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Shelf Space Devoted to Nutritious Foods Correlates with BMI

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Abstract Obesity continues to be a threat to global health. The goal of this study was to examine the correlation between shelf space devoted to various categories of food and BMI in a variety of nations. A total of 121 supermarkets in 10 different countries were evaluated by taking linear measurements of shelf space devoted to 8 categories of foods, and assessing whether there was any relationship to mean population BMI. Trends were detected for the following food categories: 1. higher percent shelf space devoted to fresh vegetables, fresh fruit, canned vegetables, and canned fruit were all associated with a lower national BMI; 2. higher percent shelf space devoted to cereals/pastas/grains/bread, junk food and dairy showed a trend to higher national BMI. Percent supermarket shelf space devoted to healthful foods across 10 different countries correlated with lower BMI ranking by WHO statistics; percent shelf space of grains, dairy and junk food was different for each country and showed a positive trend with BMI. Supermarket shelf space use can offer insight into a country's BMI, and represents a potential intervention avenue for positive health impact. Further work is needed to confirm this correlation in other nations, regions, and socioeconomic and demographic categories within nations.

Keywords: *obesity, food environment, BMI, supermarket shelf space*

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1. Introduction

Obesity is a rising worldwide public health concern and has many serious, chronic consequences, such as heart disease and type-2 diabetes. Obesity is not only a medical concern, but also imposes a substantial financial burden on individuals, entire nations, and the world.

Access to nutritious foods in local grocery stores may reflect as well as influence dietary patterns. The more accessible and abundant a food product, the more likely a customer is to purchase and consume it. For example, one study showed that an accessible supply of sugar-sweetened beverages in schools is linked to increased risk of obesity and diabetes [2]. Another study on obesity showed that people who consumed sugar-sweetened beverages were at increased risk of metabolic abnormalities regardless of body weight compared to people who did not report consuming the beverages; this study also stated that it is essential that these observations be explored in the future given the implications of a simple dietary modification on metabolic health [27]. It has also been suggested that higher prices of healthful foods is associated with decreased healthful food consumption in lower socio-economic status individuals [14]. Several studies show that supermarkets are more prevalent in wealthier neighborhoods compared to poorer neighborhoods [16,17,18,19,20]. One study in southern Louisiana in 2005 reported a modest positive correlation of energy dense snack foods and BMI, but found no significant correlation between fruit and vegetable availability and BMI [1]. Another study showed a positive association between the availability of healthful foods and BMI among individuals in predominantly white neighborhoods, perhaps due to individuals in areas of low healthful food availability traveling outside their neighborhoods to obtain such foods [21]. Proximity to a grocery store was found to have a negative impact on BMI [23]. Another study found that access to a supermarket is associated with reduced risk of obesity, while better access to convenience stores is associated with increased obesity risk [22]. Beyond accessibility and price, the type, geographic placement and number of food stores in a region have been studied extensively, but few studies have investigated the availability of products inside stores.

Approximately 2 million U.S. households live at least one mile from a supermarket and do not have an automobile or access to one [11]. Neighborhoods with insufficient access to supermarkets or larger grocery stores are characterized as "food deserts" [10]. Food deserts often include many small- scale convenience stores scattered throughout a neighborhood that contain limited variety, inflated prices and low quality produce [12]. Numerous studies confirm that lack of access to supermarkets is associated with inadequate dietary patterns and increased risk of obesity [3-9].

Not all studies agree that access to supermarkets is associated with increased risk of obesity, though [13].

Studies of proximity to supermarkets may be insufficient because of the underlying assumption that all supermarkets stock consistent products with the same, wide-array of healthful options. What is stocked by a supermarket is more complex, depending on many factors such as supply/ demand, cultural food norms and pricing. Many previous studies relied on existing databases to identify food stores, but did not survey the foods inside of the store walls [15]. Further research beyond supermarket proximity is needed to assess the complex influence of food environment on obesity.

