REVIEW ARTICLE

INFLUENCE OF COMMUNITY FOOD ENVIRONMENT ON ADULT BODY MASS INDEX (BMI): A SYSTEMATIC REVIEW

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Highlights: 1. BMI tends to increase with proximity and more supermarkets, cafeterias, and stores. 2. Higher BMI (>25 kg/m²) was more prevalent in lower socioeconomic status areas. 3. In affluent neighborhoods near markets, BMI tended to be lower.

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(as accepted)

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ABSTRACT

To verify the association between community food environment and Body Mass Index (BMI) of adults. Systematic review conducted in EMBASE, PubMed, and *Web of Science* databases, considering the period from 2010 to 2022. Out of 10,407 articles, 24 observational studies were eligible according to the inclusion criteria. The methodological approaches were evaluated using STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) and OSQE (Observational Study Quality Evaluation). The protocol was registered at PROSPERO (number 42021260594). Most studies reported that BMI tends to increase with proximity to and a greater number of supermarkets, fast-food establishments, and convenience stores. The prevalence of adults with BMI greater than 25 kg/m^2 was higher in locations with lower socioeconomic status. BMI was lower in more financially advantaged neighborhoods near grocery stores and fruit and vegetable markets. The selected studies indicate that a community food environment with higher availability of unhealthy foods is related to high BMI. The socioeconomic level can worsen this association, showing that people in social vulnerability have more difficulty accessing healthy food.

Keywords: Body mass index; Built environment; Adults; Systematic review.

INFLUÊNCIA DO AMBIENTE ALIMENTAR COMUNITÁRIO NO ÍNDICE DE MASSA CORPORAL (IMC) DE ADULTOS: UMA REVISÃO SISTEMÁTICA

RESUMO

Verificar a associação entre ambiente alimentar comunitário e Índice de Massa Corporal (IMC) de adultos. Revisão sistemática realizada nas bases de dados EMBASE, PubMed, e *Web of Science*, considerando-se o período de 2010 a 2022. De 10.407 artigos identificados, 24 estudos observacionais estavam elegíveis conforme os critérios de inclusão. As abordagens metodológicas foram avaliadas utilizando o STROBE (*Strengthening the Reporting of Observational Studies in Epidemiology)* e o OSQE (*Observational Study Quality Evaluation*). O protocolo foi registrado na PROSPERO (número 42021260594). A maior parte dos estudos relatou que o IMC elevado, aumenta com a proximidade e maior número de supermercados, estabelecimentos tipo *fast-foods* e lojas de conveniências. A prevalência de adultos com IMC superior a 25 kg/m^2 foi maior em locais com menor *status* socioeconômico. O IMC foi menor

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em bairros mais prósperos financeiramente e com proximidade a mercearias e mercados de hortifrutis. Os estudos selecionados indicam que o ambiente alimentar comunitário com maior disponibilidade de alimentos não saudáveis está relacionado ao IMC elevado. O nível socioeconômico pode agravar essa associação, evidenciando que, pessoas em vulnerabilidade social tem mais dificuldade na acessibilidade à alimentos saudáveis.

Palavras-chave: Índice de Massa Corporal; Ambiente alimentar; Adultos; Revisão sistemática.

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INTRODUCTION

The increase in body weight has shown rapid growth all over the world. According to the World Health Organization (WHO), overweight in adults has almost tripled since 1975, and the estimate is that 2.3 billion adults will be overweight by 2025. Additionally, most of the world's population lives in countries where overweight and obesity kill more people than underweight[1].

Studies have shown that the characteristics of the environment, such as the low availability and accessibility to healthy foods, the deprivation of space for physical activity, poor access to public transportation, and the low socioeconomic status of the neighborhood, may have an association with the obesity pandemic[2-4]. These elements constitute the built environment, of which the community food environment is a part. In this context, food environment (FE) is defined as the territory where people live and work and which impacts the quality of the population's food. At the same time, it also suffers economic, political, and sociocultural influences[5]. Depending on their constituent characteristics, they may be known as obesogenic environments.[5, 6] This food environment, in turn, can be divided into levels such as: community, organizational, consumer, and informational. The community food environment, it refers to the distribution, number, type, location, and accessibility of food retail outlets.[7]

According to Pereira *et al*.[8], opportunities are unequally distributed in the territory and social groups. Ethnic minorities, elderly or disabled people, women, and low-income families suffer disproportionately from disadvantages in accessing common goods, exacerbating poverty and socio-spatial inequalities. Ferreira, Vasconcelos, and Penna[9] refer to social and territorial inequalities as sides of the same coin, which are incorporated in space, condensing and expressing themselves as socio-spatial inequalities. As these places' infrastructure and living conditions improve, the valorization expels the disadvantaged to places with even worse conditions.

Therefore, these spaces' low access to opportunities (transportation, health services, employment and education, and leisure) can be characterized as a desert of opportunities[8]. Within this desert of opportunities, there is also the food desert, where there is little or no access to healthy food in the territory where one lives. Meanwhile, the same space can be covered with establishments that sell ultra-processed foods (UPFs), low-quality foods high in sugar, fats, sodium, and chemical additives, which contribute to overweight[10].

