Contents lists available at ScienceDirect

Social Science & Medicine

Using syndemic theory to understand food insecurity and diet-related chronic diseases

David Himmelgreen[a,b,*], Nancy Romero-Daza[a,b], Jacquelyn Heuer[a,b], William Lucas[a], Abraham A. Salinas-Miranda[c], Theresa Stoddard[a]

[a] Department of Anthropology, University of South Florida, 4202 E. Fowler Avenue, SOC 107, Tampa, FL, USA
[b] USF Center for the Advancement of Food Security & Healthy Communities, University of South Florida, 4202 E. Fowler Avenue, SOC 107, Tampa, FL, USA
[c] USF Center of Excellence in MCH Education, Science & Practice, University of South Florida, 13201 Bruce B. Downs Blvd, UPC 523, Tampa, FL, 33612, USA

ARTICLE INFO

Keywords:
Syndemics
Food insecurity
Diet-related chronic diseases
Life history theory
Medical anthropology
Public health

ABSTRACT

Syndemic Theory (ST) provides a framework to examine mutually enhancing diseases/health issues under conditions of social inequality and inequity. ST has been used in multiple disciplines to address interacting infectious diseases, noncommunicable diseases, and mental health conditions. The theory has been critiqued for its inability to measure disease interactions and their individual and combined health outcomes. This article reviews literature that strongly suggests a syndemic between food insecurity (FI) and diet-related chronic diseases (DRCDs), and proposes a model to measure the extent of such interaction. The article seeks to: (1) examine the potential syndemic between FI and DRCDs; (2) illustrate how the incorporation of Life History Theory (LHT), into a syndemic framework can help to highlight critical lifeperiods when FI-DRCD interactions result in adverse health outcomes; (3) discuss the use of mixed methods to identify and measure syndemics to enhance the precision and predictive power of ST; and (4) propose an analytical model for the examination of the FI-DRCD syndemic through the life course. The proposed model is more relevant now given the significant increase in FI globally as a result of the ongoing COVID-19 pandemic. The differential impact that the pandemic appears to have among various age groups and by other demographic factors (e.g., race, gender, income) offers an opportunity to examine the potential FI-DRCD syndemic under the lens of LHT.

During the 1990s, medical anthropologist Merrill Singer developed Syndemic Theory (ST) in response to the convergence of multiple epidemics (e.g., HIV/AIDS, substance abuse, and violence) taking place in Hartford, CT (Romero-Daza et al., 2003; Singer and Clair, 2003; Weeks et al., 1998). ST provides a framework to examine two or more mutually enhancing diseases or health conditions in socio-ecological settings where social inequality and inequities exist (Baer et al., 2013; Singer, 2009; Singer et al., 2017). ST has been used to examine infectious diseases (Freudenberg et al., 2006; Hill et al., 2019; Himmelgreen et al., 2009; Romero-Daza et al., 2003; Singer, 2000), non-communicable diseases (Chukwuma, 2017; Himmelgreen et al., 2017; Mendenhall, 2014; Mendenhall et al., 2017), and mental health conditions (Diderichsen and Anderson, 2019; Weaver and Mendenhall, 2014).

1. FI and diet-related chronic diseases

While ST has mostly been applied to infectious diseases, it is now being used to examine non-communicable diseases including DRCDs such as type 2 diabetes, hypertension, cardiovascular disease (CVD), and obesity (Dressler, 2003; Mendenhall, 2014, 2016a; 2016b, 2019; Mendenhall et al., 2015, 2017; Swinburn et al., 2019). Broadly defined as limited access to food of enough quantity and quality, FI is an important determinant of health. Although FI stems from social inequalities and inequities, it is directly tied to biological processes in which diseases interact. Various definitions of FI exist, such as the limited or uncertain availability of nutritious and safe foods, the lack of access to sufficient amounts of safe and adequate foods for normal growth and development, and the inability to acquire acceptable foods in socially acceptable ways (Chilton et al., 2017; Coleman-Jensen et al., 2018). These definitions include four dimensions to determine whether individuals, households, and communities are food secure (a920Td(:1)Tj/T1311Tf-203444-2.6247Td()Tj/T1011Tf125590TdAavailabilit:1

for survival (growth, development, maintenance, reproduction), and the trade-offs that occur when there is an imbalance between availability and requirements. LHT has been used to explore issues including the FI-obesity paradox. For example, Schlüssel et al. (2013) examined the impacts of the paradox among adult women, female adolescents, and young children. Their findings indicate that female adolescents who were food insecure were twice as likely to be obese as compared to their food secure peers (Schlüssel et al., 2013). Household FI has been linked to increased obesity risk throughout the life course and researchers have hypothesized that childhood FI may increase the risk for long-term ill health (Frongillo and Bernal, 2014). Miller (2014) studied the relationship among dietary intake, fat deposition, and nutritional status among breastfeeding Ariaal infants in northern Kenya, finding that infants who experienced chronic nutritional stress also accumulated fat deposits, which indicated reduced oxidation of fat.

