

Systematic Review of Obesogenic Environmental Determinants of Diet and the Implications of Obesity Prevention and Intervention Efforts

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Abstract— The environment plays a crucial role in the development of obesity. Obesity rates continue to escalate, bringing into question the efficacy of prevention, intervention, and treatment efforts. This paper identifies the previous research examining obesogenic environmental factors and sets out to determine whether physical, social, cultural, and economic environmental factors are associated with obesogenic dietary behaviors. The study searched five databases for full-text English articles, of which 103 were included in the literature review. The selection was based on keywords searching, peer-reviewed publications, stated research methodology, strategic analysis, and substantial increments in knowledge. One of the results showed an increasing pace of urbanization, media influence, and advertising emphasis on unhealthy food are associated with obesogenic dietary behavior. The discussion focuses on the most susceptible factors for obesity and the implications for future research in communities with a dense population. The objective of addressing the obesity epidemic is to employ strategies to curtail sugar use, restrict marketing efforts of unhealthy food, and increase the availability of healthy food.

Keywords-obesogenic; food environment; advertising; diet study; prevention

I. INTRODUCTION

Research has shown increasing attention on how the environment affects population health [1] [2]. Considerable studies have evidenced that population obesity was a product of the environment 30 years ago, and environmental changes are associated with epidemic obesity rates in all age groups [3] [4]. The influence of environmental stimuli on obesity prevalence must be affected to some extent by people's dietary and physical activity behavior, which ultimately leads to an imbalance in energy intake and thus to obesity [5] [6].

The obesogenic environment is defined as an environment that influences or promotes obesity in individuals or populations, which constitutes all surroundings, opportunities, or life conditions that lead to obesity [7]. The problem of the dramatic increase in obesity is complex, and may involve factors related to socioeconomic status, personal preferences, family habits, physical factors, and perhaps genetics. The theoretical framework from the consumer socialization perspective suggests that factors influencing food choice operate at four

distinct levels: individual (psychological, biological, and behavioral factors), interpersonal (family, friends, and peer networks), community (accessibility, school policy, and local facilities), and societal (mass media, advertising, social and cultural norms, production and distribution systems, and pricing policies) [9] [30] [39].

Prior reviews of the obesogenic environment literature indicated that modern sedentary activities promote the overconsumption of food, thus causing weight gain [11] [22]. However, empirical study remains lacking in terms of an appropriately designed research investigating associations of environmental factors with individuals' attitudes, genetics, and societal development. Insight probably can be gained by improving theory and methods of research [8] [29]. This study focuses on the measurement and evaluation of the obesogenic environment. Obesogenic food environments are considered to facilitate high energy intake by increasing access to stores that promote unhealthy food choices. In Section 2, three research questions are discussed and systematic review method is adopted to identify the previous research in the literature in relation to obesity and the food environment.

II. QUESTIONS AND METHODS

RQ.1 What is the previous research focus on the measurement and evaluation of the obesogenic environment?

RQ2. What risk factors, such as the physical, social, cultural, and economic environment, are associated with obesogenic dietary behaviors?

RQ3. How to use obesity prevention and intervention to decrease obesity?

Systematic review is a method often used to investigate a broad set of literature related to environments linked to obesity study [20] [21] [24]. The coding category was adopted from previous studies and included the publication year, author(s), affiliated organization, country, study design, main environmental determinants, scale of the geographical study, postulated relationship of specific risk factors (i.e., physical, social, cultural, and economic environment; individual, interpersonal, population, and global level), and analysis between the environment and weight status [22] [32]. The inclusion criteria and procedure are discussed in the followings section.