The increase in establishments selling UPFs has been driven by globalization which, according to Santos[11], can be understood as "the process by which a given local condition or entity extends its influence to the entire globe and, in so doing, develops the ability to designate as local another rival social condition or entity." In this scenario, food transnationals change the local territory, eliminating traditional trade and subsistence agriculture. The consequence might be a change in the regional healthy eating pattern, consisting mainly of low nutritional quality[12].

The influence of the FE brings to light the need for interventions and the elaboration of intersectoral public policies that go through environmental, urban, and food supply dialogues that guarantee human dignity concerning the right to healthy and adequate food. Thus, this study aimed to investigate the association between community food environment characteristics and the body mass index (BMI) of adults, considering articles that assessed the community food environment as the primary focus.

METHODS

Scientific literature search strategy

We conducted a systematic literature review to synthesize the results of observational studies that evaluated the association of community food environment and adult BMI. Therefore, the following guiding question was considered: "What is the impact of the community food environment on adult BMI?" The review was based on the *Preferred Reporting Items for Systematic Reviews* (PRISMA)[13] guideline and registered with PROSPERO (number 42021260594).

Since this is a literature review, no research ethics committee approval was required. The PECO (*Population, Exposure, Comparator, and Outcome*) acronym strategy was used to construct the research question[14] (Table 1).

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Table 1 PECO strategy

Criterion	Definition
Population	Adults
Exposure	Community Food Environment
Comparator	Eutrophic/low BMI
Outcome	High BMI

Source: The authors.

Article Selection

Articles were selected if they met the following inclusion criteria: (1) targeted adult individuals between the age range of 18 to 65 years; (2) characterized the community food environment from the following approaches: availability (density), access, proximity, and spatial distribution of food establishments; (3) compared the characterization of the community food environment with high BMI and/or its cut-off points that characterize overweight ($\geq 25Kg/m^2$) or obesity ($\geq 30Kg/m^2$); (4) were original articles; (5) were written in Portuguese or English, and (6) had a full-text version available for reading.

As the worldwide cut-off point to characterize adults in the scientific literature includes 18 years and older individuals, we chose to define it as a parameter for this review. It is worth noting that some studies have not established an upper age limit up to which an adult individual (the target population of the present study) is characterized. However, despite uncertainties regarding the possible inclusion of the elderly in these studies, we decided to include these documents in the analyses because they met the eligibility criteria. On the other hand, we excluded studies in which people older than 65 years were accurately evidenced.

The literature review was conducted in the following databases: EMBASE, PubMed, and *Web of Science*, by reason of it is a theme of great magnitude in the literature, it was decided to delimit the search period between January 2010 to March 2021. Subsequently, we updated the systematic review, comprising March 2021 to December 2021. Further updates were conducted from January 2022 to December 2022. The descriptors were defined according to *Medical Subject Headings* (MeSH) for PubMed searches and *EMBASE subject headings* (Emtree) for EMBASE searches. The search strategy used in the databases, as mentioned earlier, is shown in Table 2.

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Table 2 Search strategy for the EMBASE, PubMed, and *Web of Science* databases

Database	Search strategy
EMBASE	((community AND food AND environment) OR (built AND food AND environment) OR (neighborhood AND food AND environment) OR (local AND food AND environment) OR (obesogenic AND environment) OR (obesogenics AND environments) OR (food AND desert) OR (food AND deserts) OR (food AND swamp) OR (food AND swamps)) AND (bmi OR (body AND mass AND index) OR obesity OR overweight OR (nutritional AND status)) AND [2010-2022]/py AND [embase]/lim
PubMed	(Community food environment) OR (built food environment) OR neighborhood food environment) OR (local food environment) OR (obesogenic environment) OR (obesogenic environments) OR (food desert) OR (food deserts) OR (food swamp) OR (food swamps) AND (bmi OR (body mass index) OR obesity OR overweight OR nutritional status)) Filtres from: 2010/1/1 – 2022/12/31
Web of Science	(((community food environment) OR (built food environment) OR (neighbourhood food environment) OR (local food environment) OR (obesogenic environment) OR (obesogenic environments) OR (food desert) OR (food deserts) OR (food swamp) OR (food swamps)) AND (bmi OR (body mass index) OR obesity OR overweight OR (nutritional status))) and 2022 or 2021 or 2020 or 2010 or 2011 or 2012 or 2013 or 2015 or 2014 or 2016 or 2017 or 2018 or 2019 (Publication Years)

Source: The authors.

Data extraction

The initial selection of the articles was made by two independent researchers, following three steps: reading the title, reading the abstracts of the articles, and reading the full articles, according to the previously established inclusion criteria. After the articles were selected, the Kappa test[15] was applied to analyze interobserver agreement and find strong reliability (κ= 0.620; p=0.004; agreement= 83.3%).

Microsoft Excel version 2019 software was used to select the articles. In case of disagreement between the two researchers, a third researcher was consulted for a final decision. For data extraction, the protocol was proposed by the researchers themselves. The protocol considered the following elements: title of the article, author, country and year of publication, sample size, general characteristics of the study population, geographic coverage, objectives, statistical analysis techniques, main results, and methodological limitations of the selected articles.