Given the synergistic social and biological systems involved in DRCDs and FI, the precision and predictive power of ST is enhanced by the use of LHT, which adds the elements of time, trajectory, and life stages. This enables the examination of the interaction of diseases/health conditions during the life course. Unterberger (2018, 107) underscores this by pointing to the "intersecting and synergistic effects of place/environment, timing, timelines, and equity on health over the life span." This is important as "traumas and illnesses continue to add and build up over time," creating exponential, not merely additive or linear effects (Unterberger, 2018, 109).

Different life stages present different health issues as well as specific needs (e.g., growth and development, immunity, reproduction). Early-life adverse experiences can have health implications later in life. For example, Horton and Barker use LHT to disentangle how early-life health issues among farm workers' children produce childhood oral caries, which are linked with stigma, speech pathologies, and low self-esteem, and with later-life heart disease, stroke, and pancreatic cancer (Horton and Barker, 2016, 137-8). Here, LHT highlights the role of the environment through life course experiences. The authors found that many caregivers' rural environments in Mexico were relatively uncariogenic—involving few processed and re

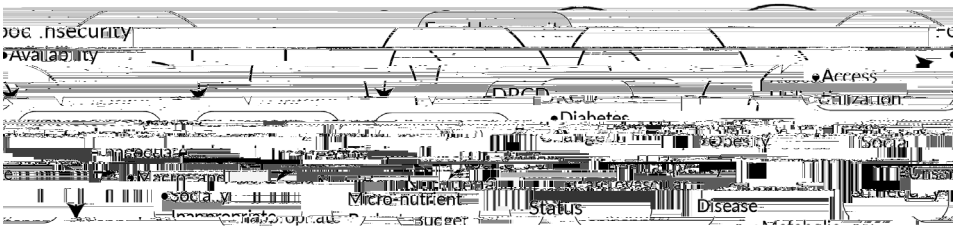

Fig. 1. Conceptual model of the FI-DRCD syndemic.

amplifying adverse health outcomes. This model is a heuristic device for the research design (e.g., mixed methodology), analysis (e.g., SEM), programming (e.g., food prescription programs), and policies (e.g., re-zoning for local urban food production) to address the FI and DRCD syndemic.

3. Mixed methods for understanding and measuring the potential FI-DRCD syndemic

ST postulates that the interaction of two or more epidemics results in a multiplying (rather than simply an additive) effect. However, there has been criticism related to the inability to differentiate between co-morbidities and true syndemics, to operationalize the specific level of interaction between the epidemics at play, and to quantify this multiplying effect. What follows is a discussion on the methods, variables, and analytical tools that can be used to examine the potential FI and DRCD syndemic and to increase the precision and predictive power of syndemic studies. Here we present an initial postulation of a model to determine whether, and to what extent, there is a syndemic between FI and DRCDs.

The dimensions of FI include limited food availability and access along with biological utilization of food and nutrients, which can result in compromised diets and increased risk for DRCDs. The timing and severity of FI during the life course can have multiplicative effects where DRCD rates are higher than expected. In order to assess these interactions in a comprehensive way, research should employ qualitative and quantitative methods. Qualitative methods offer in-depth knowledge about how people experience the realities of FI and about the overall impact it has on their well-being. In turn, this provides insight into the complex social, economic, and behavioral forces that explain the phenomena. For instance, qualitative methodologies have been used to investigate critical life-periods that are implicated in the life course while also serving as the primary methods used to first investigate syndemic interactions occurring within ecologically disadvantaged contexts. For example, the convergence of substance abuse, violence, and AIDS in Hartford, CT (Singer and Clair, 2003) and of violence, depression, diabetes, immigration, and abuse (Mendenhall, 2016b) were primarily investigated using qualitative, methods.

Quantitative methods allow for the collection of generalizable information from population-based data to assess the interactions among mutually reinforcing conditions (FI, DRCDs). Innovative methods are needed to assess the synergistic epidemics beyond just assessment of dependent variables (e.g., FI level), contextual factors or modifying variables (e.g., dietary intake, psychometric indicators of stress and depression) and health outcome variables (e.g., BMI, HbA1c levels, blood pressure, and cortisol). It should be noted that while none of these methods is unique to ST, they are all necessary tools for the systematic collection of information needed to test the proposed model.

