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Why Social Relationships Are Important for Physical Health: A Systems Approach to Understanding and Modifying Risk and Protection

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Abstract

Social relationships are adaptive and crucial for survival. This review presents existing evidence indicating that our social connections to others have powerful influences on health and longevity and that lacking social connection qualifies as a risk factor for premature mortality. A systems perspective is presented as a framework by which to move social connection into the realm of public health. Individuals, and health-relevant biological processes, exist within larger social contexts including the family, neighborhood and community, and society and culture. Applying the social ecological model, this review highlights the interrelationships of individuals within groups in terms of understanding both the causal mechanisms by which social connection influences physical health and the ways in which this influence can inform potential intervention strategies. A systems approach also helps identify gaps in our current understanding that may guide future research.

Contents

INTRODUCTION AND OVERVIEW

Humans are social animals. Across a number of social species, there is evidence that being part of a group is adaptive for survival. For example, being part of a group can provide protection from predators (Ioannou et al. 2012) and from the elements (Black et al. 2016), as well as increased access to resources such as food (Beauchamp 2014, Pays et al. 2013). Humans are one of the most vulnerable species at birth, relying on others for nearly all aspects of survival—a human infant would simply die if left alone. Although water, food, and shelter are key to survival, it is also clear that humans would not survive without the care and nurturance of others. Throughout the lifespan, social connections continue to play a vital role (Fagundes et al. 2011, Hawkley & Capitanio 2015).

From this perspective, it has been argued that social connection may be viewed as a biological need directly tied to survival. Much as thirst drives one to consume water, loneliness may be a biologically adaptive response motivating one to reconnect socially (Cacioppo et al. 2014). Neuroscience also supports the notion of social connection as being adaptive—we use more metabolic resources when coping with threat alone than when we are in the presence of others (Coan & Sbarra 2015, Coan et al. 2006), and social pain shares neural mechanisms with physical pain (Eisenberger 2012). Both of these points suggest the biological manifestation of motivational cues to maintain close social ties.

Indeed, across several different measurement approaches, evidence indicates that those who are more socially connected live longer (Holt-Lunstad et al. 2010). Epidemiological research has examined this prospectively in large community samples by measuring social connection in individuals and then following these individuals over time, often over decades, to determine if social connection predicted survival or time to death. Since the seminal review done by House and colleagues (1988), which included five prospective studies, the body of evidence has grown exponentially to now include hundreds of studies, millions of participants, and broader measurement

approaches. Several recent published reviews and meta-analyses also synthesize the relevant data, including the protective effect of social relationships (broadly defined; Holt-Lunstad et al. 2010), social contact frequency (Shor & Roelfs 2015), and family ties (Shor et al. 2013), whereas others demonstrate the risk associated with lacking social connection via loneliness and social isolation (Holt-Lunstad et al. 2015), divorce (Sbarra et al. 2011, Shor et al. 2012a), being single (Roelfs et al. 2011), and widowhood (Shor et al. 2012b). Taken together, we now have robust evidence indicating that being socially connected has a powerful influence on longevity, such that having more and better relationships is associated with protection and, conversely, that having fewer and poorer relationships is associated with risk. When benchmarked against other leading risk factors for mortality, the magnitude of this effect is equivalent to or exceeds that of obesity (Holt-Lunstad et al. 2010, 2015).

One fundamentally important question remains—what exactly is a social relationship? This question has been an area of inquiry and debate for decades among relationship scientists. Because the term relationship is commonly used by scientists and laypeople alike, it is often used with the assumption that the meaning is obvious (Reis et al. 2000). A defining characteristic of a social relationship is that there is interaction between the relationship partners and that this interaction exerts mutual influence over behavior (Berschied & Reis 1998). Although interaction is a necessary feature of relationships, it is not sufficient for all types of relationships. Close relationships include this hallmark feature of influence over behavior, but this influence occurs over extended periods of time, are emotionally laden, and are characterized by idiosyncratic representations of others (Berschied & Reis 1998). Thus, it is clear that the very nature of social relationships is complex and necessitates a nuanced approach with consideration of multiple factors.