Assessment of quality and information availability and methodological criteria/procedures

The STROBE report, translated by Malta *et al.*[16], guided the availability of information and methodological procedures in the selected articles. This report provides a checklist of 22 items considered in observational studies. Each item in the selected studies was assigned a score

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(total [1.0], partial [0.5], or nonexistent [0]) distributed according to the availability of information. Then, the scores were added up, and percentage points were calculated over the total number of applicable items. We included in this review articles that achieved 50% of the score (11 points). For the analysis of the quality of evidence in the articles, the "Observational Study Quality Evaluation (OSQE)" tool was employed[17]. The OQSE (Quality Assessment Tool for Observational Studies) consists of seven mandatory items/questions for cross-sectional studies and fourteen for longitudinal studies. The tool operates on a star-based rating system and includes vetoes based on the criteria met. Each star is equivalent to a score of 1. An article receives 1 star/1 score if it positively meets the established criteria, and if it does not, it receives a veto. If the article receives at least 1 veto, it is classified as low quality, even if it has received stars. To be designated as a high-quality article, it must receive stars for all items in the instrument[17].

RESULTS

At first, 10,407 articles were found, of which 2,250 were in EMBASE, 3,370 in PubMed, and 4,787 in *Web of Science*. After excluding duplicate articles (3,280) and titles that did not meet the pre-established criteria (7,105), 22 articles remained for abstract reading. In the end, four articles were excluded, and 18 articles were selected for a full reading. Twelve of these articles met the eligibility criteria and were selected by both researchers. After the systematic review update, one more article was selected, resulting in a review comprising 13 articles. Following the second update, an additional 11 articles were selected, bringing the total to 24 articles (Figure 1).

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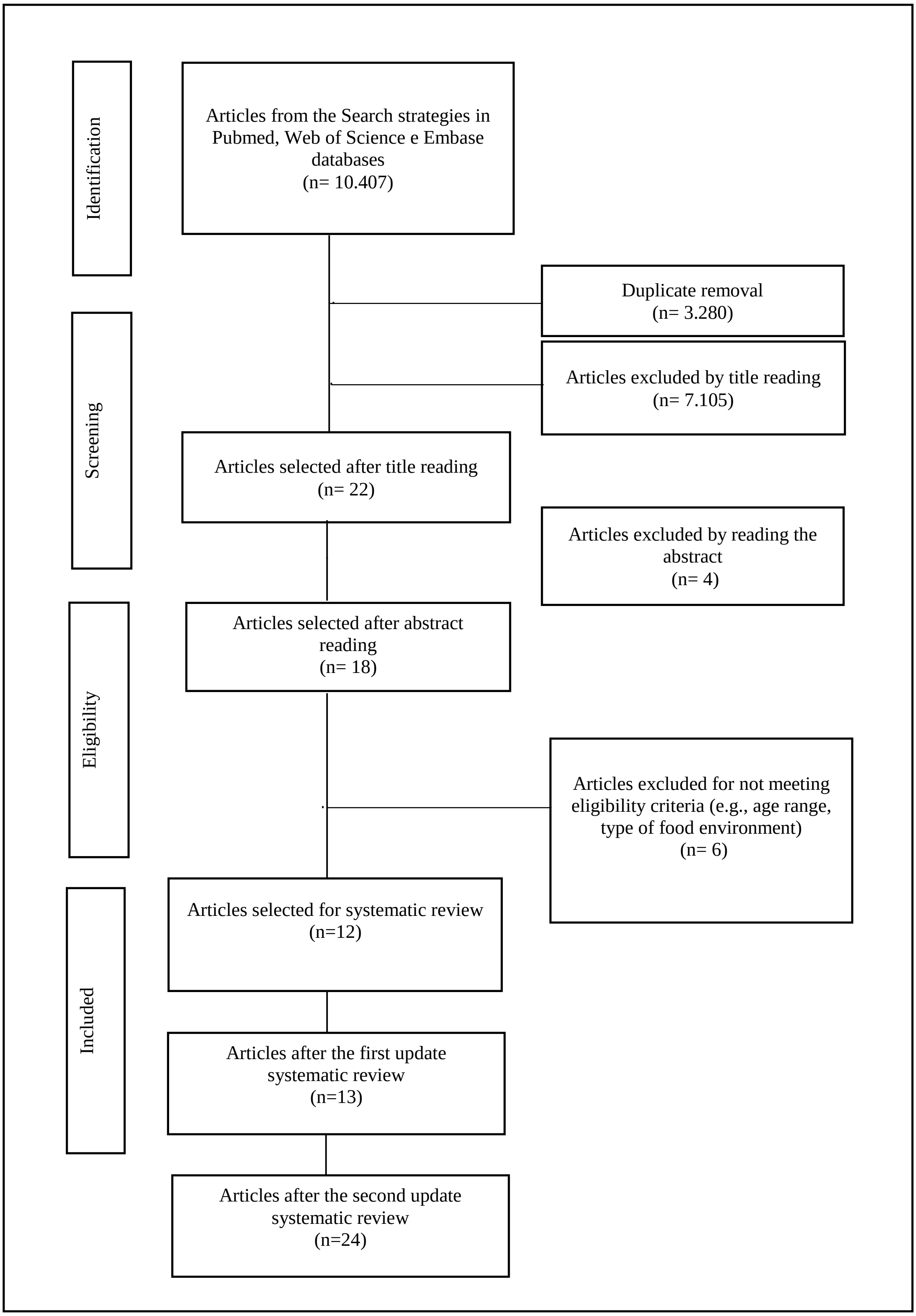

