Mobilidade urbana e acessibilidade: processos e reflexões na cidade de Montes Claros - MG	Bertolino; Bortolo (2020)	Montes Claros - MG	Local scale	Urban mobility in the aspect of sidewalks as spaces for public use.	Based on bibliographic research and local regulations, the study analyzes accessibility and urban mobility in Montes Claros, incorporating practical observations of sidewalks through photographic records.	It highlights the need to adapt sidewalks to technical standards to ensure accessibility and safety, emphasizing the importance of continuous inspection and interventions.

GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

ISSN 2318-8472, v. 12, n. 87, 2024

CAPES Newspaper	Transformações, permanências e desafios na mobilidade espacial metropolitana: movimentos pendulares na Região Metropolitana da Grande Vitória (RMGV)	Lyre; Castiglioni; Jabor; Casting (2017)	Metropolitan Region of Greater Vitória (RMGV).	Metropolitan Region of Greater Vitória (RMGV) - ES	Spatial mobility with emphasis on commuting for study and/or work, demographic and socioeconomic aspects, road system and transportation.	The study on spatial mobility in the RMGV uses bibliographic research, census data, Origin-Destination surveys and information from DETRAN/ES, classifying municipalities and employing factor analysis, cluster and georeferencing.	Between 2000 and 2010, the RMGV concentrated intermunicipal displacements, especially the municipalities of Polo Vitória, Vila Velha, Serra and Cariacica. Vitória's socioeconomic polarization persisted, while Serra underwent relevant transformations. The study emphasizes the importance of understanding interurban mobility to guide public policies in the face of urban expansion.
CAPES Newspaper	Paisagens da Mobilidade na Cidade de Anápolis: o caso da Avenida Brasil	Rézio; Valva (2016)	Avenida Brasil in Anápolis - GO	Local scale	Urban interventions	An on-site survey and literature review support the analysis of the urban landscape, involving walks to experience urban conflicts.	The urban project on Avenida Brasil, Anápolis, reveals a mismatch with the intra-urban reality, prioritizing vehicular traffic to the detriment of essential mobility. The article warns of the lack of deep reflection in urban planning, highlighting the need for more committed and less short-sighted approaches.
CAPES Newspaper	Eixos de mobilidade urbana e a (re)configuração do uso do solo e da densidade urbana: estudo de caso da Avenida Presidente Vargas, Passo Fundo/RS-Brasil	Canals; Neckel; Little Júnior (2021)	Presidente Vargas Avenue, Passo Fundo - RS	Local scale	Diversity and urban density between 2001 and 2020.	On-site surveys and thematic maps are used to understand the urban dynamics.	The increase in buildings, especially residential, contributes to the growth of vehicles, negatively impacting the road flow. The research highlights the complexity of urban mobility and the need for comprehensive understanding for effective decisions.
CAPES Newspaper	Recife, Veneza Brasileira: repensando a mobilidade urbana a partir de seus rios	Silva; Mello (2018).	Recife - PE	Local scale	Transformation of rivers into corridors for public transport.	The research on motility and potential mobility uses Kaufmann's concept and Kellerman's model, aiming at a comprehensive understanding, from users to the sustainable planning of urban mobility.	The "Rios da Gente" navigability project faces ideological, political, cultural and social challenges. The survey highlights the importance of considering both the mobile and immovable aspects of mobility in an integrated way. It points to the need for a democratic and participatory management model.
CAPES Newspaper	Acessibilidade na arborização urbana: percepção de deficientes visuais sobre a mobilidade em espaços públicos arborizados	Soares; Alves; Targino (2017)	Natal - RN	Local scale	Presence and distribution of trees in urban areas, with a focus on assessing the impacts on the mobility of people with visual impairment.	Data collection through interviews with blind residents in Natal-RN, identifying difficulties and limitations in routes in wooded areas.	Poorly planned urban afforestation impairs the mobility of people with visual impairments, generating fear and vulnerability. The lack of standardization and planning highlights the need for effective public policies to ensure accessibility and safety.
CAPES Newspaper	Detecção de padrões de mobilidade urbana em dia atípico a partir de sistema de bilhetagem eletrônica: análise das viagens na RMRJ durante o carnaval	Oliveira; Silva; Nassi (2016)	Rio de Janeiro - RJ	Regional scale	Urban mobility patterns during the carnival in Rio de Janeiro, using data from the Electronic Ticketing System, especially the State Single Ticket	The study on urban mobility patterns during Carnival in the Metropolitan Region of Rio de Janeiro uses data from the State Single Ticket, including data prospecting, identification of origins and destinations, allocation of trips and representation of origins by municipality.	During Carnival, the trips were similar to a weekend day, with emphasis on the expressive growth of the subway. The road mode is still predominant, but the more uniform distribution throughout the day and the increase during the night indicate particularities. The analysis suggests the need for a truly one-size-fits-all ticket to enhance operational schemes.