As the scientific community continues to elucidate the relationship between social relationships and physical health, it is vital to view relationships from an interdisciplinary and multilevel perspective. Therefore, this review proposes the potential utility of a systems approach when evaluating the link between social relationships and physical health. This review focuses primarily on physical health and longevity; however, a systems approach may be applied to social and mental health outcomes, as well. The systems approach views each individual as existing within a network of four separate yet embedded dimensions: the individual, the family and close relationships, the community, and the society. This approach does not sacrifice individual consideration, but rather places each individual within a broader context. The broader consideration of influences from relationship, community, and society aids in our understanding of social connection as a protective factor (or social disconnection as a risk factor) and could be applied to efforts aimed at developing effective interventions and preventative efforts.

This review first provides a background description of social systems and how they fit with current measurement approaches. Next, to emphasize the need to consider a systems approach in advancing social connection into the realm of public health, the evidence that multifactorial risk factors are both common and appropriate in public health is highlighted. The bulk of this review then places the existing literature on the association between social relationships and health into a systems framework to (*a*) better understand underlying causes and (*b*) identify gaps in our approaches to developing effective preventative and intervention efforts. In conclusion, gaps in the existing literature are presented to articulate future directions.

SOCIAL SYSTEMS

The field of psychology generally approaches scientific inquiry at the level of the individual, and the study of social relationships is no exception. This approach has garnered important insights into the factors that influence affect, cognitions, behaviors, individual differences, etc. However,

this individualistic approach represents only one of many levels that can be utilized to understand the complex ways in which social connection influences physical health.

From a systems approach, the aim is "to classify systems according to the way the parts are organized or interrelated, and . . . to describe typical patterns of behavior for the different classes of systems as defined" (Vetere 1987, pp. 18–19). Simply stated, a system is a set of interrelated or interacting elements. Thus, a systems theory approach to social relationships organizes the complex myriad of conceptualizations into a hierarchy of levels of influence. These relationships are open systems in which information, energy, and materials are exchanged between nested levels, or systems, within the environment. A systems perspective of social relationships acknowledges the following four concepts: First, each individual encompasses hierarchically organized biological and behavior systems, which are influenced by the individual's social relationships, and these systems are in place from conception. Second, each relationship has an ecological niche, which includes social and physical environmental systems. Third, each relationship's ecological niche is embedded in a larger societal and cultural system. Fourth, over time, these systems evolve and influence each other (Reis et al. 2000). Importantly, this perspective recognizes not only the influence of relationships at multiple levels (micro to macro), but also their embeddedness within each other, resulting in mutual influence.

How Does a Social Systems Approach Fit Within Current Measurement Approaches?

Social connection has been used as an umbrella term to represent the multiple ways in which individuals connect to others emotionally, behaviorally, and physically. Current measurement approaches include three broad categorizations that assess very different aspects of social relationships: structural, functional, and qualitative indicators of social connection (Holt-Lunstad et al. 2017; see **Figure 1**). Structural indicators of connection are typically quantitative in nature, assessing the number or diversity of social relationships or roles or frequency of social contact. In essence, structural measures attempt to capture the existence of relationships and their influence in one's life. Functional indicators, on the other hand, attempt to capture the actual or perceived availability of the kinds of aid and resources that relationships may provide. Thus, functional

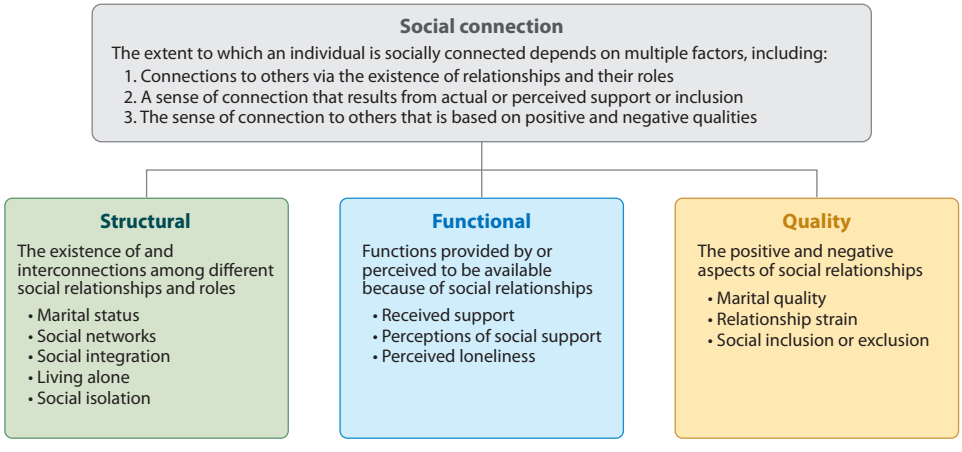

Figure 1

Social connection as a multifactorial construct including structural, functional, and quality components.

measures go beyond evaluating the presence or absence of others to assess what they may do or provide in the relationship. The bulk of the epidemiological literature has focused primarily on structural and functional measurement approaches. A growing body of evidence further indicates that the quality, or positive and negative aspects, of these relationships is also important to a complete evaluation of social connection. As argued elsewhere (see Holt-Lunstad et al. 2017), all three of these components are important to consider in assessing health and mortality risk.

