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Social Relationships and Obesity: Benefits of Incorporating a Lifecourse Perspective

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Abstract

Social networks reflect the structure of our interpersonal relationships. The effect of social networks on health is a topic of growing interest, particularly in an increasingly connected world. This review provides an overview of how social relations shape obesity risk and the effectiveness of network-based obesity interventions across the life course. The review highlights that, while the literature suggests obesity and related health behaviors are similar between socially-connected individuals, why this is the case and how to effectively intervene remains unclear. In addition, the review outlines methodological gaps limiting our understanding of how social networks shape obesity risk throughout the lifecourse. Several implications for obesity prevention and research are offered, including the need to examine the relationship of social networks and obesity across rather than within life-course stages, continued development of statistical social network analysis methods and the need for new cohort studies, particularly among children and the elderly.

Keywords

social networks; obesity; lifecourse; social relationships; diet; physical activity

Introduction

Obesity is one of today's most pressing major public health problems [1]. Obesity is a complex, multifactorial condition that is shaped, as we age, by the interactions of an individual and his/her social, and physical environments. A growing body of literature increasingly shows that interpersonal relationships contribute to obesity and obesity-related risks at different stages of life [2–5] and that, across the lifecourse, one's social ties to others

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Conflict of Interest

Mark C. Pachucki and Elizabeth Goodman declare that they have no conflict of interest.

Compliance with Ethics Guidelines

Human and Animal Rights and Informed Consent

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are inextricably linked one's health and health-related behaviors [6, 7]. Furthermore, evidence suggests that social networks may be usefully leveraged to reduce obesity and risks in both adolescence and adulthood [8–10]. While evidence has accrued within specific developmental stages, to date, there has been no life course approach that synthesizes how social relationships shape obesity – and vice versa – from cradle to grave. Considering networks and obesity from a life course perspective acknowledges that changes in one's social relationships may influence not just one's immediate obesity status, but one's future obesity, as well as the current, and perhaps future, obesity status of those to whom an individual is connected. Such a perspective also acknowledges that obesity status shapes social ties and connections, both present and future and that these ties, in and of themselves, influence life course educational, occupational and health trajectories.

This review aims to synthesize recent literature on social networks and obesity with a focus on understanding how network mechanisms operate across the life course. The review highlights that, while we have some basic knowledge, significant work is needed to effectively include social networks as part of a multifactorial response to obesity. First, the review provides a brief introduction to social network analysis, including an overview of theories linking networks to life course health and obesity. Second, the review discusses the current state of the field, providing an overview of what we know about how social relations shape obesity risk at different stages of the life course, and what we know of the effectiveness of network-based obesity interventions. Third, several methodological considerations related to social network analysis are highlighted. Finally, we discuss implications for life course obesity prevention and research, and summarize key findings and trends in the past 5 years. This article does not contain any studies with human or animal subjects performed by either of the authors.

Brief Introduction to Social Network Analysis

Social network analysis (SNA) is concerned with understanding the structure of human interpersonal relationships. Although introduced to epidemiology from the social sciences decades ago [7, 11], SNA research is not widespread and the majority of health-focused SNA studies are observational, not experimental. Social networks are typically measured by participant self-report through a questionnaire, which asks the participant to nominate up to n persons, and to provide additional information about relationship qualities [12]. The participant is referred to as the “ego” and persons named by the participants referred to as “alters” in SNA research. Investigators make inferences about how relationships may shape, or be shaped by health attributes of egos and alters.

There are two common approaches to examining networks and health behaviors – dyadic network models using multiple regression and probabilistic statistical network models. Multiple regression models accommodate network analysis, but are designed with an assumption of independent observations. Various statistical adjustments must therefore be made to reduce bias due to correlated observations. In contrast, probabilistic statistical network models are designed specifically for interdependent network data. Two common types of statistical network models include stochastic actor-based (SAB) and exponential random graph (ERG) models. ERGs test for the probability of observing a network tie based

on individuals' attributes. SAB models are useful to analyze network dynamics based on the co-evolution of an individual's network and behaviors. Overviews [13, 14] and detailed reviews [15–18] of these approaches are available.