Figure 1 Flowchart: Identification and selection process of the articles included in the systematic review on the influence of community food environment on adult BMI from 2010 to 2022. Source: Moher *et al*[18].

The data concerning the main characteristics of the studies selected for this review are shown in Table 3. The median STROBE score obtained was 18.5 points, with maximum and minimum scores of 20.5[19] and 12[20] points, respectively. The highest score obtained in the qualitative analysis of the articles was 10[30,37], while the lowest was 4[24].

The studies were primarily conducted in the United States of America[2, 19, 21-30], followed by Brazil[31-35]. However, studies in China[4], Australia[36], India[20], Indonesia[37], Netherlands[38, 39], and South Asia[40] were also eligible; all were published from 2010 to 2021[2, 4, 19-28, 36]. The sample size ranged from 155[20] to 662,000[28] individuals. Regarding the type of study, only five studies had a longitudinal design[2, 22, 29, 30, 37], while the others had a cross-sectional approach[4, 19-21, 23-28, 36,40]. The studies were conducted with individuals of both sexes in similar proportions, except for two publications, conducted in New Orleans[19] and Erie County[25], that only targeted women. Most of the publications had geographic coverage by neighborhood or cities[19-21, 23-26, 28, 30, 36]. However, five articles had territorial representation at the national level[2, 4, 22, 39, 40] (Table 3).

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Table 3 Characteristics, score, and percentage according to STROBE report of the articles selected for the systematic review on the influence of community food environment on adult BMI from 2010 to 2022.

Author and year	Country	Sample size (n)	Type of study	Features sample	Geographical Coverage	STROBE Score*	Percentage* (%)	OSQE Stars■
Chen *et al.*, 2019[2]	United States of America (US)	20,897	Longitudinal	Age range: ≥ 45 years M: 44.22%; F: 55.78 %	48 contiguous states and Washington, DC	19	86,4	9
Yan *et al.*, 2015[27]	United States of America	3,041	Transversal	Age: average of 37.46 years (SD: 4.01) for Metropolitans and 40.64 (SD: 5.10) for non-metropolitans; Sex ratio: M by F of total population 97.98 (SD: 7.27)	US metropolitan and non-metropolitan municipalities	16,5	75	6
Raja *et al.*, 2010[25]	United States of America	172	Transversal	Age: Female with an average age of 42 years (SD: 6.08)	Erie County	17,5	79,5	6
Dornelles *et al.*, 2019[19]	United States of America	710	Transversal	Age range: Female between 39 to ≥60 years	New Orleans metropolitan area	20,5	93,2	6
Mejia *et al.*, 2015[24]	United States of America	5,185	Transversal	Age range: >18 years old M: 49.6%; F: 50.4%	Los Angeles County	15,5	70,5	4
Stark *et al.*, 2013[26]	United States of America	48,482	Transversal	Age range: ≥18 years M: 41.55%; F: 54.45%	New York City	17,5	79,5	6
Zhang *et al.*, 2020[4]	China	170,872	Transversal	Age range: 18 to ≥60 years M: 42.65%; F: 57.35%	Representative sample from China	20	91	7
Bodor *et al.*, 2010[21]	United States of America	3,925	Transversal	Age range: 18-30; 31-50 and > 50 years M: 34%; F: 66%	New Orleans	16,5	75	6
Gibson, 2011[22]	United States of America	6,994	Longitudinal	Age range: 33-48 years M: 51.81%; F: 48.19%	Urban and rural areas in the US	15	68,2	7
Hosler *et al.*, 2016[23]	United States of America	1,619	Transversal	Mean age: 45.3 years for Guyanese, 44.4 years for black, and 48.4 years for whites. M: 41.56%; F: 58.44%	City of Schenectady	18,5	84,1	5
Murphy *et al.*, 2018[36]	Australia	3,141	Transversal	Mean age of 54.15 years (SD: 0.31). M: 38.6%; F: 61.9%	City of Melbourne	18,5	84,1	5
Rautela *et al.*, 2018[20]	India	155	Transversal	Age: ≥ 20 years M: 38.7%; F: 61.3%	Srikot neighborhood, Uttarakhand	12	54,5	5
Huang, 2021[28]	United States of America	662,000	Transversal	Age: ≥18 years M: 43.5%; F: 56.3%	City of Chicago	18	81,8	6