Most current measurement approaches do not explicitly target one level (individual, family, community, society); however, some appear to align more with specific levels than with others. For instance, measurement of functional support, particularly perceived support or loneliness, may be viewed as an individual-level assessment given its reliance on an individual's personal perceived reality. Measures of relationship quality may fall more squarely within the realm of the relationship or family level because this quality relates to a specific relationship, whereas structural measures such as social integration or network size may align more with network- or community-level assessments. However, we can extrapolate how each may be influenced by other levels. For instance, one's individual perception may be based on expectations set in early familial experiences or societal norms, and self-reports of relationship quality and network size may be influenced by individual personality characteristics and social sensitivity. It is also important to note that most current measurement approaches do not explicitly measure across levels, which is a considerable limitation.

A major setback for advancing social connections into the broader field of public health has been the lack of consistency in measurement approaches. Given the diversity of measures of social connection, there exists a lack of clarity on what exactly the problem is in which we should intervene. For example, should we be focused on reducing loneliness, increasing social support, reducing relationship distress, or providing assistance in the home? Another setback is the fact that most large-scale research opts for a short assessment (e.g., of marital status or living arrangements) to maximize feasibility. However, binary measures have been found to be less predictive of mortality risk than more complex measures (Holt-Lunstad et al. 2010). In cases where longer, more thorough assessment is utilized, these assessments often target only one component of social relationships (e.g., perceived social support or loneliness), making it difficult to compare findings across studies. It should be noted that, despite relative differences in predictive utility, functional, structural, and quality measures have all significantly predicted risk (Holt-Lunstad et al. 2010). However, there are low correlations between these measures, indicating that they are measuring distinct constructs and that each needs to be considered. Measurement approaches that are multidimensional, such as complex social integration, may consider multiple levels given that they include structural and functional components—although quality is less represented in these approaches (Holt-Lunstad et al. 2010, Robles et al. 2014). Importantly, multidimensional approaches have been shown to be the strongest predictor of mortality risk (Holt-Lunstad et al. 2010). Thus, it is important to recognize that most current assessment approaches may not adequately capture the different levels of social influence that may affect health via different pathways. Taking a systems approach to measurement could potentially increase the predictability of risk and improve screening.

SYSTEMS APPROACH TO UNDERSTANDING RISK AND PROTECTION

In order to better understand the impact of social connection on physical health, individual-level outcomes need to be examined within the broader context that created them. As psychologists, we can take cues from population health, which utilizes a more comprehensive approach to examining health risk over the lifespan. The ecological model, already embraced by population health, is an ideal way to include the added benefits of a broader perspective without sacrificing the detail-oriented precision of a levels approach. The Institute of Medicine has defined the ecological model