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ISSN 2318-8472, v. 12, n. 87, 2024

Methodological diversity is a hallmark of these studies, encompassing a variety of approaches ranging from statistical analysis and geocoding to case studies and critical analyses. This diversity reflects the complexity of the topics addressed, requiring both quantitative and qualitative methods for a comprehensive understanding. The main results highlight the importance of walkability and adequate infrastructure for the improvement of urban mobility. It is suggested that the restructuring of the urban form can have significant impacts on the quality of life and environmental sustainability of cities.

Similar conclusions highlight the need for innovative and effective public policies, adapted to the peculiarities of each urban context (Pereira *et al*., 2022). The studies cover several Brazilian cities, from large metropolises to smaller urban centers, reflecting a wide geographic diversity. They explore issues in metropolitan regions, medium-sized cities, and urban areas, highlighting emerging trends and future challenges. There is a consensus on the need to move towards more sustainable urban mobility, overcoming obstacles such as inadequate infrastructure and promoting urban environments that are more conducive to walking and health.

The literature review points to a gradual change in urban thinking in Brazil, with a growing emphasis on improving the quality of urban life and promoting environmental sustainability, as opposed to the previous model of uncontrolled urban development (Bernardes; Souza, 2017; Bezerra *et al*., 2022; Britto; Saints; Freitas, 2021; Carvalho *et al*., 2017; Strong; Duarte, 2014; File; Jeronymo, 2022; Pine; Gulinelli, 2020). The attention in the 30 scientific articles is focused on the fundamental aspects of urban mobility, walkability and urban form of Brazilian cities. The detailed analysis of these studies highlights the complexity of these issues and underscores the need for innovative approaches in urban planning and public policy.

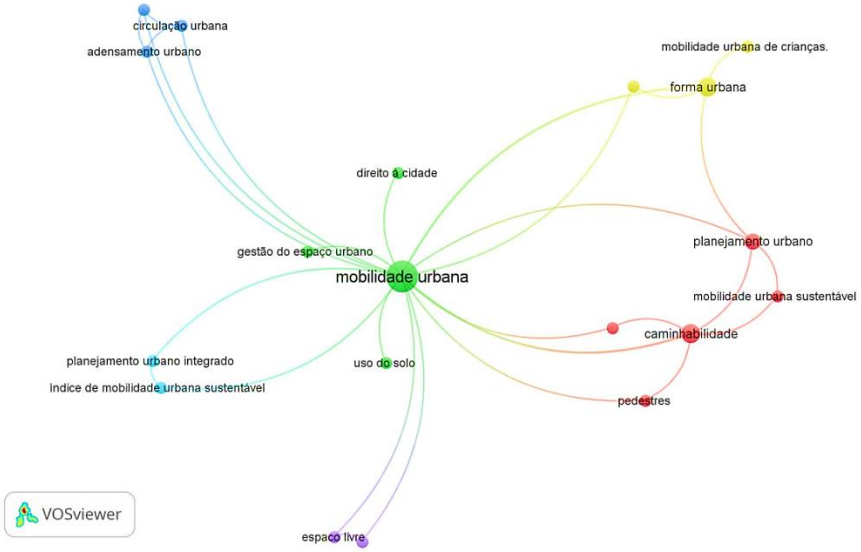
4.2 Analysis of the influence of urban form on mobility through meta-analysis

After reviewing the literature, it was decided to use the *VOSviewer software* to conduct a bibliometric analysis, a tool widely used in academic studies to quantitatively evaluate the scientific literature, as discussed by Luiz, Henning, and Kalbusch (2023). This approach aims to deepen the understanding of relationships in the concepts of the field of study in question. Graph 1, illustrates the analyses carried out, presents the connections identified in the literature, composed of nodes or circles representing keywords and concepts relevant to urban mobility and its relationship with urban form. The magnitude of each node corresponds to the frequency of its appearance in the analyzed articles, indicating prominent terms in the academic literature.

