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Perceived Neighbourhood Food Environment Applied in Urban Neighbourhoods of Malaysia: Mediation Effects

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Highlights

- The aim of the study was to examine the mediating effects of perceived neighbourhood food environment variables (PNFE) towards neighbourhood socio-economic status (NSES) and BMI status, while controlling for socio-demographic variables
- Once PNFE variables were introduced to the regression model, the result suggests that BMI status was almost wholly explained by NSES and three of the four PNFE variables
- Overall, NSES and PNFE explained 36% ($R^2 = 0.36$) variability proportion of BMI status

About Authors

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Abstract

Studies engaging the role of place in predicting health outcome in Malaysia are still very much in their infancy. A particular gap is testing the association of physical environments, particularly the food environment of different socio-economic neighbourhoods in predicting body mass index (BMI). Thus, the aim of this study was to examine the mediating effects of perceived neighbourhood food environment variables (PNFE) towards the relationship between neighbourhood socio-economic status (NSES) and BMI status, while controlling for socio-demographic variables. The four main indicators of PNFE identified from a systematic review were perceived food store type availability, perceived geographical food store accessibility, perceived healthy food availability and perceived food affordability. The BMI status of 60 subjects from three different NSES were collected. Their perceptions toward the neighbourhood food environment in which they live in were measured using a culturally and linguistically appropriate questionnaire (ICC = 0.59 – 0.82) that was adapted to Malaysians living in urban areas. Multiple regression models were run, and mediation tests were conducted. Overall, both NSES and PNFE explained a low variability proportion of BMI status ($R^2 = 0.36$), whereby perceived food store type availability was positively associated with BMI status (Beta = 0.200 (95% CI = 0.021 to 0.380), $p = 0.030$), perceived geographical food store accessibility was positively associated with BMI status (Beta = 0.644 (95% CI = 0.316 to 0.971), $p < 0.000$) and perceived healthy food availability (Beta = 0.315 (95% CI = 0.041 to 0.589), $p = 0.025$; but not perceived food affordability. Through the addition of the PNFE variables, NSES was found to be significant and positively associated with BMI status (Beta = 0.200 (95% CI = 0.021 to 0.380), $p = 0.030$). It is worth noting that although a model containing NSES and PNFE variables might be a poor predictor for BMI status, this does not negate the fact that those variables are statistically significant as predictors of BMI status. It is recommended that more environmental factors, such as physical building environment and social environment, as well as behavioural factors, such as diet quality and physical activity level, be included in future studies to better predict BMI.

1- Introduction

Food environment, as described by Glanz et al. (2005), is a closely interrelated relationship between the physical built environment and food sources which explains the environment in which an individual performs food-related activities. The study of food environment, especially on neighbourhood level (Ross, et al., 2004), stemmed from the notion that it poses high significance to food choices and consequently to body mass index (BMI) (Glanz, et al., 2005; McKinnon, et al., 2009). Furthermore, in the context of predicting an individual's BMI, Raja et al. (2010) has forwarded a model which stresses the importance of environmental factors including food environment, to be of highly significance. A plethora of past studies have suggested that with an improvement made to the food environment, the nutrition and quality of food intake can be improved as well (French, 2003; Glanz, 2009; Rummo, et al. 2015), thus decreasing health threats related to non-communicable diseases. As it has been highly recommended that the food environment which surrounds a person is significantly associated to BMI

(Powel, et al., 2006), a rise in studies of built environment-related health outcome assessments in Malaysia can be witnessed.

Multiple Malaysian-based research have indicated that inhabitants living in urban neighbourhoods are more prone to having problems in terms of food intake and BMI (Suzana, et al., 2010 and Wan Nazaimoon, et al., 2011), which decreases their quality of life as a whole. However, a research gap with regards to looking into the problem from the spatial environmental point of view remains largely untapped in Malaysia. As such, collecting data of the food environment is one of the main areas which requires much attention, especially in Malaysia where progress in this area still needs improvement. Consequently, exploring the mediating effects of the food environment in predicting BMI status also demands attention.