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Oliveira, 2022[33]	Brazil	446	Transversal	Age: 20-59 years M: 33%; F: 67%	Metropolitan Region of Recife	19,5	88,6	6
Silva, 2019[31]	Brazil	965	Transversal	Age: 20-59 years M: 44.8%; F: 55.2%	Viçosa	17,5	79,5	6
Paulitsch, 2021[32]	Brazil	1,139	Transversal	Age: ≥18 years M: 44%; F: 56%	Rio Grande do Sul	19,5	88,6	6
Jaime, 2011[34]	Brazil	2,122	Transversal	Age: ≥18 years	São Paulo	19,5	88,6	6
Domingos, 2022[35]	Brazil	289	Transversal	Age: ≥20 years M: 33,9%; F: 66.1%	Viçosa	17,5	79,5	6
Dev, 2022[37]	Indonesia	7,224	Longitudinal	Age: ≥18 years M: 38.8%; F: 61.2%	Indonesia	19	86,4	10
Buszkiewic, 2022[29]	United States of America	879	Longitudinal	Age: ≥18 years M: 38.8%; F: 61.2%	Washington	18,5	84,1	8
Van Erpecum, 2022[38]	Netherlands	149,617	Transversal	Age: ≥18 years M: 42,3%; F: 57.7%	North of the Netherlands	19,5	88,6	7
Aretz, 2022[39]	Netherlands	2,836	Transversal	Age: ≥19 years M: 50.27% (SD: 2.10)	Netherlands	19,5	88,6	6
Atanasova, 2022[40]	South Asia	12,167	Transversal	Age: ≥18 years M: 40,29%; F: 59,71%	Bangladesh, India, Pakistan, and Sri Lanka	19,5	88,6	6
Acciai, 2022[30]	United States of America	517	Longitudinal	Age: Mean 41 years (SD: 10) M: 19%; F: 81%	New Jersey cities	18,5	84,1	10

*Scoring and percentage of essential items that should be described in observational studies, according to the Strengthening the *Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE)[16]; ▪Scoring the Observational Study Quality Evaluation (OSQE); M: male; F: female; SD: standard deviation
Source: The authors.

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Table 4 Main results of the studies selected for the systematic review on the influence of community food environment on adult BMI from 2010 to 2022.

Author and year	Main results
Chen *et al.*, 2019[2]	▪ Higher BMIs were associated in socioeconomically disadvantaged locations. In contrast, lower BMIs were more likely to be found in more affluent urban neighborhoods; ▪ The food environment index (representing the percentage of food retailers that were considered "healthy") was significantly and negatively associated with BMI; that is, when the food environment index increased, the BMI of the participants decreased.
Yan *et al.*, 2015[27]	▪ The obesity rate increased in supermarkets (0.25-0.28%) and convenience stores (0.05%); ▪ Obesity decreased at grocery stores (0.08%) and specialty food stores (0.27- 0.36%).
Raja *et al.*, 2010[25]	▪ The neighborhood food environment is positively associated with female BMI; ▪ On average, a number high number of restaurants available within five-minutes walking is associated with an increase in BMI; ▪ The distance from a subject's home to a convenience store is compared to the distance from home to supermarket or grocery store; when such distance increases by 1, BMI drops by about 1 kg/m^2, holding other factors constant. ▪ A diverse mix of land use in a neighborhood is positively associated with female BMI.
Dornelles *et al.*, 2019[19]	▪ When the three food environments (community FE, organizational FE, and household FE) were combined, the number of supermarkets and the number of grocery stores in neighborhood food environments had a significant positive association with BMI ($\beta = 0.56$ and $\beta = 0.24$, $p < 0.01$); ▪ The number of full-service restaurants showed an inverse relationship with BMI ($\beta = -0.15$, $p < 0.001$); ▪ For the commuting food environment, the study found that each additional fast-food restaurant in the vicinity of a kilometer traveled contributed to a higher BMI ($\beta = 0.80$, $p <0.05$).
Mejia *et al.*, 2015[24]	▪ The number of fast-food restaurants in non-traffic areas (within a 4.8 km radius) was positively associated with fast-food consumption; ▪ The number of convenience stores within walking distance (0.4 km) was negatively associated with obesity.
Stark *et al.*, 2013[26]	▪ Inverse association between BMI and food outlet density (0.32 BMI units across IQR, 95% CI -0.45 to -0.20); ▪ A positive association between BMI and proportion of BMI-unhealthy food outlets (0.26 BMI units per IQR, 95% CI 0.09 to 0.43); ▪ The association between BMI and the proportion of BMI-unhealthy foods with outlets was more substantial in lower poverty ZIP codes than in high poverty ZIP codes.
Zhang *et al.*, 2020[4]	▪ Associations of summer and winter temperature and restaurant density were generally stronger among rural participants, while the positive association between grocery store density and obesity was stronger among urban participants;

	▪ Compared to those who lived in subdistricts/neighborhoods without any full-service restaurants, people living in subdistricts/neighborhoods with the highest density of full-service restaurants showed a higher likelihood of obesity (OR=1.28 [95% CI, 1.07-1.53] and 1.19 [95% CI, 1.03-1.39] in males and females, respectively); ▪ Similarly, compared to counterparts without any grocery stores in their subdistricts/neighborhoods, people living in subdistricts/neighborhoods with higher grocery store density had higher odds of obesity (OR=1.20 [95% CI, 1.01-1.43] and 1.17 [95% CI, 1.01-1.35] in males and females, respectively); ▪ Higher levels of education were associated with obesity and abdominal obesity in males; ▪ Obesity was associated with an increasing number of coexisting obesogenic environmental factors.