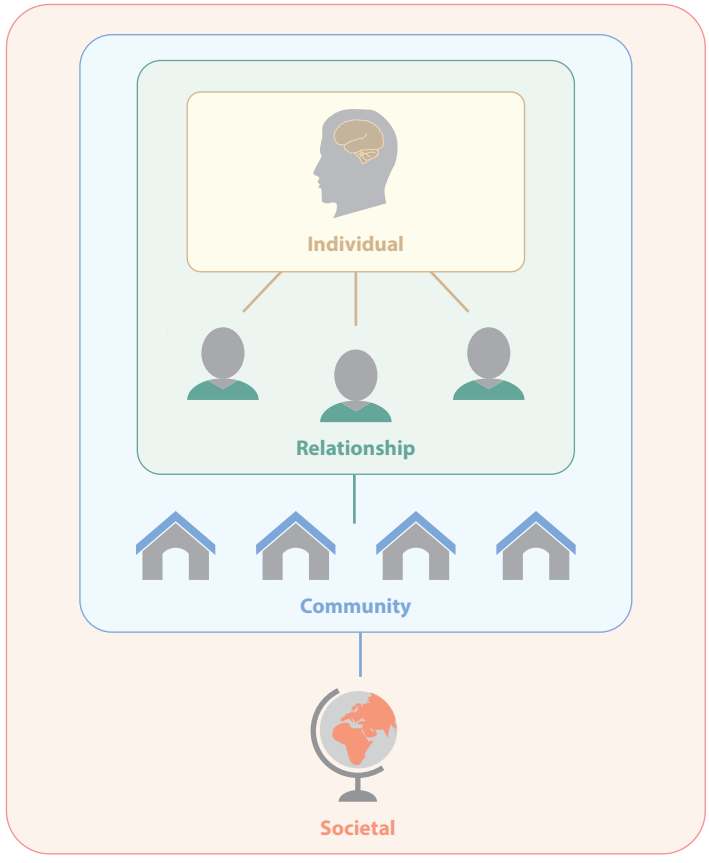

Figure 2

Social ecological model.

as "a model of health that emphasizes the linkages and relationships among multiple factors (or determinants) affecting health" (Inst. Med. 2003, p. 32). If the evidence supports elevating social connection to a public health priority, then it would serve us well to apply the existing evidence using this model to move the field forward.

In the United States, the Centers for Disease Control and Prevention (CDC) uses the social ecological model to examine the causes and potential prevention strategies of risk factors such as violence (CDC 2015). This four-level model takes into account the complex interactions between factors at the individual, relationship, community, and society levels. **Figure 2** draws upon this model, and the overlapping shapes illustrate how factors at one level are embedded within or influence factors at another level. Given the fact that social disconnection (e.g., isolation, loneliness, poor-quality relationships) is a significant risk factor for premature mortality, each of these levels could be similarly applied to examining causal factors and prevention strategies.

Social Connection as a Risk or Protective Factor

Risk factors have been defined as variables that increase the probability of an undesirable outcome (e.g., death), whereas protective factors increase the probability of a desired outcome (e.g., survival) (Kraemer et al. 1997). Social connections significantly predict health for either good or bad; thus,

they may be viewed as both a risk and a protective factor. The evidence linking social relationships to health includes clear examples of both processes (e.g., lacking companionship and relationship conflict are associated with risk, whereas social integration and social support are protective). The mortality risk from being socially disconnected, whether it be from isolation or loneliness, also appears to be linear—existing across the continuum from those who are extremely isolated to those who are moderately and mildly isolated (Tanskanen & Anttila 2016). Furthermore, combined data from four nationally representative studies found strong dose–response associations between social integration and lower risk for physiological dysregulation in both early and later life (Yang et al. 2016). Being more socially connected is protective, whereas less social connection is associated with risk.

In order to establish social connection as a risk or protective factor, it is also critical to establish temporal precedence—lacking social connection should precede poor health. Indeed, prospective studies are ideal for testing the temporal precedence. The studies included in the meta-analyses discussed above (e.g., Holt-Lunstad et al. 2010, Roelfs et al. 2011, Shor & Roelfs 2015, Shor et al. 2012a) were prospective in nature and controlled for initial health status, establishing the temporal precedence and ruling out reverse causality. Thus, we have clear and robust evidence that the degree to which one is socially connected predicts levels of risk for or protection from morbidity and mortality.

Can we claim, however, that social connection causally influences risk or protection? To establish causation, experimentation involving manipulation of the proposed causal agent is viewed as the gold standard. In humans, we cannot randomly assign individuals to be isolated or in a poor-quality relationship, resulting in difficulty claiming causal influence. However, similar challenges were faced for other public health risk factors, such as smoking, yet we are all familiar with the claim that smoking causes cancer. Indeed, causal claims in public health apply the criteria of probabilistic causation rather than that of necessary and sufficient causation (Parascandola & Weed 2001, Parascandola et al. 2006). For example, obesity increases the risk of heart disease in a probabilistic manner, but not all those who are obese will develop heart disease. Applying probabilistic causation, evidence that social isolation increases the risk of mortality in a predictive and dose-response manner bolsters claims of causal risk and protection.