Theories linking social networks to lifecourse health and obesity

In their lifecourse health development (LCHD) model, Halfon and colleagues describe generalized social connectedness as an important determinant of health [19]. This model suggests that the influence of social connectedness changes as an individual moves through the life course but does not specifically deal with social networks. There are two network-focused conceptual models that more formally link specific characteristics of social ties and network structure to health. Umberson, Crosnoe, and Reczek, whose model focuses on health-related behaviors, theorize that social ties influence behaviors over the lifecourse through social norms surrounding relationships and meanings we attach to peer groups [6]. Berkman and colleagues' theory relates to health more broadly [20]. They suggest that network ties are shaped by and interact with a broad range of health determinants. Ties provide exposure to social support, influence, engagement, person-to-person contact, and access to resources. In turn, these mechanisms impact health through behavioral, psychological, and physiologic pathways. However, because these pathways are differentially salient during different phases in human development, the impact of social ties on health likely varies by critical windows in the life course. Understanding this variation and its implications for health is an important area for future research.

Conceptual models linking social networks to obesity as a specific health outcome are lacking. While behavioral models of obesity have included networks in general terms [21, 22], none have formally included social networks as etiologic agents. For example, Davison and Birch's ecological childhood obesity model emphasizes the important roles that peer and sibling interactions and parent-child relationships have on risk factors for child obesity [21], but they do so from a dyadic, not a network perspective. Likewise, a systems-science obesity model developed by the Foresight group offers an overview of dozens of factors that shape obesity, including face-to-face social interaction and peer pressure, but this model does not formally include network structure [22]. Further theoretical development is necessary to include social network in models of obesity risk and development.

Current State of the Field: What We Know

Social relationships and obesity risk at different stages throughout the lifecourse

Weight Status—Roughly a dozen studies have used high-quality network data to examine the association between networks and obesity status [2–5, 23–30]. Fewer of these have longitudinal data to make causal inferences [2, 3, 23–27, 29]. A foundational study that spurred development in this field was an analysis of adult obesity in the Framingham Heart Study (FHS) [31]. Social ties between 12,067 adults were analyzed between 1971 and 2003, and longitudinal regression models showed that having an obese friend was associated with a 57% greater likelihood of future obesity; having an obese sibling, 40% greater; and having an obese spouse, 37% greater [2]. Importantly, these models estimated the relationship between an ego's BMI and alter's prior BMI, while adjusting for ego's prior and alter's

current BMI, and a range of socio-demographic confounders. There has been little adult sociocentric network research that replicates this finding. One study by the same authors found similar effects in a re-analysis of FHS adults using a different statistical model [24]. A separate study used a database of email correspondence to infer co-workers' network ties, and found significant associations in co-workers' BMI [32].

Both cross-sectional and longitudinal SNA studies of adolescents show that body weight tends to be similar amongst socially-connected friends [33]. Many adolescent network studies of obesity have relied on data from the National Longitudinal Study for Adolescent Health (Add Health). One persistent problem is that it remains unclear whether weight similarity comes from adolescents befriending similar-weight others [26] or from friends influencing a change in each other's weight status [29]. These studies do show that social stigma and avoidance are important factors in network formation; overweight adolescents are less likely than non-overweight students to be chosen as a friend [30]. Furthermore, studies highlight that, while social environmental factors that shape obesity vary by home, school, and neighborhood, friends tend to have similar body weights even after adjusting for these multi-level factors [28].

Diet and Physical Activity—Diet and physical activity (PA) are key weight-related behaviors. More social network research has been done on these behaviors than on obesity, itself. With regard to diet, network studies have shown that the volume and type of food consumed by socially-connected peers is associated with one's own consumption [34–37]. Though connected peers' diets tend to be similar, the amount of similarity varies depending on whether the specific peer is a friend, spouse, or sibling [37]. For both children and adults, eating behaviors are shaped by peer modeling, social norms, and for reasons of belonging to a certain social group [34]. Research has not yet systematically documented how such mechanisms operate at different lifecourse stages.

Compared with diet, there is a more substantial body of network research on PA. Prevailing norms within a social network affect how much PA and which types of PA a person engages in. Friends or family members often serve as PA role models, and also provide social support [38–40]. These social norms are not always salutogenic but can be targets for intervention. For example, a school-based study of 5th-graders gathered information on peer connectedness and exposure to friends' healthful and unhealthful PA and diet behaviors [41]. The behaviors of students who were randomized to participate in an obesity-prevention program did not appear to be influenced by friends with unhealthy behaviors. Thus, inclusion in the prevention program arm is thought to have buffered negative peer effects. As with diet, evidence is inconclusive as to which network mechanisms shape PA at different life course stages [39].

Gender is an important moderator of network effects on PA. A recent study of several thousand Minnesota adolescents showed important moderating effects of gender in the relationship between an adolescent's PA and that of specific friends. Specifically, girls' PA and was positively associated with friends' behaviors while boys' PA were only associated with female friends' behaviors [42]. Though PA network research largely relies upon self-reported PA, a recent study of 5 to 12 year-olds measured PA using accelerometers and

showed that PA of close friends, as opposed to friendship selection, was the predominant influence on children's PA [43].