Inclusion criteria

A comprehensive scholarly and multi-disciplinary full text databases including Academic Search Complete [51], Health Reference Center [52], Medline [6] [24], Springer Link[53], and Proquest Medical Library [22] [32] were searched for studies published from 2004 onward in full-text English articles. This study included only peer-reviewed articles that present advances in assessment methods, analytical result, up-to-date research studies or substantial increments in knowledge examining obesogenic environmental factors and evidence. A systematic study was recommended to assess at least one environmental factor. The search terms such as “diet study” and either “obesogenic,” “intervention,” “prevention,” “obesity,” “food marketing,” “food advertising,” or “mass communication campaign” were included. The researchers screened 3,139 de-duplicated records, of which 103 met the inclusion and exclusion criteria. Inter-rater percentage agreement between reviewers and Cohen’s kappa coefficients were calculated: Academic Search Complete, 90% and 0.213; Health Reference Center, 92% and 0.392; Medline, 95% and 0.421; Springer Link, 89% and 0.316; and Proquest Medical Library, 91% and 0.396, respectively. All disagreement in coding was discussed and consensus was reached by the coders and authors. In Section 3, the research findings are reported by answering the three research questions.

III. RESEARCH FINDINGS

A total of 99 journal articles and 4 book chapters were included in this study. The distribution of the publication year for the obesogenic environmental studies has been increased steady. Two articles were published in the year of 2004 and 20 publications were found in 2014. The publication of obesogenic environmental studies has increased and the prolific years were 2014 (n = 20, 19%), followed by the years of 2010 (n = 14, 14%), 2013 (n = 12, 12%), and 2006 (n = 12, 12%).

Examining the authors’ nationality of affiliated organization indicates the diversity of journal contributors. Authors’ affiliated organization from European countries were the main source of evidence (n = 58, 52%), followed by America (n = 33, 29%), Oceania (n = 10, 9%), and Asia (n = 8, 7%). Specifically, the nationalities of the authors’ affiliated organization were mostly American (n = 29, 26%), followed by British (n = 20, 18%) and Finnish, Norwegian, Swedish, and Australian with the same number of papers published (n = 8, 6%).

Table 1 illustrates the research methods used for the previous research published related to obesogenic environment determinants of diet. The most frequently used survey method was experiment (n = 36, 35%), followed by questionnaire (n = 19, 18%), review (systematic and scoping, n = 19, 19%), and mixed qualitative and quantitative method (n = 12, 12%). The previous 19 review studies only recruited publications with human as the subject of research. However, in this study, the result found 15 studies adopted mice or white swine for experiment to examine and improve the potential interactive effects of diet, exercise, and genetic

background. These studies suggest that physiological reactions may not merely increase in response to obesity but may also have a direct causal role in obesity and biological resistance. Another four research methods such as content analysis, interview, observation, and focus group were used with a relatively low percentage in obesogenic environment study. We also discovered that a large proportion of articles omitted crucial information on their methodology (n = 13, 13%), population description (n = 14, 14%), and sample size (n = 31, 30%).

TABLE 1 RESEARCH METHOD USED FOR THE 103 STUDIES RELATED TO OBESOGENIC ENVIRONMENT DETERMINANTS OF DIET

Method	Frequency	Percentage
experiment	36	35%
Questionnaire	19	18%
systematic review	10	10%
scoping review	9	9%
mixed method	12	12%
content analysis	2	2%
Observation	1	1%
Interview	1	1%
focus group	0	0%
Unclear	13	13%
Subtotal	103	100%

Table 2 presents a summary of 14 selected studies with advances in assessment methods that specifies risk factors, such as physical, social, cultural, and economic environment, associated with obesogenic dietary behaviors. The most susceptible factors for obesity according to obesogenic studies confirm the importance of the societal development of urbanization, media influence, and marketing activities (n = 11, 38%), followed by specific cultural food diet (n = 9, 31%), physical activity and habit (n = 7, 24%), and product-related factors (n = 2, 7%). The effects of eating habits and preferences have been investigated at several levels with substantial increments in knowledge by five studies listed in Table 2 [13] [15] [17] [18] [44].

Table 3 summarizes the solutions to increasing obesity proposed by eight studies. The method of diet intervention and policy restriction for television advertising is shown. Intervention (n = 6, 75%) and prevention (n = 2, 25%) efforts such as diet and physical activity are indicated while regulation of food industry and treatment of obese population lacks equal research attention. In Section 4, the discussion was extracted from the included studies emphasizing the food environment, marketing efforts, and prevention and intervention efforts from communication and marketing perspectives regarding an unhealthy food environment.

