Contextual Uncertainties, Human Mobility, and Perceived Food Environment: The Uncertain Geographic Context Problem in Food Access Research

We examined the uncertainty of the contextual influences on food access through an analytic framework of the uncertain geographic context problem (UGCoP).

We first examined the compounding effects of two kinds of spatiotemporal uncertainties on people's everyday efforts to procure food and then outlined three key dimensions (food access in real time, temporality of the food environment, and perceived nutrition environment) in which research on food access must improve to better represent the contributing environmental influences that operate at the individual level.

Guidelines to address the UGCoP in future food access research are provided to account for the multidimensional influences of the food environment on dietary behaviors. (*Am J Public Health.* 2015;105:1734–1737. doi:10.2105/AJPH.2015.302792)

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THE INCREASING RATE OF obesity and its health consequences have become major concerns in the United States and many other countries.[1] A potential contributing factor to the rise of obesity is an obesogenic environment, which includes the prevalence of fast food that elicits unhealthy eating habits.[2] Public concerns about obesity have prompted a growing number of studies on spatial food access that investigate the role of physical access to food stores by different modes of transportation.[3,4] A complicating factor is the perspective that food, which is otherwise accessible, may not be perceived, purchased, or consumed because of an array of informational, financial, or cultural obstacles.[5] Exploring an individual's access or exposure to the food environment via location-based activity measures has recently received substantial attention.[6,7] Food access at the individual level contributes to an improved understanding of the associations between food accessibility and the quality of diet,[8–10] as well as between food accessibility and obesity-related outcomes.[7,11]

An overlooked facet of these studies is an explanation of the discrepancies among their conclusions. For example, although better access to fast food has been found to be associated with a higher likelihood of obesity, in selected cases this association was not identified.[12] Although a nutritious food environment that includes better access to supermarkets has commonly been associated with a better diet,[13] other studies have not observed this association.[14] One possible explanation for these different observations lies in the uncertainty of contextual influences on people's eating habits, such as the possibility that previous studies did not consider whether interpersonal communications affected food access.

The uncertainty of contextual influences that individuals experience calls for an analytic framework that conceptualizes the uncertainties involved, facilitates the use of robust research methods for capturing all significant contextual influences, and ensures the rigor of research findings. An important source of this kind of uncertainty is a recently proposed geographic problem: the uncertain geographic context problem (UGCoP).[15,16] The UGCoP refers to the fact that findings about the effects of area-based attributes (e.g., density of fast food outlets) on individual behaviors or health outcomes (e.g., obesity) could be affected by how contextual units are geographically delineated. We used the UGCoP framework to elucidate the various contexts associated with food procurement activities. Exploring the inferential errors in context delineation and initiating coping strategies to address the UGCoP could help demarcate the true causally relevant geographic context[17] in which food is perceived to be accessible, easily purchased, and consumed.

SPATIOTEMPORAL UNCERTAINTIES OF FOOD ACCESS

The food environment, the place in which food is procured or consumed, can be delineated in many different ways.[18] Traditional studies have consistently been area based, meaning variables representing high or low food access are based on predemarcated areal units (e.g., census tracts, zip code zones) or are buffered to a walkable distance around food outlets per se.[4] Another subset of studies has emphasized the availability and accessibility of food at the individual or household level on the basis of individuals' home addresses, in which the spatial and nonspatial mediators of food access were derived via standardized assessment tools such as interviews or surveys.[11,19,20] Spatial mediators, such as distance to the nearest supermarket, can be estimated with ease by using geospatial technologies, such as geographic information systems.[4] However, quantifying nonspatial mediators of food access is more difficult because the exact geographic context in which food is procured cannot be precisely delineated. This is attributable to the compounding effects of two types of uncertainty in any attempt to assess the contextual influences on people's access to food.

First, the traditional conceptualization of the food environment is very different from that which individuals actually experience.[21] Studies have found that research participants are more likely to perceive neighborhoods as larger than do investigators and that the potential activity space an individual could reach is even larger.[22] As a result, drawing evidence from generalized variables, such as available food outlets in the census tract, may misrepresent the true geographic boundary within which the individual shops for food. Second, food-related activities are affected by time constraints, including the flexibility of individuals' scheduling of activities[23] and the temporal availability of food outlets.[24,25] In reality, food procurement can only take place when an individual's discretionary time for food shopping aligns with the operating hours of food outlets. Because these spatial and temporal uncertainties have been ignored in existing food access studies, those studies' conclusions have not accurately captured the impact of the food environment on restricting access.