Evidence for the effectiveness of social network interventions in preventing or reducing obesity

In addition to the above findings from observational social network studies, evidence from social network based health interventions suggests that using information on social connectedness may be effective at reducing obesity risk [44]. Network interventions seek to change the behavior of persons in a population by using information about network structure to promote behavior change. Common types of social network interventions include 1) targeting key individuals, 2) targeting groups within networks, 3) provoking interpersonal interaction, and 4) adding an individual to, or dropping them from a network, or intentionally re-arranging ties between certain individuals [44]. The literature is mixed regarding whether network-based obesity interventions are more effective than standard interventions [39, 45, 46].

Research on network interventions for obesity is an area in its infancy. A sophisticated randomized online experiment offers an example of the promise of this approach [47]. In this study, participants signed up to an online fitness program and were assigned "fitness buddies" for social reinforcement. Unbeknownst to participants, the investigator manipulated which specific buddies would be paired with a given participant. In this way, the level of obesity similarity in participants' networks could be manipulated. Individuals were more willing to adopt a new health behavior with reinforcement from similar-weight others in their social network.

Simulation studies can be useful to predict how a network-based intervention may unfold in a population. In one recent study, prospective cohort data from the UK were used to simulate obesity prevention and reduction interventions [46]. There was no difference in population obesity prevalence if individuals were targeted randomly or because they were highly connected, suggesting that a more sophisticated intervention strategy may be necessary. A different simulation study showed that social influence alone may not be sufficient to change behavior, depending on whether an intervention is implemented once, or is sustained over a long period of time [48]. Though simulation models can only offer approximations of complex systems, population-level obesity research can benefit from the further development of these models.

Increasingly, online social networks and social media are being utilized as new avenues for social network research [9, 10]. In such studies, investigators often leverage patterns of social connectedness established through a website or social media platform like Facebook or Twitter to evaluate whether social reinforcement may lead to a desired behavior change. A recent systematic review and meta-analysis of internet-based intervention efficacy for obesity prevention among adults (n=10 studies) and adolescents (n=2 studies) suggested that interventions with some type of social networking component could lower BMI [49]. Though effects were small, the authors suggest that online strategies may be useful as part of a multi-faceted approach to obesity reduction and prevention. The comparative efficacy and utility of such strategies by lifecourse stage has not yet been studied.

Methodological Considerations

Practical Limitations

Network analyses share generic measurement, sampling, and generalizability concerns common to all obesity studies, but also have special challenges. As with non-network studies, clinically-measured height and weight are preferable to self-report, but these data are particularly challenging to obtain across a network of individuals. To obtain complete network BMI or other attribute data, all individuals in the network must consent to be research subjects.

Like height and weight, relationship measures are also often obtained through self-report. Data quality can be affected by how the question is asked, whether a roster is used to prompt recall, and even whether an open-ended number of nominations are allowed. For example, Add Health, which was designed to assess networks, asked adolescents to name up to 5 female and 5 male friends [50]. In contrast, FHS, which was not designed to assess networks, asked participants to name important persons in their lives with whom the study could follow up should the participant be lost to follow up [2]. These named individuals were used to specify a social network and its boundaries, thereby creating a social network for each FHS participant. To reduce biases inherent in self-report, passive measures that do not rely on respondent recall are increasingly being used to detail social relations. Smartphones, electronic radio-frequency (RFID) sensors, and online social media can passively track relationship data [51–53].

Generalizability is another methodological concern in network studies. In addition to the usual problems related to sample selection, additional care is required in the case of network studies because patterns of friendship may vary significantly across otherwise similar settings. For example, even in two populations with similar gender, SES, and racial/ethnic group balances, the number and distribution of types of friends may vary, and the distribution of reciprocated and one-way friendships may differ.

One specific methodological concern for social network based interventions, particularly randomized controlled trials (RCTs), relates to interdependence. A key assumption in experimental studies such as RCTs is that the treatment and control groups are distinct from one another and, thus, that observations within each arm are also independent. This assumption of independence cannot easily be assured in network-based studies unless explicitly addressed. If two people are socially connected across or within treatment arms, bias can be introduced. Fortunately, solutions such as online experiments, methods for adjusting for spillover and interference effects between groups, and methods for monitoring network changes during an intervention are beginning to be used to account for this interdependence [10, 54, 55].