TABLE 2 SUMMARY OF EXISTING STUDIES SPECIFYING RISK FACTORS OF PHYSICAL, SOCIAL, CULTURAL, AND ECONOMIC ENVIRONMENT

	Author (Year)	Objective/Aim	Population description	Sample description	Conclusion related to risk factors
1	Murphy, M. & Mercer, J. G. (2013) [44]	The aim of this review is to bring together existing knowledge of how food components affect anxiety at various stages of development, while highlighting some major gaps in our current understanding.	n/a	n/a	Assembled from study of preclinical models of diet challenge from gestation to adult life, supports the role of dieting as an important connection between psychology, physiology, and behaviour. Analogous processes in the human population in our current obesogenic environment are likely to contribute to individual and societal challenges in this area.
2	Hoek, J. & Gendall, P. (2006) [25]	To examine an alternative means of framing the debate and explore the role advertising plays in reinforcing behavior patterns.	n/a	n/a	In addressing obesity, policymakers have directed their efforts primarily at creating more informed individuals, without first having created a regulatory environment that will support social marketing and education programs.
3	Jääskeläinen A. et al. (2014) [5]	To study prevalence of stress-related eating and its association with overweight, obesity, abdominal obesity, dietary and other health behaviors at the age of 16.	n/a	3,598 girls and 3,347 boys	Stress-related eating is highly prevalent among 16-year-old girls and is associated with obesity as well as adverse dietary and other health behaviors among both genders, but intrauterine conditions are seemingly uninvolved.
4	Feng, J., et al. (2010) [20]	The aim is to give an overview of the wider environmental determinants of diet such as the national food supply, food availability and accessibility in different settings and economic food environment in relation to socio-economic status.	n/a	87 papers	There was very little similarity in methods and approaches which prevented estimation of pooled effects. The great heterogeneity across studies limits what can be learned from this body of evidence.
5	Firk, S. F. L., Penney, T. L., & McHugh, T. L. F. (2009) [21]	This presents a major challenge towards our understanding of environmental research for obesity, and the development of a desperately needed contextualized evidence base to support action and policies for curbing this epidemic.	n/a	146 primary studies	Gaps in the literature were clearly identified at the level of the macro-environment, and the political and economic micro-environments, highlighting key areas where further research is warranted if we are to more fully understand the role of the obesogenic environment.
6	Giskes, K., et al. (2011) [22]	This study examined whether physical, social, cultural and economic environmental factors are associated with obesogenic dietary behaviors and overweight/obesity among adults.	n/a	28 papers	Associations between the environment and weight status are more consistent than that seen between the environment and dietary behaviour. The environment may play an important role in the development of overweight/obesity, however the dietary mechanisms that contribute to this remain unclear and the physical activity environment may also play an important role in weight gain and obesity.
7	Adair, L. S. & Popkin, B. M. (2005) [18]	To examine the extent to which child dietary patterns and trends are changing globally.	Nationally or regionally representative data from 4 countries	25,247 Participants from USA, 4,253 from Philippines, 4,758 from Russia, and 7,417 from China	This research suggests that globalization of the fast food and nutrition transition. However, the contribution of fast food and soft drinks to the diet of children remains relatively small in China, Russia, and Philippines. Other modern food sectors are beginning to affect child eating patterns in several countries undergoing.
8	Ambler, T. (2006) [37]	This paper reviews previous research on the extent and nature of food promotion to children and the effect and promotion has on children's food knowledge, preferences and behaviour. It intends to ascertain reliability that appear to have been drawn by the UK Food Standards Agency for national policy making.	n/a	Hasting's study	The paper's first conclusion is that considering the effect of branded food and drink promotions outside their socio-economic and cultural context is unreliable. Second, while there are promotional effects at the brand level, these do not extend to product category level, still less overall diet, where the evidence is thin at best.