The connectivity between the nodes is represented by lines whose thickness reflects the strength of the associations between the terms. This allows you to identify correlated concepts and their relationships. The colors associated with the nodes relate to groups or *clusters* of terms that share more substantial relationships, helping to identify subthemes within the broad spectrum of study related to urban mobility and urban form.

ISSN 2318-8472, v. 12, n. 87, 2024

Graph 1: Simulation through the VOSviewer software of the related keywords identified in the 30 articles



Source: VOSviewer (2024). Org.: The authors (2024)

The core of the graph focuses on the term "urban mobility", surrounded by other key concepts, evidencing its frequent discussion in the context of urban space management and planning. In addition, the chart highlights *clusters* of correlated terms. For example, a blue *cluster* includes "urban circulation", "urban densification" and "integrated urban planning", suggesting the influence of planning on urban circulation and density. Another yellow *cluster* addresses children's urban mobility, urban form and urban planning, emphasizing urban *design* in mobility, especially for children. A third red *cluster* connects "walkability", "sustainable urban mobility" and "pedestrians", indicating the importance of walking in sustainable mobility. The inclusion of the term "right to the city" reveals considerations about equity and access in urban mobility, highlighting the social dimensions and spatial justice.

4.3 Patterns and trends among the variables of urban form in relation to mobility in Brazil

Considering the previous conclusions and the variables associated with the urban form, as proposed by Rossi (2001), such as the design and connectivity of roads, topography, population density, diversity of land uses, quality of spaces for pedestrians and public transport, Graph 2 presents the trends and patterns identified in the analyzed articles on the interaction between the urban form and mobility in the Brazilian context.

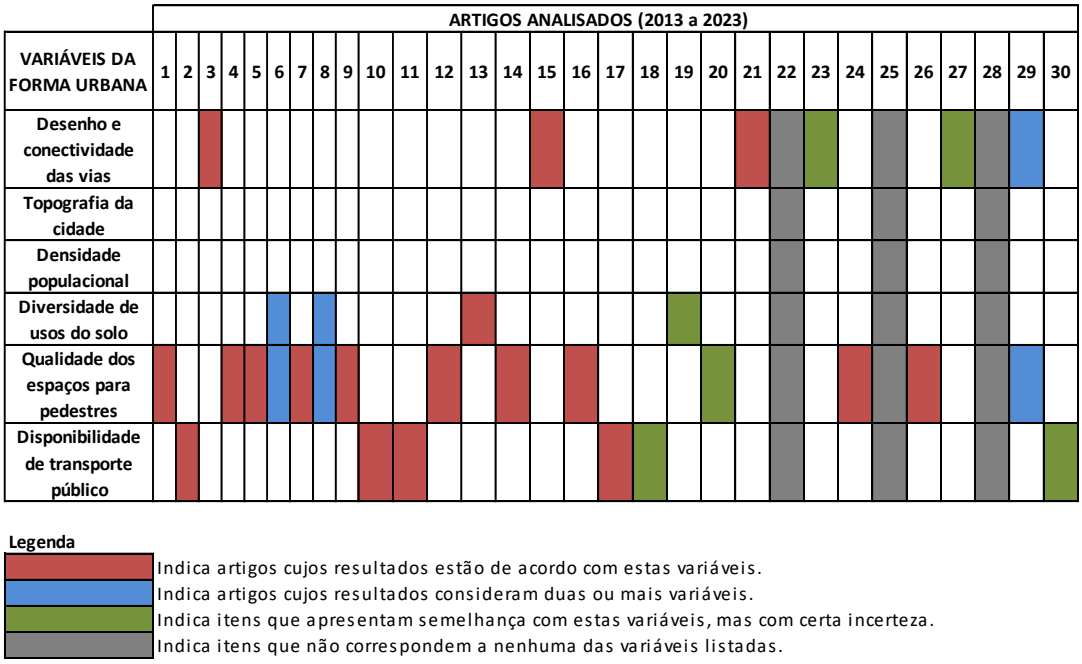
Based on Graph 1, it is observed that articles 3, 15 and 21 are aligned with the variable "Road design and connectivity", evidencing the importance of urban road planning in Brazil. These studies emphasize how such planning directly impacts urban mobility, emphasizing that good design and connectivity can facilitate traffic flow, reduce congestion and, consequently, improve the efficiency of urban transport.