Multiply Determined Risk Factors

Similar to the influence of other health risk factors (e.g., hypertension, obesity, smoking, cholesterol levels), the influence of social relationships is complex and multifactorial (Stampfer et al. 2004). What does it mean for a risk factor to be multifactorial? Simply put, it means that there is no single putative causal factor. A prime example of a multifactorial risk factor is obesity, which has been targeted as a top priority for public health interventions because it has been associated with an increased risk for type 2 diabetes, cardiovascular disease, cancer, and all-cause mortality (Flegal et al. 2013). Within this initiative, physical activity, nutrition, and obesity are interrelated constructs, each independently linked to risk and protection (Dietz & Gortmaker 2016, Lombard et al. 2009, Plotnikoff et al. 2015). Poor nutrition and lack of physical activity are both behaviors linked to obesity, but they also work in conjunction with biological predispositions and environmental factors. For example, poor nutrition is impacted by genetics and early life experience, which can both result in physiological changes that increase obesity. In addition, physiological determinants are joined by socioeconomic influences. Large portion sizes, saturated and trans fat intake, refined carbohydrate consumption, and highly available fast food are more likely within certain socioeconomic contexts, such as food deserts (Ebbeling et al. 2002). Therefore, there are multiple factors to consider, and there is no single mechanism on which to intervene.

Social connection (or lack thereof) is likewise multiply determined (see **Figure 1**). Within a systems approach, the field can further explore the extent to which individual, family, community, and societal factors within each level influence the structure, function, and quality of social connections. Because social (dis)connection is multiply determined, to address social connection within the realm of public health, modifiable risk factors and viable targets for intervention must be identified.

SYSTEMS APPROACH TO UNDERSTANDING CAUSAL MECHANISMS

In order to address the public health relevance of social connection, the field could benefit from applying a systems approach. Using the social ecological model, the following sections identify and describe potential causal pathways at the individual, family, community, and society levels that significantly influence risk or protection. The major conceptual approaches and supporting evidence are summarized for each level, and a brief description of how it is or may be influenced by other levels is provided. It is important to note that such descriptions do not represent exhaustive reviews, but rather are illustrative examples. Furthermore, level-based descriptions are merely for organization's sake and do not imply that each level is independent of other levels.

Individual-Level Factors

Within an individual, there are biological, cognitive, psychological, and personality characteristics that may increase the likelihood that one is socially connected or, conversely, isolated. Of course, even these individual factors are themselves intertwined and exert mutual influence.

Given that social connection has a strong link to survival, evidence points to the possibility that (via biological mechanisms) we are wired to desire and to be rewarded by connection and, conversely, to feel discomfort when we lack these connections. Reviews of data indicate biological indicators of social sensitivity, including genetic factors (Way & Lieberman 2010) and inflammatory processes (Eisenberger et al. 2017). For example, studies of gene association suggest that variation within genes that affect brain functioning (specifically serotonin and opioid transportation) influence the degree to which individuals are emotionally responsive to their social environment. Research has also suggested potential neurochemical mechanisms that support social bonding and affiliative behavior, such as oxytocin (Ross & Young 2009). Although this evidence is more developed within the animal model literature, evidence in humans is emerging. According to the "brain opioid theory of attachment," endogenous opioids (e.g., μ-opioids) are triggered by social experiences to mediate the reward associated with social bonding and affiliation (Loseth et al. 2014, Machin & Dunbar 2011). It is important to note that even genetic markers of social sensitivity are influenced by the larger social environment (Mitchell et al. 2013), suggesting that these biological (microlevel) processes are interacting within the larger context of macrolevel factors.

Social cognition describes the way the brain processes social information. Being able to infer the intentions, thoughts, and feelings of those around us is critical to engaging in our social world. Neuroscience evidence suggests that we may have both common and dedicated systems for social processing and that there may be evidence of self–other overlap (Beckes et al. 2013). According to the "social baseline theory," the brain expects social relationships that include interdependence, shared goals, and attention. If these expectations are not met, the brain will perceive that fewer resources are available. This results in increased physiological and cognitive effort, which can be accompanied by acute and chronic distress (Coan & Sbarra 2015). This suggests that the brain is designed to expect social relationships as the baseline, or the normal operating state. Furthermore, social insults such as rejection produce the same pattern of brain activation as physical pain, thereby

alerting the individual to damages in social connections (Eisenberger et al. 2003). These findings, when taken cumulatively, could suggest that individual differences at the cognitive level impact perception and actual experience of social interactions, connection, and disconnection.