Author and year	Main results
Bodor *et al.*, 2010[21]	▪ Each additional supermarket in a respondent's neighborhood was associated with a reduced risk of obesity; ▪ Fast-food restaurants and convenience stores were associated with higher odds of obesity.
Gibson, 2011[22]	▪ For residents of urban areas, neighborhood density of small grocery stores was positively and significantly related to obesity and BMI; ▪ For individuals who moved from a rural to an urban area for longer than two years, changes in neighborhood supermarket density, small grocery store density, and full-service restaurant density were significantly related to change in BMI during that period.
Hosler *et al.*, 2016[23]	▪ On average, respondents used 3.5 different places to buy food; ▪ Supermarkets and ethnic markets were associated with lower BMI in Guyanese adults; ▪ Among black adults, vegetable markets were associated with a lower BMI, while supermarkets, wholesale clubs, and food pantries were associated with a higher BMI; ▪ Among white adults, food cooperatives and supermarkets were associated with lower BMI, and wholesale clubs were associated with higher BMI; ▪ Neighborhoods with a food environment with greater travel distance to a supermarket were associated with lower BMI in Guyanese adults; ▪ The associations between specific food shopping locations and BMI varied substantially by race and ethnicity, suggesting that culture may be an essential modifying factor.
Murphy *et al.*, 2018[36]	▪ Fast food density was positively associated with BMI in established areas and negatively associated in urban growth areas; ▪ The interrelated challenges of car dependency, poor public transportation, and low-density development have made it difficult to access healthy food.
Rautela *et al.*, 2018[20]	▪ The prevalence of overweight was 14.8%, and obesity was 55.5%; ▪ 92.9% of the study participants reported junk food consumption. ▪ The total number of food outlets was 116;

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	▪ The density of any one food outlet per study participant was 0.7. The number of establishments selling healthy food is greater than the number of unhealthy food establishments; ▪ According to the participants, the high consumption of junk food was related to high palatability and convenience. There was no association between community food environment and overweight and obesity.
Huang, 2021[28]	▪ The results indicate that the obese population is highly concentrated in the African American community; ▪ In Chicago, each additional convenience store in a community is associated with a 0.42% increase in the obesity rate; ▪ Access to fast food restaurants is predictive of a higher obesity rate, and access to grocery stores is predictive of a lower obesity rate in a community with a higher percentage of African American population.
Oliveira, 2022[33]	▪ High prevalence of overweight; ▪ The higher density of stores that sell UPF, in relation to those of the UF-MPF; ▪ The high number of stores with UPF at check-outs; ▪ The greater offer of soft drinks and filled cookies.
Silva, 2019[31]	▪ An inverse association was observed between the density of public and private locations for physical activity and obesity (OR = 0.95, 95% CI: 0.92-0.99; OR = 0.98, 95% CI: 0.97-0.99) in models adjusted for individual and environmental variables; ▪ The highest third of per capita income was inversely associated with obesity ($p \leq 0.05$).

Author and year	Main results
Paulitsch, 2021[32]	▪ Living near a convenience store was associated with a higher BMI and a higher likelihood of being above normal weight and obese; ▪ In contrast, living near a restaurant was associated with a lower BMI and a lower likelihood of being above normal weight and obese; ▪ In addition, participants who lived close to fruit shops had lower BMI and a lower likelihood of being above normal weight.
Jaime, 2011[34]	▪ Average prevalence of overweight was 41.69% (95% confidence interval 38.74, 44.64), ranging from 27.14% to 60.75% across the submunicipalities. There was a wide geographical variation of both individual diet and physical activity, and indicators of food and built environments, favoring wealthier areas; ▪ After controlling for area socioeconomic status, there was a positive correlation between regular fruits and vegetables (FV) intake and density of FV specialized food markets (r=0.497; pG0.001), but no relationship between fastfood restaurant density and overweight prevalence was found. A negative association between overweight prevalence and density of parks and public sport facilities was seen (r=−0.527; pG0.05).
Domingos, 2022[35]	▪ Prevalence of overweight and food insecurity was high, 70.9 % and 72 % respectively; ▪ Stores that sell UPF had the highest density rates;