Road connectivity refers to the extent and quality of connections and intersections between different road segments in an urban or road network. In other words, it is the measure of how easily vehicles, pedestrians, and cyclists can move between different parts of an urban area or along a highway. High connectivity usually implies a denser road network, with frequent

ISSN 2318-8472, v. 12, n. 87, 2024

intersections, facilitating the flow of traffic and accessibility to different locations. On the other hand, poor connectivity can result in isolated roads, *cul-de-sacs*, and limitations on efficient access to different areas. Road connectivity plays a crucial role in urban planning and transport infrastructure design, influencing the mobility and efficiency of the road system (Oliveira *et al.*, 2022).

Graph 2: Crossover between "variables of the urban form" and "articles analyzed" in the period from 2013 to 2023



Source: Authors' organization (2024)

Amâncio (2005) catalogs the variables found in the literature about the aspect of road design that should be considered in urban planning. It lists elements such as pedestrian permeability, number of intersections per kilometer of road, average block size, percentage of *cul-de-sacs*, average slope of roads, average width of roads, length of roads per hectare, number of blocks per hectare, percentage of the area of the zone occupied by the road system, among others. The connectivity of the road network, in turn, is related to the number of intersections present on a given road.

As for the variable "Topography of the city", there is an absence of articles that are exclusively aligned with this variable. However, it is crucial to mention that topography plays a significant role in urban mobility, especially in Brazilian cities with varying relief, such as Rio de Janeiro or Belo Horizonte, where hills and valleys can pose challenges to the development of efficient transport infrastructure (Cardoso; Oak; Nunes, 2019; Mayan; Netto; Costa, 2019; Olive tree; Silva; Nassi, 2016).

Similarly, the variable "Population density" also does not have articles that are exclusively aligned with this variable, suggesting that there may be less focus on this variable in isolation in urban mobility in the academic context. However, in practice, areas of high population density in Brazil may face challenges such as overcrowding and high demand for

ISSN 2318-8472, v. 12, n. 87, 2024

public transportation, which directly impacts mobility (Bernardes; Souza, 2017; Carvalho *et al*., 2021; Debatin Neto; De Mello Zabot, 2023; Fanelli; Santos Junior, 2013; Strong; Duarte, 2014; Lira *et al*., 2017; Silva; Mello, 2018).

On the other hand, the variable "Diversity of land uses" is supported by an article, article 13, which recognizes the importance of a mix of land uses to reduce travel distances and promote more sustainable urban mobility. This approach allows residents to access services and jobs without the need for long commutes, contributing to more efficient mobility.

Land use diversity refers to the variety of activities and functions performed in given urban areas, combining residential, commercial, industrial, institutional, and recreational uses. This diversity is crucial in urban planning, influencing several aspects, such as mobility, economic vitality, quality of life, and environmental sustainability.

Analysis of the relationship between urban form and activity-based commuting patterns includes land use as a crucial factor, providing perspectives on how land use disposition can influence urban mobility (Medrano; Taco, 2013). In addition, land use diversity plays a crucial role in understanding the dynamics of mobility and accessibility in medium-sized cities, especially in the context of public transport and the trajectories taken by buses (Bernardes; Timothy; Souza, 2017).

The variable "Quality of pedestrian spaces" is addressed in articles 1, 4, 5, 7, 9, 12, 14, 16, 24 and 26, indicating a trend towards interdisciplinary analysis and a growing appreciation of public spaces and walkability in Brazilian cities. This emphasis on the quality of pedestrian spaces is key to sustainable and more inclusive urban mobility.