CHALLENGES IN RESEARCH ON FOOD ACCESS

Uncertainties that contribute to the UGCoP can be identified with regard to the spatial and temporal dimensions of contextual influences on human behaviors and outcomes. As articulated by Kwan,[16] the UGCoP

> arises because of the spatial uncertainty in the actual areas that exert contextual influences on the individuals being studied and the temporal uncertainty in the timing and duration in which individuals experienced these contextual influences.[16(p245)]

The UGCoP arises because of an inability to establish precise spatial and temporal configurations of the physical and social factors that affect the phenomenon under study in area-based geographic units. Thus, the inconsistent findings related to the UGCoP are the result of the variations in the geographic units and temporal framework used to derive the explanatory or predictive variables that represent the contextual influences of the built environment and the temporal variability of such influences. The dynamic contextual influences across space and over time are vital to dietary behaviors and health outcomes related to food procurement.

The UGCoP suggests that increased attention should be paid to delineating the spatial scope and temporal duration of individuals' activity spaces as well as to investigating composite physical and interpersonal variables that indirectly affect actual behaviors.[26] We have established three key dimensions for improving food research to better represent and capture the contributing environmental influences that operate at the individual level: (1) food access in real time, (2) temporality of the food environment, and (3) perceived nutrition environment.

Food Access in Real Time

Because individuals' range of travel often extends beyond the administrative boundaries of their residential neighborhoods, food access is not limited to a fixed location or a predefined region.[19] The types of food outlets available along individuals' nonresidential travel routes or at their real-time location better represent the true geographic context in which food could be purchased or consumed. Although traditional food access studies also frequently emphasize nonhome food environments, such as schools or worksites, they overlook the extent of individuals' daily mobility that leads to encounters with different food sources along their travel routes.[6,27,28] The extent of people's activity space must be considered in analyses of their dynamic environmental exposure that affects their perceptions about and availability of food.

To capture the space–time sensitivity of food access, an emerging subset of food research has emphasized real-time food access by using activity-based data collection in the form of activity surveys,[6,23] Global Positioning System tracking,[8,29] and volunteered geographic information.[9,30] In these studies, data on people's food-related activities and procuring travels are collected in real time (or at a fairly high space–time resolution) with respect to the spatiotemporal coordinates of the activities. Activity surveys describe human mobility in greater detail, but collecting a sufficient number of representative samples is labor intensive and time consuming. Global Positioning System tracking is beneficial for automating data retrieval with greater granularity but poses a considerable challenge for isolating activities from segmental travels.[29] Volunteered geographic information generated from social media is a potential resource for large-scale sampling but does not contain individuals' socioeconomic attributes and may underrepresent certain subgroups of the population.[9] Collecting activity data with a high degree of efficiency while maintaining data integrity needs further exploration to capture the exact nature of food activities while mitigating selection biases.[29]

Temporality of the Food Environment

Food systems manifest specific temporality (e.g., in the times food outlets are open and closed).[31] Studies on the density and proximity of food outlets across space and their impact on dietary behaviors have been widely discussed. However, the availability of food sources over time and how this temporality changes individuals' experienced foodscape and eventually influences their eating behaviors have been investigated in a limited manner.[25] Time has been introduced as a context in comparing the before-and-after patterns of food consumption on different temporal scales. Comparing the change over a decade, Wrigley et al.[19] found that the opening of a large supermarket greatly improved the consumption of fresh fruits and vegetables for those with a poor diet. Focusing on one year, Widener et al.[32] identified the weekly fluctuation of opening and closing times of farmers' markets in relation to the socioeconomic deprivation of local neighborhoods. Over 12 weeks, Evans et al.[33] found that the intervention of farm stands in low-income communities significantly encouraged the consumption of quality local food. On a daily basis, Chen and Clark[24] visualized the hourly variability of healthy food access on the platform of the three-dimensional geographic information system. An extension of the study suggested that people living in poor neighborhoods are more constrained in acquiring food by shorter store hours.[25] Although two of these studies[25,32] discussed the measure of temporal food access with socioeconomic correlates, how the temporality of the food environment acts as an important contextual influence on

community health as a whole must be further scrutinized.

Another overlooked facet is temporal influences on individual mobility. As food access studies have gradually shifted to a smaller, personal scale, the constraints of time on an individual to allow for food trips has become a critical concern. Space–time accessibility measures have been used to demarcate the activity spaces of individuals and the availability of food outlets in these spaces.[23,34] A remaining question is whether these food outlets are open for business at the time of the visit, because the availability of food is not only influenced by individual mobility but is also determined by the joint space of both the individual activity spaces and the space–time domain of activity venues. Therefore, a pressing need is to incorporate the temporality of the food environment to further refine individual opportunities for food procurement.