Psychological factors including both states and disorders (e.g., stress, depression, and anxiety) can also provide important insight, as both are associated with social withdrawal and impairments (Craske & Stein 2016, Ditzen & Heinrichs 2014). Social conditions such as rejection and interpersonal stress can also increase the risk of depression, suggesting that the associations between social conditions and health are complex and may share common mechanisms (Slavich & Irwin 2014). Our relationships are also closely tied to perceptions of stress. The stress buffering effect of social support is perhaps one of the most widely researched influences of social relationships on health. Indeed, many recent reviews summarize the processes, conditions, and biological mechanisms by which this effect operates (Ditzen & Heinrichs 2014, Hostinar 2015, Hostinar & Gunnar 2015). Recent research also indicates that our social relationships can be a source of stress influencing health (Oliveira et al. 2016). Regardless of the direction, it is clear that social relationships influence health via stress processes and that early experiences, developmental factors, and differences in genetically influenced biological systems can moderate this effect (Ditzen & Heinrichs 2014, Hennessy et al. 2009, Uchino 2009).

Personality, by definition, is a set of enduring traits distinct to an individual. Certainly, such characteristics could have profound effects on the degree to which individuals engage socially and the quality of those relationships. These characteristics would include temperament and individual differences. Some psychologists argue that there are five basic personality dimensions (the so-called Big Five): extraversion, agreeableness, openness, conscientiousness, and neuroticism. When evaluating social connection from the perspective of the Big Five approach, studies have found that the traits of extraversion and neuroticism are important correlates of loneliness (Asendorpf & van Aken 2003). In addition, loneliness covaries in a linear fashion with emotional stability, surgency, agreeableness, conscientiousness, shyness, and sociability (Cacioppo et al. 2006). There is also evidence that hostile individuals find social support stressful and do not benefit from intimacy in daily life (Vella et al. 2008).

Overall, when we consider the myriad of factors at the individual level, we also need to consider their influence on structural, functional, and quality aspects of social connections. We need not limit our consideration to the measurement approaches that are perhaps most closely associated with the individual (perceptions of loneliness and perceptions of support). As an illustrative example, an individual-level personality characteristic, openness to new experience, may influence the degree to which one forms new relationships that, in turn, may influence the size and diversity of one's social network. Systematically applying each of the individual-level factors across the domains of social connection further points out areas where the field has strong evidence and areas where we have gaps in the literature.

Relationship-Level Factors

When examining factors beyond the individual level, psychologists and relationship scientists may consider dyads (e.g., romantic partner, caregiver) but often stop short of considering the larger familial context. Close relationships, such as those with a romantic partner, family members, and even close friends, may influence an array of experiences and a host of behaviors. Research in the area of close relationships (i.e., couple, caregiver, or familial relationships) is most closely tied to the relationship level. Within the close relationships literature, attachment, early childhood experiences, and social control have been the most widely used conceptual approaches. Thus, these are highlighted as illustrative examples.

Attachment. Attachment processes may be relevant to understanding how parent–child relationships and adult romantic relationships may influence health and well-being. First proposed nearly 50 years ago, attachment theory asserts that we have a biologically based, innate tendency to form bonds with an attachment figure as an adaptive means to protect us from harm and to regulate distress (Bowlby 1969). Attachment processes were originally proposed to involve infant–caregiver bonds but are now thought to continue to play an important role in maintaining relationships throughout the lifespan, with the primary attachment figure shifting to a romantic partner in adulthood (Mikulincer & Shaver 2007).

Attachment has been linked to health-relevant processes (physiology, affective states, health behavior, and health outcomes; for reviews, see Pietromonaco et al. 2013, Robles & Kane 2014). The attachment system was initially thought to primarily act on emotion regulation by reducing threat and increasing feelings of security, thereby blunting physiological reactivity (Diamond & Hicks 2004); however, additional pathways and interactions between these pathways have been noted. For example, the social-cognitive and emotion regulatory functions associated with attachment provide increased energy to the brain, in turn influencing eating behavior and health (Robles & Kane 2014). Despite the growing body of evidence linking attachment to a variety of health-relevant processes, additional data is needed linking attachment to chronic disease-related clinical endpoints (Robles & Kane 2014). Although attachment processes are clearly dyadic, attachment style can be viewed as an individual difference characteristic—again underscoring the importance of the embeddedness across social system levels.