In the traditional context of transport planning, walking is often relegated to a secondary role, with the quality of pedestrian spaces receiving little attention from public authorities. This is partly due to the common underestimation of walking trips in surveys of travel demand, especially short-distance travel, children's routes, recreational activities, and trips to access other modes of transportation, which are often neglected in surveys. The presence of sidewalks and their quality, notably in terms of safety, protection, comfort, connectivity and visual aspect, can promote the choice of pedestrians for walking, resulting, therefore, in the reduction of the use of motorized means of transport (Amâncio, 2005).

The *Pedestrian Environment Factor* (PEF) index, (1000 FRIENDS OF OREGON, 1993), considers the quality of a pedestrian area, based on four distinct attributes of the natural and built environment: the ease of street crossing, the connectivity of sidewalks, the local features of streets (such as grilles or *cul-de-sacs*), the topography of the terrain. According to the General Report of the National Association of Public Transport (ANTP, 2020), in Brazil, walking trips corresponded to the largest number of urban trips in 2018 (most recent survey), totaling 26.3 billion trips. Other data provided indicate that the use of this modal grows with the reduction in the size of the municipality, with more pedestrian displacement in small cities, and the average distance of the trip per pedestrian is 1.5 km.

And, with regard to the variable "Availability of public transport" it is corroborated by articles 2, 10, 11 and 17, which recognize its relevance in the discussion on urban mobility in Brazil. An accessible and efficient public transport system is considered essential to meet the mobility needs of the urban population.

ISSN 2318-8472, v. 12, n. 87, 2024

Law No. 12,587, enacted on January 3, 2012[1], establishes the guidelines for Brazil's national urban mobility policy. This law aims to integrate the different modes of transport and improve the accessibility and mobility of people and goods in the municipal territory, defining public transport as a public service accessible to the entire population on an individual basis, whose routes and prices are set by the public authorities. Accessibility, in turn, is defined as any equipment made available to people that allows everyone to move independently, in accordance with the legislation in force. The availability of public transportation is considered an essential public service and a social right, as established in the Federal Constitution of 1988[2].

In terms of patterns and trends, there is a tendency towards interdisciplinarity in the analysis of variables, indicating the recognition that urban mobility issues are multifaceted and interconnected with various aspects of urban planning. In addition, the concentration of articles on variables such as "Road design and connectivity" and "Quality of pedestrian spaces" suggests that these areas are considered priorities in academic research on urban mobility in Brazil.

Finally, variations in the concentration of articles by variable may reflect the different priorities and challenges faced by Brazilian cities. Cities with traffic problems may have more research focused on "Road design and connectivity," while those seeking to improve sustainability may direct their efforts to "Quality of pedestrian spaces" and "Availability of public transportation." This variety of approaches reflects the complexity of urban mobility in a country as diverse as Brazil.

5 CONCLUSIONS

Based on the analysis of the variables related to urban mobility in Brazil and considering the results of this research, it is possible to reach a comprehensive conclusion. Urban mobility is not just a matter of passive infrastructure, but rather a dynamic and active element that influences individuals' travel decisions.

The results highlight the importance of urban planning and transport policies in creating urban environments conducive to the promotion of sustainable modes of travel and to meet the diverse needs of the population. This implies that the design and connectivity of urban roads, the topography of the city, population density, the diversity of land uses, the quality of pedestrian spaces, and the availability of public transport all play interconnected roles in building more efficient and sustainable cities.

The conclusions of these studies transcend the academic sphere and provide a solid basis to guide decision-makers in the development of urban policies aimed at sustainability and the quality of life of citizens. Therefore, urban form and decisions related to urban mobility should be considered carefully, since they have a direct impact on the daily lives of Brazilian city dwellers. This integrated and holistic approach is key to addressing the complex challenges of urban mobility in a diverse country like Brazil.

[1] LAW NO. 12,587, OF JANUARY 3, 2012.

[2] The Brazilian Constitution of October 5, 1988 is the 7th Constitution of the Brazilian State. It was approved by the National Constituent Assembly on September 22, 1988 and promulgated on October 5, 19881.

ISSN 2318-8472, v. 12, n. 87, 2024

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ISSN 2318-8472, v. 12, n. 87, 2024

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