3.1. Qualitative methods: interviews, focus groups, and photovoice

Qualitative methods offer an ideal tool for the collection of rich data on the lived-experience of people affected by FI and related conditions. Free listing, pile sorting, and ranking serve to examine the way in which individuals (especially those of diverse cultural backgrounds) conceptualize issues related to diet and FI (Bernard and Gravlee, 2014). For example, to assess perceptions related to diet quality in Costa Rica, Himmelgreen and colleagues (2012; 2014) first asked participants to list all the foods they commonly consumed (free listing) and then to categorize them into those they considered “healthy,” “unhealthy,” “prestigious,” etc. (pile sorting). By analyzing the way individuals classified food items, and their rationale for doing so, researchers obtained a culturally nuanced understanding of food preferences and choices.

Another method often combined with free listing involves the ranking of items. For example, to assess how the types of foods consumed vary depending on level of FI, researchers can elicit a ranking of food items in terms of “desirability,” from most to least preferred foods, along with an explanation of when the least desirable items are consumed. When combined with dietary recalls, this ranking allows for the identification of strategies used to cope with FI. Ranking is also useful when exploring how individuals prioritize competing needs such as food/nourishment, health care, rent, transportation, etc. Similarly, these methods can be used to explore the interaction between FI and associated conditions, through the use of prompts to list, categorize, and rank the impact FI has on overall health in general, and on DRCDs specifically.

Data collected through open-ended and semi-structured interviews and focus groups serve to contextualize statistical data and “put a face” to the numbers. When working with children or teens, visual methods such as photovoice are especially useful. In photovoice, participants take pictures that show what a given issue means to them and engage in discussion with peers about the topic. They then create a public exhibit to raise awareness about the issue at hand and to advocate for action from various stakeholders. Burris et al. (2020) used photovoice in their study of adolescent FI in Florida. Their research highlighted strategies teenagers adopt to deal with FI such as shoplifting at convenience stores and skipping meals so that their younger siblings can eat. The study also

elucidated the stigma of participating in school-based reduced-lunch initiatives, which leads teenagers to avoid using this much-needed program. Importantly, the exhibit generated from this project helped the school district modify the way in which it provided food assistance.

Interviews, focus groups, and photovoice are especially suited for the study of syndemics since they yield rich in-depth data to illustrate the impact health conditions have on one another. An inductive approach to qualitative data analysis is most appropriate for these methods. Open coding allows themes to emerge naturally from the data, reducing the risk of confining qualitative data to predetermined categories and misrepresenting participants' experiences. Ryan and Bernard (2003) identify numerous ways to effectively analyze qualitative data, each best-suited for specific research goals. A number of techniques are relevant for coding textual data collected from free lists, interviews, and focus groups. Applicable scrutiny techniques include looking for repetitions, similarities and differences, and metaphors and analogies in text.

Processing techniques such as word lists, key words in context (KWIC), and word co-occurrence are also useful for identifying major themes. As photovoice generates non-textual data in the form of pictures, analysis should rely on an examination of similarities/differences, repetitions, and/or what is missing from the collected photographs and accompanying narratives (Ryan and Bernard, 2003). The themes generated from coding will be useful for developing an understanding of the FI-DRCD syndemic by unearthing the major and overlapping life experiences. Qualitative methods are important in FI-related and syndemic-focused research because of their ability to capture powerful narratives that provide insight into the embodied experiences of participants.

3.2. Quantitative methods: measurements and analytic frameworks

Syndemics are unobservable factors or constructs that represent latent variables or latent traits. Thus, it is important to utilize reliable measures for such constructs. There are several evidence-based scales that have been validated to measure FI, including: the USDA Household Food Security Survey Module (HFSSM), the Household Food Insecurity Access Scale (HFIAS), the Latin American and Caribbean Food Security Scale (ELCSA), and the Food Insecurity Experience Scale (Tuholske et al., 2018). These scales measure uncertainty in the ability to obtain food, compromises regarding the quality and variety of food, reductions in food quantity (including skipping meals), and lack of food consumption for a day or more. Together with other methods, these scales can examine and measure the FI dimensions of limited food access, availability, biological utilization, and stability as previously discussed. The HFFSM module is used widely and is administered nationally in the US; it provides data that can be scored to categorize individuals and households into four levels of food security (USDA, 2019).