This gap in the literature led us to look deeper inside food stores of various kinds. Thus, we conducted a cross-country investigation of the percent shelf space dedicated to healthful and less healthful foods, and examined the relationship to current WHO population BMI statistics.

2. Methods

BMI and life expectancy statistics for the nations studied were obtained from the most recent WHO databases [24]. The nations studied were representative of varying regions spanning mostly high income countries and one middle-income country--Greece: the high income countries studied were: Italy, Croatia, Switzerland, Luxembourg, Belgium, the Netherlands, Norway, the United Kingdom, and Ecuador (upper-middle income) [25]. Gross national income per capita was categorized as: high income ($12,476 or more), middle income ($4,036-12,475) [25]. Santa Cruz Island in the Galapagos Islands was surveyed as a representation of Ecuador. The purpose of including the Galapagos Islands in this study was exploratory, as we could identify no existing BMI data for the Galapagos Islands.

Linear shelf space of eight categories of food—fresh fruit, fresh vegetables, canned fruit, canned vegetables, soda, cereals/pastas/grains/bread, dairy, and junk food--was obtained via a tape measure. The measurements for the study were conducted by a single co-author. “Junk food” was classified as snack foods that are high in calories, low in nutritional value, and require little-to-no preparation [26]; for example, chips, crackers, candy, cookies, pastries, and other snacks, including both pre-packaged items and items baked and sold in-store.“Energy bars,” cereal bars, and selected “diet foods” were not measured. Soda was classified as carbonated beverages and included artificially sweetened “diet” beverages, but did not include non-carbonated beverages such as high-sugar juices. Frozen fruits and vegetables were not measured because they were of limited availability in virtually all stores surveyed.

Shelf length of each category of food was obtained using a measuring tape. These measurements accounted for the number of shelves, as well as if another food category was available in the space measured. Measurements did not account for depth or height of shelves. Measurements were summed to attain a total shelf length for each store. Percent shelf space for each category of food was defined as the linear shelf space measured occupied by that category divided by the entire linear shelf space measured in the store.

Only supermarkets were included in the study; corner stores and specialty stores were not. Supermarkets were selected at random across different regions in each country. WHO BMI and life expectancy statistics pertaining to each country surveyed were utilized for data analysis. All statistical analysis was performed using Mathematica Version 9. Regression models were used to assess correlations between shelf space and BMI when applicable. This study was considered exempted by the Johns Hopkins University Institutional Review Board in Baltimore, Maryland.

3. Results

Figure 1- Figure 3 show average fraction of a store’s total shelf space devoted to a category of food versus mean country adult BMI.