Early childhood experiences. More recently, a growing body of research has suggested that early childhood may be a sensitive period, and experiences during this time may have long-term influences on health-relevant biology. For example, the National Child Development Study in the United Kingdom found that social isolation in children aged 7–11 predicted higher midlife rates of C-reactive protein—a reliable marker of inflammation associated with coronary heart disease (CHD), depression, and type 2 diabetes (Lacey et al. 2014). Similarly, parental separation (i.e., divorce) during childhood predicted inflammation as an adult (Lacey et al. 2013). Indeed, despite heterogeneity in measurement approaches, childhood adversity appears to have consistent effects on the risk for CHD (Appleton et al. 2016). Early childhood adversity, whether it occurs via neglect or threat, has also been shown to influence neural development (McLaughlin et al. 2014). Moreover, the growing body of work on early childhood experiences suggests the importance of considering gene–environment interactions from a developmental perspective (Lemery-Chalfant et al. 2013, Lovely et al. 2017). For example, evidence suggests that children with a particular gene variant may be more sensitive to their early childhood environment than children without that variant (Berry et al. 2014). Together, these data suggest the importance of the early social environment and the potential need for early interventions.

Social control. Close relationships, including friendships and romantic and familial relationships, can also exert tremendous influence over health-relevant behaviors and self-regulation. Any attempt to influence a relationship partner, whether it is direct (e.g., by requesting, urging, or demanding) or indirect (e.g., by motivating, inspiring, or supporting), would be defined as social control (Lewis & Rook 1999). Meta-analytic data examining social control on health behaviors and psychological responses (well-being and affect responses) indicate that social control generally improved health behaviors and psychological well-being (Craddock et al. 2015). However, social control strategy (positive or negative) was a moderator of these findings—indicating that positive social control (e.g., logic, positive reinforcement, modeling) was associated with improved health behaviors and well-being, whereas negative social control (e.g., disapproval, pressure, restriction)

was associated with decreased well-being and health behaviors (Craddock et al. 2015). Of course, these results may occur through both conscious and unconscious processes (for reviews, see Fitzsimons & Finkel 2010, Fitzsimons & vanDellen 2015) resulting from individual-, community-, and society-level factors.

Direct influence on physiology. Friendship and familial ties may also have direct influences on health-relevant physiology (Robles & Kiecolt-Glaser 2003, Uchino 2006). Of course, it is often difficult to disentangle interpersonal processes to distinguish the relationship influence from the individual's perception of the relationship (individual-level influence). Dyadic approaches and analytic strategies, which model actor and partner effects, suggest the importance of considering both relationship partners. Partner effects have been found on a variety of health-relevant physiological processes including cardiovascular, endocrine, and immune function (Robles & Kiecolt-Glaser 2003). In an innovative study examining the role of social connection on fibrinogen levels (a biomarker of inflammation and cardiovascular risk), ratings of social connection completed by a person's friends and family were more predictive than the person's own ratings of perceived connection (Kim et al. 2016). These data suggest that the relationship has objective influence that is just as, if not more, important for health risk than individual perceptions.

Many other functional, structural, and relationship quality dimensions may also be important to consider. For example, there is a burgeoning area of research on the influence of partner responsiveness on not only relationship outcomes, but also health-relevant physiology (Slatcher et al. 2015) and health behaviors (Derrick et al. 2013). There is also evidence that structural indicators of relationship status, such as marital status (Manzoli et al. 2007), as well as marital quality (Robles et al. 2014), are also strong predictors of longevity. To fully grasp the causal influence of social relationships on health, these and other relationship-level factors will need to be considered.

Community-Level Factors

Although one's social network usually encompasses close relationships with family members, it also extends to larger social contexts such as one's entire social network, neighborhood, or community. It is important to evaluate this broad perspective of social influence, as even distant connections within this social network can impact health. Christakis & Fowler (2007, 2008, 2013) conducted a series of studies examining the powerful influence of social networks. Using large-scale data sets, they were able to identify clustering of a variety of health-related outcomes of interest. For example, in one study, they examined the interconnections of relationships within the social networks of 12,067 people over the course of several decades and found that one's body mass index (BMI) was highly related to the BMIs of one's friends (Christakis & Fowler 2007). In other words, there was clustering of obesity within social networks. These data showed that a person's likelihood of becoming obese was significantly increased if they had a friend, spouse, or sibling that was obese—thus, obesity spread through social network ties. This clustering has been found among at least 15 different health-relevant behaviors (e.g., smoking, sleep, obesity, heavy drinking) and affective states (e.g., happiness, loneliness, depression) (Christakis & Fowler 2013). More specifically, these studies have found that the effect extends to three degrees of influence—i.e., to the friends of our friend's friends (Christakis & Fowler 2007, 2008, 2013). There are some health-related factors (health screening and sexual orientation), however, that do not spread via social network ties. This influence, or spread, may be due to individuals choosing to associate with others who are similar (homophily), sharing an environmental context, or being directly influenced by their contacts (induction). The three degrees of influence have also been demonstrated in a large-scale analysis

of over 40 million Twitter responses (Bliss et al. 2011), suggesting the potential impact of online social networks.