In examining food environment, the proxies used to denote healthy and unhealthy food stores is equally important. Based on several criteria in determining the categorisation of a food store, including but not limited to main food sold, selection and price, Franco, et al. (2008) supported by Larson, et al. (2009) suggested that the healthiest food store type in a descending order is supermarket,

Table 1: Description of food store types categorisation

Food store type	Description
Supermarket	Located in a large space in regional areas, usually has chains, has a balanced mix of healthy and unhealthy food products in large quantity and variety, items range from daily to yearly necessities (e.g. Jusco AEON, Econsave, Giant Hypermarket, AEON Big, Cold Storage, Maslee and any large local wet markets)
Grocery store	Mostly located in shop lots of neighbourhood areas, small to medium space, does not necessarily has chains, has good mix of healthy and unhealthy food products in smaller quantity and variety, items mostly range from daily to weekly necessities (e.g. neighbourhood mart and mini mart)
Non-fast food restaurant	Offers balanced mix of healthy and unhealthy foods, mostly, if not all items are prepared from raw fresh foods and mostly are full-service diners
Convenience store	Mostly located in shop lots of neighbourhood areas and gas stations, small space, mostly has chains, mostly foods and snacks sold are high fat protein foods, fat-rich foods and sugar-rich foods, items mostly cater for daily necessities (e.g. 7-eleven, KK Mart, Mesra Mart and Shell Mart)
Fast food restaurant	Mostly, if not all items sold are high fat protein foods, salt-rich foods, sugar-rich foods, processed and ready-made foods (e.g. McDonald's, KFC, Pizza Hut, Dominoes, Dunkin' Donuts and Texas Chicken)

grocery store and non-fast food restaurant. This is followed by unhealthy food store type as suggested by Stark, et al. (2013), including convenience store and finally, fast food restaurant. The descriptions of food store type characteristics are shown in Table 1. As for the definition of neighbourhood, the current study adopts the combination of expressions used by Oyeyemi, et al. (2012) and Raja, et al. (2010) which suggests “neighbourhood” as any area within the radius of 10 minutes walking time and driving within 5 minutes from the subjects’ homes.

As subjectively measured environmental factors was found to be more consistent than to those objectively measured (Caspi, et al., 2012; Svastisalee, et al., 2016), the current study proposed a perception-based measurement method. This is evident, as studies have shown that BMI is highly influenced by perceived neighbourhood food environment as demonstrated by Green & Glanz (2015) and Freedman & Bell (2009). As such, the four main indicators of perceived neighbourhood food environment that were found to be strongly associated with BMI are; *perceived food store availability*, denotes the count of food store types within the neighbourhood area; *perceived geographical food store accessibility*, signifies the distance of food store types from a subject’s house; *perceived healthy food availability*, is expressed as the quality and variety of healthy foods available in the neighbourhood area; *perceived food affordability*, shows the subject’s affordability towards healthy and unhealthy foods.

Perceived food store type availability, as mentioned by Glanz, et al. (2005) is highly significance and has positive relationship with BMI. As presented by studies including that of Ho, et al. (2010) and Svastisalee, et al. (2016), whereby both reported higher consumption of fast foods, sugar sweetened beverages, and high fat foods when subjects reported a higher perception of fast food restaurant availability within reach. In a 2-year longitudinal study, it was stated that changes were observed in subjects’ BMI levels when they move to and from two places of different supermarket, grocery store and non-fast food restaurant densities (Gibson, 2011).