9	Chang, A. (2013) [15]	This study conducted a comparative analysis of the media and food environment in China to determine a method to combat childhood obesity.	n/a	46 brands with 489 television commercials	Preschool children can demonstrate an understanding of cultural dietary rules. Young children, even at three years of age, can recognize and implement cultural rules regarding appropriate food choices for meals. Although children of all ages are affected by advertising, those between seven and eleven years of age are most likely to be targeted and persuaded by advertising.
10	Chandon, P. & Wansink, B. (2012) [13]	The review begins with an examination of the multiple ways in which 1) food pricing strategies and 2) marketing communication (including branding and food claims) bias food consumption. It then describes the effects of newer and less conspicuous marketing actions, focusing on 3) packaging (including the effects of package design and package-based claims) and 4) the eating environment (including the availability, salience, and convenience of food).	n/a	Updating two existing reviews	To summarize how food marketing has made us fat, it is most likely through increased access to continuously cheaper, bigger, and tastier calorie-dense food. Throughout, this review underscores the promising opportunities that food manufacturers and retailers have to make profitable “win-win” adjustments to help consumers eat better.
11	Drewnowski, A., et al. (2014) [15]	To compare the associations between food environment at the individual level, socioeconomic status (SES) and obesity rates in two cities: Seattle and Paris.	n/a	7,290 participants	Lower SES was linked to higher obesity risk in both Paris and Seattle, despite differences in urban form, the food environments and in the respective systems of health care. Cross-country comparisons can provide new insights into the social determinants of weight and health.
12	Edwards, J., Engstrom, K. & Hartwell, J. H. (2005) [17]	The purpose of this paper is to consider the facts from a food service perspective, the role and relevance of portion size, product bundling and all you can eat buffets in the current debate on overweight and obesity.	n/a	n/a	The causes of overweight and obesity are multifactorial, complex and in many areas not particularly well researched. In many instances it seems almost as if the consumer and food service operator, through the media and government, are blaming each other for the current situation, and then expecting the other to somehow find a solution.
13	McMullan, J. & Keeney, S. (2014)	This article reviews the previously published literature on the social and environmental factors which influence children (aged 3–5 years) to be obese/overweight and the accuracy of parental perceptions.	Studies published between 1995-2013 on childhood obesity and environment, and socioeconomic status.	n/a	Obesity levels are on the increase in today’s society and habits are being passed from parents to children, with family lifestyle choices often influencing this health condition. The results confirm the available research does not allow robust identification of ways in which that physical environment influences adult weight status.
14	Goris, J. M. et al., (2009) [23]	To estimate the contribution of television (TV) food advertising to the prevalence of obesity among 6–11-year-old children in Australia, Great Britain (England and Scotland only), Italy, The Netherlands, Sweden and the United States.	Data of 6-11-year-old children in six Western countries.	n/a	The contribution of TV advertising of foods and drinks to the prevalence of childhood obesity differs distinctly by country.