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	▪ People living within a milieu with the highest density of stores predominantly selling UPF (OR = 1.92; p < 0.05), with the highest average UPF sold at check-out (OR = 2.19; p < 0.05), with the highest average of soft drinks available in the stores (OR = 1.68; p < 0.05), and availability of filled cookies within the intermediate category (OR = 2.26; p < 0.01), had the highest probability of being overweight; ▪ Food environment is associated with overweight, after controlling for individual factors, and it is suggested that there is a food syndemic involving overweight and food insecurity, which is influenced by the food environment.
Dev, 2022[37]	▪ Living in a more built-up area was associated with greater BMI and risk of being overweight or obese; ▪ The contribution of the built environment was estimated to be small but statistically significant even after accounting for individuals' initial BMI.
Buszkiewicz, 2022[29]	▪ Road intersection density, access to food sources, and residential property values were inversely associated with BMI at baseline; ▪ At year 1, participants in the 3rd tertile of density metrics and with 4+ fast-food restaurants nearby showed less BMI gain compared to those in the 1st tertile or with 0 restaurants; ▪ At year 2, higher residential property values were predictive of lower BMI gain. There was evidence of differential associations by age group, gender, and education but not race/ethnicity.
Van Erpecum, 2022[38]	▪ Participants with one fast‐food outlet within 1 km had a higher BMI than participants with no fast‐food outlet within 1 km (B=0.11, 95% CI: 0.01, 0.21); ▪ Effect sizes for at least two fast‐food outlets were larger in low NSES areas (B=0.29, 95% CI: 0.01, 0.57), and especially in low NSES areas where at least two healthy food outlets within 1 km were available (B=0.75, 95% CI: 0.19, 1.31).
Aretz, 2022[39]	▪ Regional clusters of high obesity were observed in selected areas in the north-east, the south-west, and south-east; ▪ Limited accessibility to unhealthy food was globally associated with lower obesity prevalence, whereas better accessibility to fresh food stores and supermarkets was not; ▪ The association regarding worse accessibility to unhealthy food was strongest for urban neighbourhoods, especially for the Randstad region;
Author and year	**Main results**
Atanasova, 2022[40]	▪ The presence of a higher share of supermarkets in the neighbourhood was associated with a reduction in body size (BMI, β = - 3·23; p < 0·0001, and waist circumference, β = − 5·99; p = 0·0212) and obesity (Average Marginal Effect (AME): − 0·18; p = 0·0009); ▪ High share of fast-food restaurants in the neighbourhood was not significantly associated with body size, but it significantly increased the probability of obesity measured by BMI (AME: 0·09; p = 0·0234) and waist circumference (AME: 0·21; p = 0·0021). These effects were stronger among females and low-income individuals.
Acciai, 2022[30]	▪ Overall, over 18 months, an increase in the number of small grocery stores within 0.4 km of a respondent's residence was associated with a decrease in BMI (β = −1.0; 95% CI: −1.9, −0.1; P = 0.024), while an increase in the number of fast-food restaurants within 1.6 km was associated with an increase in BMI (β = 0.1; 95% CI: 0.01, 0.2; P = 0.027).

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	▪ Interaction analyses suggested that associations between changes in the food environment and changes in BMI varied by social standing. For instance, the association between changes in fast-food restaurants and changes in BMI was only observed in the social-disadvantage group (β = 0.1; 95% CI: 0.02, 0.2; P = 0.021).

BMI: Body Mass Index; IQR: Interquartile Range; ZIP: Zip Code; NSES: Neighbourhood socio-economic status.
Source: The authors.

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Most articles had adult BMI as the dependent variable[2, 19, 21-23, 25, 26, 36]. Therefore, we used multilevel linear regression to assess the association between community food environment and BMI[2, 19, 21-26]. The independent variables were socioeconomic factors, demographics, lifestyle, and density of outlets selling unhealthy foods[2, 4, 19-28, 36].

Table 4 refers to the main results listed by the authors of the selected studies. High BMI was prevalent in places with lower socioeconomic status[2, 26, 30, 31, 38], and where there was a higher number of supermarkets, fast-food establishments, and convenience stores near the subjects[2, 19-21, 24, 26, 28-30, 32-38]. BMI was lower in more financially advantaged neighborhoods with proximity to grocery stores and fruit and vegetable markets[2, 22, 23, 25, 27, 32]. In addition, two studies in the US have highlighted that UPF purchase and BMI can vary substantially by race/ethnicity[23, 28]. The study conducted in India and South Asia found no association between FE and overweight[20, 40]. The main methodological limitations mentioned were: the impossibility of establishing causal relationships[2, 21, 24, 26-28, 32-34, 36] and the non-inclusion of all food outlets[4, 22-24, 27, 36].

DISCUSSION

Interest in the food environment's impact on the health of individuals, especially regarding the prevalence of obesity, has increased in the last decade[1]. In addition to biological factors, obesity is multifaceted and a consequence of environmental, social, and economic factors[41]. For example, the FE can lead to unhealthy food choices, causing an increase in individuals' BMI, leading to overweight or obesity[42].

The results of this review suggest an association between overweight and community food environments with a high density of ultra-processed foods, as well as low income. In general, there was also an observed association between lower BMI and proximity to supermarkets and produce markets, along with higher income. Additionally, two studies indicated that food purchasing behavior may vary according to race/ethnicity.

Most eligible studies were conducted in the US, which may be related to the fact that the country has one of the highest obesity rates in the world. In 2019, 35% or more of adults reported obesity in 12 US states. This number has been increasing since, in 2018, there were nine states, and in 2017, there were only seven states where there was self-reported obesity[44]. Paradoxically, a large part of the transnational food corporations come from the US[45]. Research conducted by Dixon *et al*[46] on the built environment noted that more than half of the studies were from high-income countries, especially countries first experiencing the epidemiological

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transition[47]. Research in different contexts is needed better to elucidate the relationship between the FE and obesity.