As for *perceived geographical food store accessibility*, the majority of past studies agreed that the said indicator has a positive significant association with quality of BMI. Presented in an intervention by Caldwell, et al. (2009) found that greater geographical food access results in higher consumption of that particular food. For example, Caspi, et al. (2012), Rose and Richards (2004) as well as Sharkey, et al. (2010) all mentioned that subjects with higher perceived geographical access to supermarket reported of having higher consumptions of fruit and vegetables, thus having healthier BMI as a whole. Past studies have reached a consensus that *perceived healthy food availability* has positive strong association with diet quality, as demonstrated by Caldwell, et al. (2009), supported by Williams, et al. (2010) and Ding, et al. (2012). This situation is also apparent when Inglis, et al. (2008) stated that a high perception of healthy food availability not only increases the odds of healthy food consumption, it also simultaneously decreases unhealthy food consumption, especially fast foods. Vedovato, et al. (2015) continued to present supportive statements by proving that higher perceptions toward fresh produce availability results in lower consumption of ultra-processed foods, thus more prone to having healthier BMI level.

Finally, studies on *perceived food affordability* were usually found to be closely related to cost of foods and socio-economic level of the subjects. That being said, those who perceived fruits and vegetables as being within the range of affordable, tend to consume more of those items (Blitstein, et al., 2012; and Inglis, et al., 2008). As such, it can be said that subjects who reportedly perceived food types to be affordable, are more prone to consume more of the particular food item, hence, influencing BMI level. This has highlighted the influence of socio-demography into the picture, whereby most studies agree that the higher the education level (Giskes, et al., 2008; and Lucan, et al., 2014) and the higher the income level (Giskes, et al., 2007; and Dachner, et al., 2010) results in healthier BMI values.

2- Methods

a. Subjects

A total of 60 subjects were included in the cross-sectional study which was conducted through face-to face interview, whereby stratified sampling was utilized to select subjects from areas of high, medium and low neighbourhood social-economic status (NSES). Hence, 20 subjects were randomly approached for each NSES level stratum, totaling up to 60 multi-racial participants aged 18 years and above living in urban neighbourhoods of Johor Bahru, Johor with varying education levels. Inclusion criteria of the subjects are that they should have been living in their current places of residence for at least 3 years and is familiar with their neighbourhood surroundings. Five socio-demographic measures were used in this study; age, gender, race, monthly household income and highest education level. Age was categorized into three categories of 18 to 30 years old, 31 to 50 years old and above 51 years old. Race was categorized into four categories of Malay, Chinese, Indian and Others. Subjects were also asked to provide their monthly household income which ranged from less than RM3000, RM3001 to RM5000, RM5001 to RM7000, RM7001 to RM10000, and above RM10000. As for highest education level, the categories were primary, secondary and tertiary education.

b. Measures

Predictor variable: Neighbourhood socio-economic status

The study required subjects to provide the name of the street that they are living in, name of neighbourhood area and type of house they are currently residing in. This is to aid in the categorization of subjects' neighbourhood socio-economic status (NSES). The NSES is determined by checking the median property value of subjects in a local website which contains the history of Malaysia properties transacted data which links with the Valuation and Property Services Department of Malaysia. This is done by typing in the name of street, name of neighbourhood area and type of house that the subjects are currently residing in, into the website. As mentioned earlier, the sampling stratification was based on median property values of low, medium and high in the neighbourhoods of Johor Bahru, whereby properties of below RM299 per square feet is considered low value, properties of between RM300 to RM399 per square feet is considered medium value, and properties of more than RM400 per square feet is considered high value.

Outcome variable: BMI status

Subjects' BMI were calculated through the formula of weight in kilograms divided by height in meters squared. Asian cut-offs (Kelly, et al., 2014; Kanazawa et al., 2002; Thaikruea and Seetamanotch, 2006; World Health Organization, 2004) were used to categorize subjects into ordinal scales of 1: underweight (BMI<18.5), 2: normal (BMI 18.5 - <23), 3: at risk of overweight (BMI 23-24.9), 4: obese I (BMI 25-<30), and 5: obese II (BMI >30). However, as the current study is interested in the predictors of normal and overweight/obese BMI groups, data readjustment to BMI status produces only 2 categories of (1) normal and (2) overweight/ obese, extracting out the underweight subjects (n=4) from the analysis as well as combining overweight, obese type 1 and obese type 2 subjects in a single category. After which, subjects were then classed into two groups of 1: normal (BMI 18.5 - <23) and 2: above normal (BMI>23).