TABLE 3 SUMMARY OF STUDIES IN PROVIDING SOLUTIONS TO INCREASING OBESITY THROUGH PREVENTION AND INTERVENTION

	Author (Year)	Objective/Aim	Population description	Sample Size (n=)	Conclusion of prevention and/or treatment
1	Maynard, M., et al. (2009)	This exploratory study assesses the feasibility, efficacy and cultural acceptability of child- and family-based interventions to reduce risk factors for childhood and adolescent obesity among ethnic minorities.	n/a	44 children	The emergent findings suggest that while the school setting may be better for the main implementation of healthy lifestyle interventions, places of worship provide valuable opportunities for family and culturally specific support for implementation.
2	Brown, T. & Summerbell, C. (2009)	To determine the effectiveness of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity.	n/a	38 studies	The finding suggests to combine diet and physical activity school-based interventions to help prevent children becoming overweight in the long term.
3	Hammarström, A. et al. (2014)	The aim of this study is to explore barriers and facilitators to weight-loss experienced by participants in a diet intervention for middle-aged to older women in the general population in Northern Sweden.	Middle-aged to older women to a weight-loss program	24 women	It is important to include drop-outs from diet interventions in order to fully understand barriers to weight-loss. A gender-relational approach can bring new insights into understanding experiences of barriers to weight-loss.
4	García-Calzon, S. A. et al. (2014) [48]	The aim of this study is to assess the relationship between telomere length (TL) and changes in adiposity indices after a 5-year nutritional intervention.	Women (60–80 years) & men (55–80 years) with no previously history of cardiovascular disease, but at high cardiovascular risk	521 participants	The research suggests that TL is inversely associated with changes in obesity parameters. The assessment of TL can provide further insights for biological pathways leading to adiposity.
5	Doyle-Baker, P. K. et al. (2011)	The biochemical evaluation of a health intervention program investigates the impact of progressive exercise intensity in overweight and obese children.	Overweight and obese male (M) and female (F) children (aged 5-10) in Canada	25 children	The high-intensity exercise within a comprehensive health program includes nutrition education improves the lipid and physiological health profiles of obese children.
6	Zambrano E., Martínez-Samayoal, P. M., Rodríguez-González, G. L., & Nathanielsz, P.W. (2010)	This paper discusses whether maternal obesity-induced programming outcomes are reversible by altered dietary intake commencing before conception.	female rats	n/a	Obesity involving women of reproductive years is increasing dramatically in both developing and developed nations. This study shows reversibility of adverse metabolic effects of maternal obesity on offspring metabolic phenotype.
7	Birch L. L. & Anzman, B. L. (2010) [3]	The article provides examples of learning paradigms—familiarization and associative and observational learning—that present opportunities for parents and caregivers to restructure children’s environments in early life, increasing the likelihood of healthy weight-status outcomes in the context of the current obesogenic environment.	n/a	n/a	This study uses a developmental perspective and argues that this probabilistic outcome is not predetermined. Effective early preventive interventions are urgently needed to address the obesity epidemic among all segments of the population, but especially among groups at highest risk of childhood obesity.
8	Edmond, S.(2006) [164]	To ensure that the public policy objectives are met without unnecessarily and unjustifiably damaging the broadcast and advertising industries.	n/a	n/a	Government’s report on obesity is important in leading healthier and more active lifestyles. The advertising industry wants to work in partnership with the government, and other stakeholders, to ensure that it gets the balance right between consumer concerns and business needs.

IV. DISCUSSION

With an estimated 2.1 billion people overweight globally, tackling obesity is one of the most serious challenges, requiring a societal and systems change in our approach to food, lifestyle, and the environments [41].

A. Food Environments

British researchers concluded that food retail access in urban areas does not have a profound or prolonged effect on dietary patterns [19]. However, for the Chinese community, vending machines, mini grocery shops, convenience stores, and supermarkets were all found to sell large quantities of sweetened beverages, snacks, or high-calorie, high-fat, and low-nutrient food [28] [38]. This food supply led to the association of unhealthy food products and obesity. The patterns of food product types lacked the elements of delivering essential food groups and correct dietary information [34]. The literature tends to indicate that consumers in all age groups are likely offered and encouraged to choose a diet with super-saturated fat and excessive salt. In addition, the research showed the importance of urban-rural differences and the contribution of fast food and soft drinks in children's diets [12] [18]. Although snacks and drinks remained relatively insignificant in the total diet of most people, the researchers emphasized that the globalization of the fast food and other local or modern food sectors is affecting our eating patterns and exposes us to the threat of nutrition transition towards higher-fat diets in all regions of the world [34] [38].

B. Marketing Efforts toward Obesity

Several studies examined the array of food products available on television and concluded that fast food restaurants, sweetened soft drinks, and sweetened cereals consistently dominate television food advertising. The identified patterns of food product types are commonly associated with unhealthy diets [42] [43]. For example, the exposure of sampled youth to 100 TV ads for sugar-sweetened soft drinks was associated with a 9.4% increase in their consumption of soft drinks [10]. Thus, advertising has been accused to be a catalyst in problems of obesity for some age groups and in some countries [15] [23] [37]. For marketing efforts related to obesity research, sufficient studies have shown an association between promotional activity and children's food knowledge, preferences, and their choices of daily snacks at playtime [13] [16] [25] [26] [33] [36] [40]. These studies have supported the notion that children's age is a critical factor in the influence of advertising, especially in regard to nutrient imbalance diets.