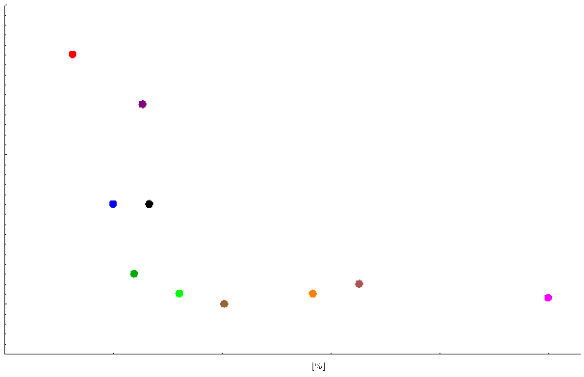

Figure 1. Combined Fruit and Vegetable Shelf Space Versus BMI

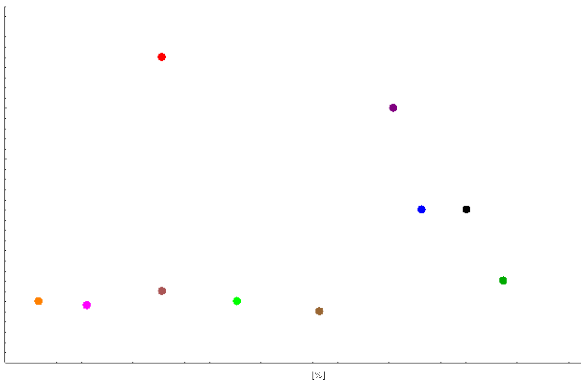

Figure 2. Soda and Junk Food Shelf Space vs. BMI

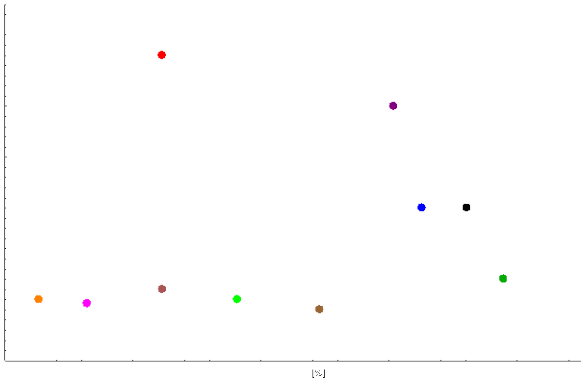

Figure 3. Cereals, Pastas, Grains Shelf Space vs. BMI

Figure 1, *Combined Fruit and Vegetable Shelf Space vs. BMI,* does not show a linear dependence, but does suggest

that increasing the shelf space devoted to fresh vegetables, canned vegetables, fresh fruit, and canned fruit may have a relationship with the overall BMI. Countries that devoted under 15% of their shelf space to fruits and vegetables displayed the highest BMIs. The highest BMI displayed by a country that devoted over 15% of its shelf space to fruits and vegetables (the Galapagos/Ecuador) was less than the lowest BMI of a country that devoted under 15% of its shelf space to fruits and vegetables (Norway). The average and standard deviation of countries that devote less than 15% shelf space to fruits is 26.36±0.88. However, for countries with over 15% shelf space devoted to fresh fruit and vegetables, the mean and standard deviation is 25.09±0.073. These two distributions do not overlap at the 1 sigma level (they do at ~1.36 sigma). The data suggests that there is a saturation effect: increasing the amount of shelf space devoted to fruits and vegetables has a increasingly smaller effect on BMI.

There is an overall trend of increasing percent shelf space devoted to soda and junk food and BMI (Figure 2). Aside from Greece, the average BMI of countries that devoted less than 45% of the total shelf space to soda and junk food was 25.1 with a standard deviation of 0.07. However, for the countries surveyed that devoted over 45% of their shelf space to soda and junk food products, the average BMI was 26.1 with a standard deviation of 0.699.

Thus, for countries with less than 45% of the shelf space devoted to soda and junk food, there is a BMI of 25.1 ± 0.07 versus 26.1 ± 0.699 for countries devoting more than 45% of their shelf space to junk food. Note that these two BMI distributions are over 1.3 standard deviations apart, however the data set is relatively small.

Note that Greece devotes less than 45% of their shelf space to junk food and soda, yet has the highest BMI of the countries surveyed. This discrepancy maybe because of the large number of specialty stores observed in Greece. Including Greece, the statistics for countries devoting less than 45% of their shelf space to soda and junk food is a mean BMI of 25.49 with a standard deviation of 0.98.)

Figure 3, *Cereals, Pastas, Grains Shelf Space vs. BMI*, shows that percent shelf space of cereals/ pastas/ grains/ bread has a positive trend with BMI. As percent shelf space increased, BMI increased across many countries. Luxembourg supermarkets devoted one of the smallest shelf spaces to grains (12.9%) and had one of the lowest BMIs of the countries surveyed (25.06). Norway (Shelf Space: 16.7%, BMI: 25.3), Switzerland (Shelf Space: 18.7%, BMI: 26), Croatia (Shelf Space: 22.6%, BMI: 26), the United Kingdom (Shelf Space: 22.9%, BMI: 27), and Greece (Shelf Space: 25.8%, BMI: 27.5) all devoted an increasing amount of shelf space to grains and had monotonically increasing BMIs. These data points give rise to an r= 0.918 and r2= 0.843. This strong positive trend is overshadowed by the fact that Luxembourg, the Galapagos, Belgium, and Italy all had a BMI approximately equal to that of Norway, despite devoting ~20%, ~25%, ~27%, and ~33% of shelf space to grains, respectively. Increasing percent shelf space of dairy displayed a modest positive trend with increasing BMI, but was not statistically significant.