Environmental mediators: Perceived Neighbourhood Food Environment

Four perceived neighbourhood food environment (PNFE) variables were included in this study. Firstly, perceived food store type availability is adapted from Morland, et al. (2006), Treuhaft and Karpyn (2010) and Ploeg (2010), which collects the number of food store types available within a stipulated radius. As the current study gathers subjects' perceptions, the question is rephrased to "please indicate the estimated number of the following food sources available within 10 minutes' walk or 5 minutes' drive radius from your home. Leave blank if the food source is unavailable" in order to collect perceived counts of food store types available within a 10-minute walk or 5-minute drive from subject's house. The 5 food store types given were; 1: supermarket, 2: grocery store, 3: non-fast food restaurant, 4: convenience store, and 5: fast food restaurant. After a pre-test, the survey questions were added with examples familiar to the Malaysian context in an effort to make the questions more comprehensible by local subjects. As such, the example of food store types given were as follows; supermarket e.g. Giant, Econsave and AEON Jusco; grocery store e.g. neighbourhood marts and specialty stores; non-fast food restaurant e.g. local restaurants, "mamak" restaurants and cafes; convenience store e.g. 7-eleven, Petronas Mesra Mart and Shell Mart; as well as fast food restaurant e.g. Mc Donald's, Pizza Hut, Domino's Pizza and KFC.

Secondly, perceived geographical food store accessibility is adapted from numerous sources, whereby the item of "perceived distance of food stores from home" as demonstrated by Gustafson, et al., (2011), Bridle-Fitzpatrick (2015) and Caspi, et al. (2012) is rephrased to "about how long would it take to get from your home to the nearest food sources listed below if you walked to them?" and the open-ended answering section in the original versions were changed to close-ended questions of likert-scales to 1 to 5 minutes, 6 to 10 minutes, 11 to 20 minutes, 21 to 30 minutes, more than 30 minutes and not sure. Some of the original versions only included certain types of food store, as such, the current study decided to include all types of food stores indicative of healthy (supermarket, grocery store and non-fast food restaurant) and unhealthy (convenience store and fast food restaurant) food sources.

Thirdly, perceived neighbourhood healthy food availability is adapted from the original Perceived Nutrition Environment Measures Survey (NEMS-P) developed by Green & Glanz (2015), supported by Moore, et al. (2008) in Gustafson, et al. (2011) and Moore, et al. (2012), which consists of 6 questions and 5-point likert scales. The current study maintained the nature of the questions, but reduced the scale to a 4-pointer ranging from strongly agree, agree, disagree and strongly disagree. The purposely reduced scale is to force subjects to form much needed opinions and specific responses for the study, rather than choosing the “neutral” middle category. The 6 questions that the subjects have to rank were “it is easy to buy fresh fruits and vegetables (local/ imported) in my neighbourhood”, “the fresh produce (tempe, tauhu, meat, seafood) in my neighbourhood is of high quality”, “there is a large selection of fresh fruit and vegetables (local/ imported) in my neighbourhood”, “it is easy to buy low fat products, such as low fat milk and lean meats, in my neighbourhood”, “the low fat products in my neighbourhood are of high quality” and “there is a large selection of low fat products available in my neighbourhood”.