3.2.1. Measures of dietary intake

Dietary intake at the individual and household levels can be examined using 24-hour food recalls, food frequency questionnaires (FFQ), and Food Accounts. The first two provide individual-level data, while the latter give a daily record of all the food entering the household (Gibson, 2005). Abbreviated FFQs can be used to identify which nutritionally adequate, safe, and socially appropriate foods are uncertain or limited. There is an array of scales to assess whether a set of foods aligns with national and international dietary guidelines. For instance, the Healthy Eating Index (HEI-2-16) measures dietary quality and assesses individual and group compliance with the U.S. Dietary Guidelines for Americans (

multiplicative for the joint effects of the two syndemic factors. It is also necessary to determine the size and the statistical significance of interactions to quantify how large the mutually reinforcing relationship between epidemics is. Also, syndemic factors may affect health outcomes in direct and/or indirect ways due to the effects of intermediate (mediation) or contextual (confounding) factors. Clearly, testing ST in tandem with LHT presents several challenges that cannot be easily addressed with simple bivariate analyses. Very important effects may be missed if single factors are examined independently.

Researchers need a collection of tools and techniques to study synergistic relationships. The attributable proportion due to interaction and the synergy index are two measures that have been used to assess simple interactions and are readily applicable to categorical outcomes with observed variables (e.g., odds ratios, logistic models) (Rothman, 1976, 1974). Assessing interactions with covariates is also possible with multiple factors using generalized linear models. This can be done by introducing interaction terms or by conducting moderation analyses using stratified models. However, if syndemics are conceptualized as latent variables (with continuous scales) that influence each other, the simpler indexes and conventional regressions will not be appropriate as they cannot assess multiple dependent variables and the co-variation of a large number of determinants at multiple levels (e.g., SDoH at individual, household, and community levels) simultaneously. Also, principles of the LHT need to be considered to identify disease interactions during critical periods of human development (i.e., vulnerability), with a longitudinal view (latency of exposure/outcomes) and considering cumulative exposures (chronicity) over the lifespan. Because ST assumes the presence of factors as underlying mechanisms, rather than simple bivariate relationships of observed measures or indicators, more complex analyses are needed to assess interactions with latent variables.

4.1. Modeling syndemic interactions using structural equation modeling

One useful set of techniques is structural equation modeling (SEM), which is a collection of multivariate statistical techniques (i.e., parametric regression, confirmatory factor analysis, path analysis, and latent growth curve modeling) especially suited to assess structural relations of multiple independent variables with multiple dependent variables, including latent variables and latent classes. We argue that SEM, also known as simultaneous equations or covariance structure models, can be effectively utilized to model complex relationships between directly observed and indirectly observed (latent) variables, which is precisely the inquiry under ST constructs. SEM simultaneously solves systems of both linear and non-linear equations.

Recently, SEM has gained popularity in syndemic research applications in diverse fields such as public health, epidemiology, medicine, and the social sciences. A variety of proprietary and open-source soft-

Angeles, CA, pp. 1998–2012.
Myers, C.A., Martin, C.K., Newton, R.L., Apolzan, J.W., Arnold, C.L., Davis, T.C., Katzmarzyk, P.T., 2019. Cardiovascular health, adiposity, and food insecurity in an underserved population. Nutrients 11 (6), 1376.
Nagata, J.M., Palar, K., Gooding, H.C., Garber, A.K., Bibbins-Domingo, K., Weiser, S.D., 2019. Food insecurity and chronic disease in US young adults: findings from the national longitudinal study of adolescent to adult health. J. Gen. Intern. Med. 34 (12), 2756–2762.
National Cancer Institute. (n.d.). NCI Dictionary of Cancer Terms. https://www.cancer.gov/publications/dictionaries/cancer-terms/.
National Cancer Institute, 2019. Developing the healthy eating index. https://epi.grants.cancer.gov/hei/developing.html#2015.
National Council on Aging, 2019. SNAP and senior hunger facts. https://www.ncoa.org/news/resources-for-reporters/get-the-facts/senior-hunger-facts/.
National Institutes of Health National Heart, Lung, and Blood Institute. (n.d.). BMI tools. https://www.nhlbi.nih.gov/health/educational/lose_wt/bmitools.htm.
Okafor, C.N., Christodoulou, J., Bantjes, J., Qondela, T., Stewart, J., Shoptaw, S., Rotherman-Borus, M.J., 2018. Understanding HIV risk behaviors among young men in South Africa: a syndemic approach. AIDS Behav. 22 (12), 3962–3970.
Ostrach, B., Singer, M., 2012. At special risk: biopolitical vulnerability and HIV/STI syndemics among women. Health Sociol. Rev. 21 (3), 258–271.
Page-Reeves, J., Shrum, S., Rohan-Minjares, F., Thiedeman, T., Perez, J., Murrietta, A., Ronquillo, F., 2019. Addressing syndemic health dispGen0naries/cyndemicwomen.-303((ind.)-300)-33mmi9.3869-340339(ousyndemtta,)-3pects.poreartARarisk:B.(s-1.2448Td[Ronquillo,)-3mal3