Figure 4 shows pie charts representing the distribution of shelf space devoted to various types of food. Food was divided into the four categories: grains, fruits and vegetables, soda and junk food, and dairy. Other categories of food in the store were not included. In most countries, the largest amount of shelf space was devoted to the `Soda and Junk Food' component (60% of the time, it was the largest, mean is ~41%). In general, the smallest amount of shelf space was devoted to dairy products (mean is ~16%). Fruits and vegetables showed the greatest variance between countries, with a mean of 20% and a standard deviation of 13%.

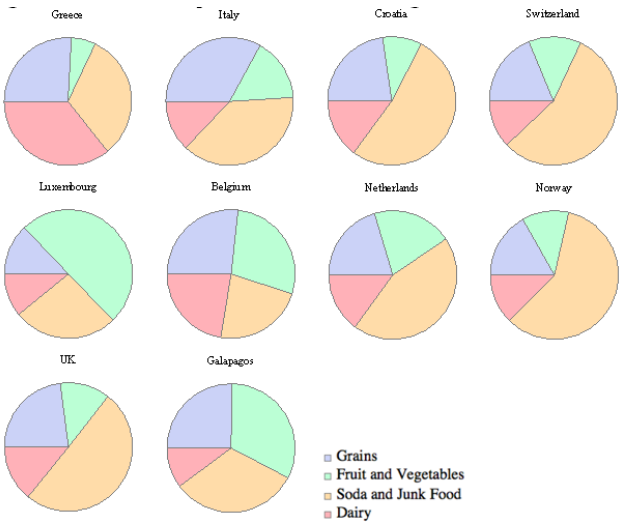

Figure 4. Percent Shelf Space of Different Categories of Food

4. Discussion

This is the first reported transnational study of the relationship between linear shelf space in supermarkets devoted to various categories of foods and the populations' mean adult BMI. The method of linear measurement used, while not measuring the volume of products on the shelves, has two advantages: linear shelf space is the dimension most clearly apparent to the consumer, and linear shelf space also allows for a simple comparison of products as a fraction of the total shelf space facing the consumer without respect to the volume stocked, which varies by store size. Thus, this measurement method may be most appropriate because a customer is most affected by the length/spread of products displayed for purchase in front of them, not the depth of the shelf.

The pie charts in Figure 4 confirm that different countries vary in the shelf space devoted to certain types of food in their supermarkets. Perhaps the reason for this is due to local demand. There are no trends that are universally true, and thus, what type of product was greatest/least represented on store shelves is not easily predicted. For example, Luxembourg devoted 49.9% of its shelf space to fruits and vegetables and 10.8% to dairy. Neighboring Belgium devoted 28.2% of it's shelf space to fruits and vegetables and 22.3% to dairy.

Results showing a statistical trend between percent shelf space of healthful foods and BMI would infer a relationship between food environment, diet and obesity, and thus offer a plausible avenue for public health and policy interventions.

Countries whose grocery stores devoted, on average, a higher fraction of the total shelf space to these individual

categories had, on average, a lower BMI. The country with the smallest shelf space (<5%) devoted to fruits and vegetables had the highest BMI. There does not appear to be any strong functional form of this relationship, but the countries with the highest BMI of those evaluated tended to devote a lower fraction of their shelf space to fresh vegetables, canned vegetables, fresh fruit, canned fruit. The data infers diminishing returns—having more and more shelf space devoted to fruits/vegetables has a decreasing effect. The effect saturates at about ~15%, such that shelf space >15% seems to have very little effect on BMI. This correlation does not imply sole causation. It is important to remember that a decrease in, for example, fresh vegetables is not only a decrease in fresh vegetables, but by definition is an increase in the shelf space devoted to another category of food products—perhaps junk food.