Finally, perceived neighbourhood food affordability is adapted from Blitstein, et al. (2002) and Inglis, et al. (2008), whereby although the original questions only include gauging perceived affordability towards fruit and vegetables, the current study extended the question to more food type categories, with answering range of a 4-point likert scale. The questions were “the fresh fruits and vegetables (local/ imported) in my neighbourhood are affordable to me”, “the fresh produces (tempe, tauhu, meat, seafood) in my neighbourhood are affordable to me”, “the low fat products, such as low fat milk and lean meats, in my neighbourhood are affordable to me”, “the sugar sweetened beverages in my neighbourhood are affordable to me”, “the snacks (sweets, candies, chocolates, cookies, ice creams and etc.) in my neighbourhood are affordable to me” and “the fast foods in my neighbourhood are affordable to me”; while the 4-likert scale ranking were strongly agree, agree, disagree and strongly disagree.

Tests of Cronbach’s alpha coefficient showed moderate to good internal consistency ($n=56$); perceived food store type availability (ICC: 0.591), perceived geographical food store accessibility (ICC: 0.693), perceived healthy food availability (ICC: 0.817) and perceived food affordability (ICC: 0.822). Each of the four PNFE variables were summed and classed into two groups of higher and lower categories, e.g. higher perceived food store type availability and lower perceived food store type availability; higher perceived geographical food store accessibility and lower perceived geographical food store accessibility; higher perceived neighbourhood healthy food availability and lower perceived neighbourhood healthy food availability; as well as higher perceived food affordability and lower perceived food affordability.

c. Statistical Analyses

Analyses were conducted using Statistical Package for Social Science for Windows, version 22.0. For appropriate variables; descriptive statistics such as means, medians, standard deviations and percentages were computed as needed. The study adopts the approach introduced by Baron and Kenny (1986) whereby in order to assess the mediation potential of a variable, two conditions have to be met;

firstly, the predictor variable (NSES) will have to be significantly associated with the potential mediator (PNFE variables); and secondly, the potential mediator (PNFE variables) will have to be significantly associated with the outcome variable (BMI status). As such, inclusivity was set to significance level of $p < 0.05$ to fulfil these initial criterion. The test for main effects and potential mediators were ran in three steps. Firstly, in order to avoid interruption of association between the variables of interest, the confounding variables (socio-demographic characteristics) were included in step one. Next, the predictor variable (NSES) was added in to the regression model while retaining the socio-demographic characteristics in step two. After that, the socio-demographic characteristics and NSES variables were retained, while adding in the potential mediator (PNFE variables) in step 3.

3- Results

The total sample size of the study was initially 60 subjects as shown in Table 2, however, it is to note that those who are underweight ($n=4$) were excluded from further statistical analysis part. Forty-five percentage (45%) of the subjects were female, 67% were Malays, 55% have had finished secondary school, with 30% household income of less than RM3000. The mean age was 39 years old and 35% of subjects has normal BMI. More than half (58%) of the subjects were reportedly either overweight (23%) or obese (35%) with type 1 accounted for 20% and type 2 accounted for 15%, respectively. The BMI distribution of the study is reflecting that of the current Malaysian statistical distribution, as reported by Chan, et al. (2017), approximately 1 in every 2 subjects recruited in the Malaysian National Health and Morbidity Survey in 2015 (51.2%) had a BMI of more than 25 and were categorized as either overweight or obese.

All the sub-scale scores were summed up with the mean of item for each subject was calculated and subsequently categorized into dichotomous scales of higher and lower categories. For perceived food store type availability, subjects' scores were categorized as 1: higher food store type availability and 2: lower food store type availability, where the result showed that more than half of the subjects (54%) reported as having lower perceived availability of food store type. Secondly, for perceived geographical food store accessibility, frequencies showed that 59% of subjects responded as having lower perceived geographical food store accessibility. This shows that most subjects felt that the food stores within their immediate neighbourhoods were not as geographically accessible as desired. Thirdly, perceived healthy food availability showed that most subjects reported as having the perceptions that they have higher healthy food availability within their immediate neighbourhood areas (64%). Lastly, perceived higher food affordability was accounted for 62% of subjects which signified that the majority of subjects felt their food affordability level is considered acceptable.