Perceived Nutrition Environment

The nutrition environment can be viewed from many different perspectives, including community, consumer, organization, and information environments.[35] Two questions invariably arise during studies of the nutrition environment: (1) Is inequality in healthful food access correlated with place-based socioeconomic status and racial/ethnic composition, and (2) are levels of food access correlated with individual-based dietary quality and obesity-related outcomes?[13,36,37] Answers to these two questions vary and do not fully explain effects on individual human health. This variation may be attributed to the fact that consumers perceive the nutrition environment differently from what investigators have objectively observed in areal analyses or in-store audits. It is very likely that those being surveyed could not identify the nearest supermarket because of a recent move or may not patronize nearby restaurants that are culturally inappropriate. The disparity between individuals' perceptions and investigators' interpretations can cause inferential errors that misrepresent the actual food context in which individuals are exposed.

Mechanisms that affect individuals' sensitivity to contextual influences, such as conversations, advertisements, and social media (referred to as food cues) that stimulate food intake, have been heavily investigated using various psychological approaches.[38,39] These behavioral studies, however, have not taken into account the particular commercial contexts in which food is promoted and the compounding effects of individual recognition and activity-based constraints, such as available transportation and the amount of time allowed for shopping. Studies on the causal relation between food perceptions and consumption patterns are scant because environmental exposure that changes the perception of food access is difficult to monitor.[40]

To capture individuals' perceptions and to fully understand the mechanisms through which food choices are made, examining the social dynamics of the food environment comes to the forefront. It must be noted that the complex social contexts that foster individuals' perceptions of the nearest foodscape cannot be analyzed by means of simple approaches. Rather, potential solutions exist in scrutinizing the physical and interpersonal influences on people through their continuous activity trajectories and examining how these influences are altered through people's cultural lenses and are interpreted through their long-term nutrition education. For example, research has observed that food shoppers tend to adapt their shopping patterns to a positive relationship with the environment; they selectively shop at stores patronized by people of their own race and those operated by people with whom they have established a long-term connection.[41] In this case, the influences of area-based socioeconomic status or spatial food access cannot adequately explain the intrinsic motivations through which food is procured or consumed.

To illuminate food access at the individual level, it becomes essential to examine the social and cultural relationships between people and their perceived nutrition environment. Because these relationships are also circumscribed by spatiotemporal contexts that heavily influence food access, a promising way to address the problem is to combine qualitative activity research with spatially and temporally tagged human mobility data, which could be obtained through cutting-edge geospatial technologies such as Global Positioning System tracking.[29] The lack of contextual details and people's subjective experiences in mobility data can be mitigated by coupling these data with activity surveys or ecological momentary assessment, which has been adopted to collect people's real-time emotions or sentiments.[42] Another potential apparatus is qualitative geographic information systems that portray consumers' perception of food availability and accessibility in an interpretive manner,[43,44] such as mental maps.[45]

These emerging methods require the investigator to carefully examine environmental variables that are assessed differently by individuals. They help to elucidate individuals' thoughts and feelings about purchasing and consuming foods and to document the nutrition environment in which foods are labeled, promoted, and priced as stimuli for changing individual perceptions. Although they involve considerable effort, these methods provide an overarching understanding of how contextual influences shape people's choices for food as well as offer plausible evidence for food and nutrition policy intervention.

CONCLUSIONS

Activities to access and procure food at the individual level can take place beyond traditionally conceptualized neighborhoods,[22] are restricted by the operating hours of food outlets,[24] and are shaped culturally and interpersonally by social contexts.[41] These issues embodied within the UGCoP are far from a simple relationship between food environment and diet. Instead, food access entails complex interactions between food contexts and people. Identifying these interactions requires considerable effort to delineate the spatiotemporal contexts in which people are situated and to illuminate the perceived nutrition environment in which a multitude of physical, cultural, and interpersonal relationships play out. Moreover, the uncertainties in the geographic context of food access call for increased attention to the spatiotemporal dynamics of individual mobility and the perceived environmental exposure as a way to more accurately assess how contextual influences affect actual dietary behaviors. Only when these contextual uncertainties are taken into account can we more accurately

assess the causal relations between the food environment and its effects on health outcomes. ■

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X. Chen proposed the study and led the writing. M.-P. Kwan contributed to the conceptualization of the study and revision of drafts of the article.

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