C. Preventions and Interventions in Increasing Obesity

The intake of fruit, 100% juice, and vegetable and regular physical activity are advised to be healthy behaviors related to obesity prevention at the individual level [31]. The emphasis of parental control may be another possible

solution. The portrayal of family togetherness and parents' role is effective for promoting a healthy eating environment, and also helps in regulating children from over-engaging in sedentary activities. For example, a survey [28] indicated that Chinese parental influence, especially the father's role modelling, is significantly related to attraction toward physical activity in overweight children. For boys, both the father's and mother's influence is strong. Parenting style such as role modelling and encouragement can positively influence an overweight child's physical activity involvement.

Furthermore, modifying the larger context and the microenvironment associated with health education for knowledge of nutrient dense diets is crucial. It is argued that school environments should provide access to healthy food and help reduce exposure to cues that encourage overeating or underactivity [15] [33]. At the community level, the solution to increasing obesity by employing interactive and mass media campaigns to change health behavior for health promotion is proven to be effective [24]. The goals of public awareness campaigns are to increase the awareness of the obesogenic environment, improve access to a healthy diet, and tackle obesity problems. In Section 5, the limitation and suggestions for future research are included in the conclusion.

V. CONCLUSION

This review provides a systematic and objective process for collecting knowledge applied to diet-related behavior in an obesogenic environment. The reviews of 203 previous studies showed that few investigations of environmental associations have been replicated, and that most studies used weak research designs and non-validated self-report measures.

Medical studies have found that certain people have an increased risk for obesity, for example, minority ethnic children [45], 16-year-old girls with stress-related eating [5], truck drivers with insufficient sleep and older than 40 years [46], adults at least 22 years old with abnormal blood pressure [47], women (60–80 years old) or men (55–80 years old) at high cardiovascular risk but without previously documented history of cardiovascular disease [48], and infants associated with maternal obesity [49].

The present paper contributes to elucidating the role of obesogenic environmental factors by proposing a possible pathway linking obesogenic environmental determinants of diet and obesity prevention and treatment. Potential relevant factors such as political policy and regulation [50] and mental status to diet [44] have also been evaluated because of the complexity of the task. The objective of addressing the obesity epidemic was to employ strategies to curtail sugar use, restrict marketing efforts, and increase the availability of healthy food.

As the number of published obesogenic research grows, we hope to see direct effects on health and wellbeing and

indirect benefits from increased support from related research. There are no large pediatric randomized trials and very few published papers in treatment of obesity. One of the limitations in this study was the publication bias in the sampled database. There was substantial heterogeneity among studies with respect to study samples, interventions, and outcomes. There is a need to develop refined tools and indicators to monitor environmental changes on the basis of the amount of data available in the scientific literature and the potential for intervention.

There is an improvement in the following area. First, the research focus on the measurement and evaluation of the obesogenic environment has been led by Western countries. Further study in the rest of the world with highly dense populations should be conducted for comparison in the global obesogenic environment.

Second, the solutions for ensuring individuals' responsibility in achieving and maintaining a healthy weight from early life throughout their school years and into adulthood remain unclear. The relatively weak empirical evidence implies the absence of causal relationships between environmental factors and individuals' diet. A longitudinal approach would provide more robust evidence concerning the links among media use, diet behavior, and obesity prevention and treatment.

Third, a lack of appropriate research design exists in the previous studies, which may have reduced the validity of the results. Abundant previous review studies have used indirect methods to assess the environment and excluded nonhuman subjects from their analyses [20]. Future studies should adopt a rigorous methodological design to assist in providing strong evidence for the complex association of obesogenic environmental determinants of diet.

To determine the casual relations between food intake and the obesogenic environment, the influence of interactive, social, mass, or community-based media should be examined. Raising public awareness of obesogenic environmental determinants of unhealthy diet is a costly and complex endeavor. As public awareness campaigns become increasingly sophisticated, additional studies would help to evaluate the success of campaigns, tracking changes in attitudes and behaviors of people with obesity.

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