Regression models predicting BMI status are shown in Table 4. During the first step, none of the socio-demographic characteristics were found to have direct significant associations in predicting BMI status and the model accounted for a variation proportion of 0.072, which means that the socio-demographic characteristics only explained 7.2% of the BMI status variability. Next, the addition of NSES in step 2 only increases the dependent variable's variability proportion to 9.8%. In step 3, by adding in PNFE variables, it substantially increased the variability proportion of R^2 to 36%, whereby

Table 2: Socio-demographic characteristics of subjects, n = 60

n = 60	
Age	39.4 ± 14.4
Gender, %men	55
Race, %	
Malay	67
Chinese	27
Indian	5
Others	1
Education, %	
Elementary	13
Secondary	55
Tertiary	32
Household Income, %	
≤ RM3000	30
RM3001-RM5000	23
RM5001-RM7000	25
RM7001-RM10000	9
≥RM 10001	13
Body Mass Index, %	
Underweight (≤18.5)	7
Normal (18.5-23)	35
Overweight (23.1-24.9)	23
Obese 1 (25-30)	20
Obese 2 (≥30)	15

Table 3: Descriptive information of PNFE and its indicators, n=56

PNFE (n=56)	
Perceived food store type availability, %	
Higher food store type availability	46
Lower food store type availability	54
Perceived geographical food store accessibility, %	
Higher geographical food store accessibility	41
Lower geographical food store accessibility	59
Perceived healthy food availability, %	
Higher healthy food availability	64
Lower healthy food availability	36
Perceived food affordability, %	
Higher food affordability	62
Lower food affordability	38

Table 4: Regression models predicting BMI status (n=56)

Variables	Step 1: socio-demography only		Step 2: socio-demography + NSES		Step 3: socio-demography + NSES + perceived environmental mediators	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age	-0.056 (-0.251 to 0.139)	0.567	-0.048 (-0.243 to 0.146)	0.621	-0.093 (-0.268 to 0.082)	0.290
Gender	0.084 (-0.187 to 0.355)	0.536	0.096 (-0.175 to 0.366)	0.480	-0.037 (-0.285 to 0.211)	0.766
Race	-0.097 (-0.33 to 0.137)	0.410	-0.107 (-0.34 to 0.126)	0.362	-0.217 (-0.440 to 0.005)	0.056
Education	-0.193 (-0.427 to 0.041)	0.104	-0.206 (-0.440 to 0.028)	0.083	-0.186 (-0.397 to 0.025)	0.082
Income	-0.008 (-0.113 to 0.097)	0.874	-0.049 (-0.174 to 0.076)	0.435	-0.061 (0.174 to 0.053)	0.289
Neighbourhood socio-economic status (NSES)	-		0.116 (-0.079 to 0.312)	0.237	0.200 (0.021 to 0.380)	0.030
Perceived food store type availability	-		-		0.644 (0.316 to 0.971)	<0.000
Perceived geographical food store accessibility	-		-		-0.407 (-0.720 to -0.094)	0.012
Perceived healthy food availability	-		-		0.315 (0.041 to 0.589)	0.025
Perceived food affordability	-		-		-0.219 (-0.493 to 0.054)	0.113
R	0.269		0.314		0.600	
R ²	0.072		0.098		0.360	
Adjusted R ²	-0.210		-0.012		0.217	
S.E. of Estimate	0.493		0.491		0.432	

perceived food store type availability was positively associated with BMI status (Beta = 0.200 (95% CI = 0.021 to 0.380), $p = 0.030$), perceived geographical food store accessibility was positively associated with BMI status (Beta = 0.644 (95% CI = 0.316 to 0.971), $p = <0.000$) and perceived healthy food availability (Beta = 0.315 (95% CI = 0.041 to 0.589), $p = 0.025$; but not perceived food affordability. Through the addition of the PNFE variables, NSES was found to be significant and positively associated with BMI status (Beta = 0.200 (95% CI = 0.021 to 0.380), $p = 0.030$). Although the low R^2 (0.36) indicates that a model containing only variables of the socio-demographic characteristics, NSES and PNFE variables might be a poor to moderate predictor for BMI status, it is important to highlight that this does not negate the fact that variables of PNFE and NSES are statistically significant as predictors of BMI status.