Studies have shown that the prevalence of overweight is expressive mainly in places where socioeconomic status is lower[43, 47, 48]. A similar result was found in this review and may be related to the fact that unhealthy food environments are more prevalent in territories where social inequality is prevalent[2].

Suresh and Schauder[49] conducted ABM (Agent-Based Model) research to explore how income segregation affects access to healthy food for poor households. Their research was the first to expose that even under idealized conditions of perfect information and rational consumers, with no knowledge or preference distinctions between rich and poor households, social segregation leads to significant adverse consequences for access to healthy food by the poor. Thus, socio-spatial inequality can lead to food segregation and, consequently, overweight and poor health.

Among the selected articles, BMI was lower in neighborhoods with better socioeconomic status and closer proximity to grocery stores and fruit and vegetable markets. Research conducted in Germany[50] described a similar result, which shows that socio-spatial inequalities deepen and reinforce that human right to food and nutrition is not guaranteed to all people. Thus, urban planning and public health policies addressing food and nutritional security are essential to prevent overweight.

The rate of overweight/obesity increased with the increasing proximity and number of supermarkets, fast food, and convenience stores. This finding corroborates the reviews presented by Kraft *et al.*[51], An *et al.*[52], and the research described by Bivoltsis *et al.*[53], which identified that the greater the availability of UPF in the territory and the shorter the distance between UPF establishments and individuals' homes, the greater the likelihood of purchase[53]. With UPF availability and purchase, there is a consequent tendency of increase in body weight[51, 52].

In the study conducted in India by Rautela *et al.*[20] and in South Asia by Atanasova *et al.*[40], no association was found between community food environment and BMI, similar to a study produced with English adults and the elderly[54]. However, it is worth noting that the study was conducted in a neighborhood in India with high purchasing power and that the prevalence of overweight, although not associated with FE, was related to high consumption of UPFs among the study group. According to the participants of the Indian study, the preference for UPF is due to hyper palatability and because they are more convenient than other food choices.

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In this case, it is essential to have policies for taxing these products. Public policies should also consider food and nutrition education actions that reinforce the damage of UPF to health and develop cooking practices that use regional foods, preserving and strengthening the food culture[55]. Governmental actions, through public policies, are central factors that subsidize the access to healthy, fresh, and minimally processed food to all individuals, considering the regional and cultural crops and singularities, as exemplified by the Brazilian public policy of school feeding[56, 57].

Hosler *et al.*[23] described a study that found that food purchase and BMI might vary by race/ethnicity. In addition, research presented by Huang[28] found significant racial disparities in food access. This research highlights that food choices do not depend on individual issues but the equal socio-spatial distribution of food and opportunities. Thus, it indicates the need for affirmative policies in access to food to overcome the prejudice and discrimination that some races and ethnic groups have historically suffered.

Another explanation could be the racial-ethnic issue reported in research with Australian and Thai adults[58]. Food culture is closely linked to history, the environment, and the demands of a particular social group, and above all, it expresses peoples' identity, full of symbols and meanings. Thus, it is evident that food choices, i.e., the acquisition of food, can vary according to customs, but also, as already mentioned, with access to goods and services of this group[59].

Regarding the methodological limitations of the selected articles, most of the studies refer to the impossibility of establishing causal relationships, a situation that is inherent to the cross-sectional design[60]. The failure to include all food outlets was another limitation cited and may be associated with the lack of inclusion of informal establishments at various territorial levels in geographic information systems (GIS). Despite its limitations, GIS is widely used method for assessing community food environments due to practicality and low cost[61]. However, it is necessary to demand an information system that includes the informal establishments from all three levels of government public agencies.

Some limitations from this review are the racial/ethnic and age differences in the selected studies. However, the evaluative methods were similar, as was the relationship between BMI and FE. Therefore, we can infer that the standardization of food environments worldwide may cause the obesity pandemic. In addition, most studies showed a low percentage of people over 65 years of age.

The collection of information that synthesizes and evaluates the results exposed in this review allows for a better understanding of the relationship between community FE and BMI.

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It also allows for the identification of inequality in access to healthy foods. Therefore, it is essential to understand the factors that influence adults' food and nutritional security and design public policies that overcome food segregation.

In summary, the studies showed that the risk of overweight is higher in low-income territories because there is greater availability of unhealthy foods in these spaces, highlighting that there are socio-spatial inequalities in access to healthy and adequate food.

CONCLUDING REMARKS

The selected studies indicate that a community food environment with higher unhealthy foods is related to higher BMI. Furthermore, the socioeconomic level can aggravate this association since the socially vulnerable are more likely to have difficulty accessing healthy foods.

Likewise, it is necessary to develop intersectoral public policies that consider various eating establishments and promote greater commercialization of healthy foods. At the same time, it is also essential to develop research with different methodologies and designs that include other dimensions to have a deeper view of the FE beyond the community, such as prices, variety, quality of food available, among other characteristics.

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