Last, there is a paucity of high quality data for this research. Few longitudinal population-based or nationally-representative datasets contain high-quality data on obesity and other health conditions and only a minority of these studies also include network data. Add Health, for example, gathered unique, high-quality longitudinal network data beginning in 1994. However, at 20 years old, these data are becoming outdated. Adolescent obesity

prevalence and its demographic distribution has changed significantly in the past two decades [56], and new forms of social connectedness are enabled by electronic media were not even present in that era. New, modern cohort studies containing both weight status and social network data are needed if the field is to advance.

Statistical concerns with SNA studies

As noted above, bias due to interdependence is a design concern for SNA studies. This interdependence is also a statistical concern. Challenges related to correlated observations have prompted debate as to the best way to assess causal effects in network studies [15, 23, 57–60]. It is largely agreed that network models, whether regression-based or probabilistic, can do a reasonable job of evaluating whether a statistical association exists between ego and alter's health attribute, such as obesity, diet, or PA. However, identifying the reasons underlying that association (i.e. evaluating whether social selection, influence, or some other mechanism is responsible) is more complicated. Unobservable factors that could lead to similar preferences or behaviors between two people are particularly problematic. The obesity similarity between two friends could be confounded by the fact that several new fast-food restaurants recently opened in their neighborhood. If the existence of these restaurants is not known to investigators, but is associated with changes in both of the friends' eating behaviors, it serves as a source of latent homophily. Instrumental variable approaches [61] and experimental designs [47] offer possible solutions, though implementation is rarely straightforward. Other areas for statistical development include friendship dissolution [62], how social ties related to positive sentiment (i.e. liking or friendship) may be related to ties with negative sentiment (i.e. teasing or stigmatization) [63], and how these dynamics may shape obesity or related behaviors and changes to network structure.

Implications for Life Course Obesity Prevention and Research

Shoring up life course gaps in research on networks and obesity

The inter-relationships between the structure of our social ties and obesity and its attendant risks is important for research at any life stage. However, a significant gap exists in terms of our understanding of obesity and social networks during childhood. Research has focused on adults and adolescents. Given our robust understanding that childhood social conditions can shape later-life disease and illness [64], how familial, friendship and school-based social networks affect and are influenced by obesity in childhood would benefit from greater attention. A large-scale study of children with both obesity and network data is needed. A study similar in design to the former National Children's Study could potentially be developed to provide these data. Similarly, more network studies investigating obesity in adulthood are needed, and especially among older adults (70+ years). Given the aging American population and high obesity prevalence, understanding how networks may serve as determinants of obesity risk in the elderly is timely, and necessary.

Examining networks and obesity across lifecourse stages

While we call for life-stage specific studies of social networks and obesity in childhood and the elderly above, we note that research within a stage of the lifecourse, as opposed to across

lifecourse stages is the norm in this field. In fact, we found no studies of social network and obesity and related behaviors across lifecourse stages. This is a significant gap in the literature and should be an area of focus for future studies. There are sensitive periods in the life course during which the social environment has a disproportionate impact on current and future health [65]. Without such within-person longitudinal studies, we do not yet know if social networks disproportionately influence obesity at such critical windows of development. For example, whether relationships during childhood, adolescence or early adulthood are more strongly associated with an older adult's obesity status is currently unknown. We also do not know if different types of networks differentially influence obesity risk at particular developmental stages. For example, are peer influences relative to obesity risk stronger in adolescence or adulthood? Because obesity prevalence varies both by gender and lifecourse stage [1], we might also expect significant gender differences in how network ties shape obesity risk and the influence of obesity on social network structures. Treating these concerns in a lifecourse perspective will likely require methodological innovation to combine existing network approaches with the use of nonlinear developmental trajectories and multi-level modeling.

Conclusions

In addition to the range of physiological, genetic, and environmental factors that shape obesity risk, the social ties that bind us also influence obesity and obesity-related behaviors. The relationships between social networks and these health outcomes are complex and recursive. Although studying the relationships between social networks and obesity is a relatively young field, there are four key points to highlight from this literature. First, while it is clear that obesity is associated between socially-connected individuals, the mechanisms that produce this similarity have not yet been reliably established across life-course stages. Second, PA network research is relatively more developed than network studies of eating behaviors, obesity risks or weight status, itself. Third, use of social networks in obesity-related interventions is rare, but signs point to network data being useful for intervention studies. Fourth, well-established methods exist for analyzing social networks and obesity, but evaluating causal effects using network data continues to be challenging, and limited population-level datasets exist to test lifecourse hypotheses. A major gap identified by this review is the lack of network studies of obesity that span lifecourse stages. Considering individuals' connectedness throughout the life course is a promising area of research and has the potential to contribute to multifactorial solutions that can help with both primary and secondary prevention of obesity.

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