4- Discussion

The current study aims to integrate interdisciplinary fields of urban planning and dietetics. Although past studies have recognized the importance of the surrounding environment in influencing health outcome, particularly between the construct of food environment and BMI; Malaysia have yet to explore this area of interest to explain its inhabitants' obesity epidemic that has been on the rise for the

past decade especially in urban areas. To the knowledge of the author, this is the first study which aims to measure the contribution of perceived urban neighbourhood food environment as a mediator in predicting the causal relationship between neighbourhood socio-economic status and BMI, while controlling for socio-demographic characteristics. An initial systematic review highlighted four perceived neighbourhood food environment (PNFE); perceived food store type availability, perceived geographical food store accessibility, perceived healthy food availability and perceived food affordability. Care was given to turning the collated measures in the questionnaire to be linguistically and culturally appropriate. In addition to that, it was phrased in short sentences and categorized in close-ended questions where possible, while avoiding complex terminologies, acronyms and abbreviations.

Overall, the result shows that the majority of urban neighbourhood areas in Malaysia is perceived as having medium quality of food environment. However, the worth highlighting results are that of the high percentage of lower perceived food store type availability and lower perceived geographical food store accessibility, denoting that many subjects felt that their neighbourhoods' food store types are not diverse enough, and that they find it harder to reach those food stores by foot. From the regression models, it shows that the confounding variable, i.e. socio-demographic characteristics, were non-significance in predicting BMI status. Once the PNFE variables were introduced to the model, it suggests that BMI statuses were almost wholly explained by NSES and three of the four PNFE variables. The current study concurs with findings of previous studies that perceived food store type availability, perceived geographical food store accessibility and perceived healthy food availability are significant and positively associated with BMI, with the exception of perceived food affordability which is found to be non-significant.

The overall R² for the correlation between socio-demography, NSES and PNFE with BMI variables of 0.36 showed that the relationship between those items are weak and positively related. However, as mentioned earlier, this does not negate the fact that these variables are significant in predicting BMI status. This outcome means that BMI status can be mediated by other factors such as diet quality and physical activity level, as well as directly affected by other factors of the physical environment such as the built environment and social environment. As explained by Raja, et al. (2010) and Glanz, et al. (2015), supported by Casey, et al. (2011), when predicting BMI and other health outcomes, it is imperative to include other environmental and behavioral factors due to the complex interrelationship between human and the physical environment.

As a conclusion, the three key findings which warrants further explorations are; i) the inclusion of more explanatory variables in predicting BMI status; inserting direct and/or mediating roles, such as other physical environmental factors e.g. built environment and social environment, as well as health behaviors factors e.g. diet quality and physical activity; ii) the inclusion of the food environment factor in studies predicting changes of health behaviors and health outcomes, and iii) the consideration of urban and regional planning aspects when predicting nutritional health behaviors and health outcomes. As a whole, the study adds to the existing literature by providing more evidence to the effect of the

food environment-perceived, particularly in the vicinity of South East Asia, in predicting health outcome expressed in BMI status. It also adds to the viability of linguistically and culturally adapted instrument in measuring the food environment. More efforts in improving the food environments of Malaysia to achieving healthier BMI levels among inhabitants to lower national percentage of overweight and obese population is necessary.

5- Conclusion

Neighbourhood socio-economic status and perceived neighbourhood food environment variables; perceived food store type availability, perceived geographical food store accessibility and perceived healthy food availability, were positively significant in predicting BMI status. The association between neighbourhood socio-economic status and BMI status was mediated by perceived food store type availability, perceived geographical food store accessibility and perceived healthy food availability.

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