It is plausible to say from the fresh/canned vegetable shelf (and fruit) space versus BMI graph (Figure 1) that it is not necessarily the case that if you double the shelf space devoted to vegetables, a country's BMI is lower. However, it is the case that countries that had the lowest shelf space (<5%) had the highest BMI. If the mean population was BMI>26 mg/kg^2, shelf space devoted to vegetables tended to be inversely correlated with BMI. Up to 5%, the shelf space had no effect on the mean population BMI of the country. Increasing shelf space decreased BMI 80% of the time while the shelf space was less than 5%. This is the same case with canned vegetables, fresh fruit, and canned fruit; however, the UK shows a large amount of shelf space devoted to fresh fruit, yet a high mean population BMI. Thus, as both percent fruit and vegetable shelf space increase, BMI tends to decrease.

As noted, there was an overall positive trend of increasing percent shelf space devoted to soda and junk food and BMI (Figure 2). Unfortunately, it is hard to quantify many of the effects in some countries due to the prevalence of specialty stores and markets. Healthy items such as fresh fruits and vegetables in these countries could not be quantified accurately as they were for sale in places not suitable for applying the measurement metric of percent of total shelf space available—outdoor markets, street vendors, specialty stores, etc. Thus, for some countries, such as Greece and Norway, the representation the overall use of junk food may be overestimated because much of the measured store held junk food items, while more healthful items were for sale in outdoor markets, etc. Even with Greece and Norway included, countries with a larger fraction of shelf space devoted to junk food tended to have a higher average BMI.

There is a modest trend between increasing shelf space of cereals, pastas, grains, bread and BMI (Figure 3). Italy may have even higher grain availability than reflected in this study due to the large number of specialty stores and local dietary habits. Because of Italy's large shelf space of grains, shelf space devoted to other, healthful foods must be smaller. Overall, there is a definite trend-as percent shelf space of grains increases, BMI also increases. However, there are exceptions to this rule, Belgium, for example, shows a large allocation to grains and a lower BMI.

Our results showing a qualitative trend between percent shelf space of healthful foods and lower population BMI imply a relationship between food environment, diet and obesity, and thus offer a plausible avenue for public health and policy interventions. A limitation to this assumption is that while food environment does play a role, there are multiple other factors that influence a population's BMI, such as genetics, demographics, socio-economic status, societal norms, availability of transportation to healthy food stores, and individual behavioral patterns.

The specific limitations of this study include the relatively limited BMI range of countries surveyed and small number of countries surveyed. The results found may reflect general trends in the countries surveyed, and illustrates a successful methodology to assess food availability in stores.

It is important to note, though, that correlation does not mean causation. Some things, like pasta availability in Italy, may reflect cultural or historical factors, and not be directly influencing BMI. Also, the fact that total shelf space is limited requires that stocking one more food item means the space for something else is decreased or eliminated. Thus, having a substantial amount of space dedicated to display of fruit, for example, could reduce BMI not necessarily because people consumed more fruit, but because there is a decreased amount of other foods available.

Culturally based food store practices are also a major factor, as the study was multi-country, and thus cross-cultural. One major confounding variable to this study is the different specialty store practices. In some countries, for example Luxembourg, large supermarkets supplied almost all food. Other countries, like Italy, Greece and Norway, had more specialty stores and outdoor markets. Due to the difficulty in quantifying the various effects of these specialty stores, the data in this study was solely based on stores that were closest to conventional supermarkets in each country studied.

5. Conclusion

Percent supermarket shelf space devoted to healthful foods across 10 different countries correlated with lower BMI ranking by WHO statistics; percent shelf space of grains, dairy and junk food showed a positive trend with BMI. Supermarket shelf space use can offer insight into a country's BMI, and represents a potential intervention avenue for positive health impact. Further work is needed to confirm this correlation in other nations, regions, and socioeconomic and demographic categories within nations.

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