Characteristics of one's community or neighborhood environment can also favorably or adversely influence health beyond the impact of individual-level characteristics (Baum et al. 2016). Public health is increasingly recognizing the importance of the characteristics of the built environment, including walkable areas, traffic, and recreational facilities, that influence a variety of health-related outcomes (Malambo et al. 2016). For instance, older adults in high-crime neighborhoods report feeling trapped, making social participation difficult—thus, neighborhood factors may contribute to social isolation (Portacolone et al. 2017). Those in disadvantaged neighborhoods are less likely to enjoy the health advantages associated with strong social networks (Wen et al. 2005). Of course, the influences of social class on neighborhood racial and ethnic composition and neighborhood resources such as community centers may all be important factors to consider. Neighborhood characteristics have received wide attention, but characteristics of other settings should be further investigated to clarify the link between social network impact, environmental context, and health.

Community-level characteristics may also include educational, clinical and health care, and workplace settings. Importantly, these community settings are social contexts (i.e., settings where social relationships may develop or where social interaction occurs) as well as normative contexts (i.e., settings providing informal or formal rules about the appropriateness of social relationships or interactions). Educational settings can shape social experiences, attitudes, and information from childhood through early adulthood, and perhaps beyond. Although exposure to health care settings is typically infrequent, the health care setting is highly influential in setting the stage for what is considered important for health. Furthermore, workplace settings are where individuals spend a significant portion of almost every day, making this setting highly influential due to chronic exposure.

Society-Level Factors

Society-level factors help create a climate in which social connection may be encouraged or inhibited. These factors include social and cultural norms that influence health-related behaviors, such as physical activity and eating patterns (Ball et al. 2010, Templeton et al. 2016). For instance, messages that convey normative lifestyle expectations and desirability may be communicated via television, movies, books, or newspapers (Berkowitz 2004). Of course, we need to acknowledge that these social messages do not always promote healthy lifestyles (e.g., physical activity) and can also shape societal norms that may promote risky behaviors (e.g., smoking, alcohol and drug abuse).

Societal norms also influence the level of social participation viewed as acceptable or desirable. For example, there is cultural variation in norms that value independence and interdependence. Western cultures such as that of the United States place a high value on personal independence. This may be reflected in demographic trends indicating that there are more people in the United States living alone now than ever before, and fewer people are getting married and having children (Vespa et al. 2013). Among older adults in the United States, the socially desirable living arrangement is independent living. Indeed, in a nationally representative sample of adults over the age of 60, 90% indicated that they intended to stay in their current home (AARP 2012). These trends, taken together with an increasing aging population, suggest that older adults will have fewer social and familial resources to draw upon in old age (Rook 2009). Thus, societies that value independence, and communities that support it, may be doing so at the detriment of long-term health.

Of course, society-level factors may be influenced by factors at other levels. Indeed, there is evidence to suggest that genetic variation and neural activation (individual-level factors) may influence cultural differences. For example, a review of cross-national data reveals robust

correlations between variants in genes with social sensitivity alleles and the degree to which each population is characterized by individualism or collectivism (Way & Lieberman 2010). Likewise, meta-analytic data has demonstrated that cultural differences in brain activity related to social and nonsocial processing are mediated by distinct neural networks—such that individuals from Western cultures demonstrate greater activation in brain regions associated with self- and emotion regulation, whereas those from Eastern cultures, which value collectivism more highly, show greater activation in regions associated with social cognitive processing (Han & Ma 2014).

Independent, Additive, and Synergistic Effects of Component Social Factors

Most research focuses on only one component of social connection, and, thus, we have a vast literature establishing these components in a variety of populations. However, we have less data in which these different components have been measured within the same sample. By doing so, we can examine the relative influence of each component independent of the others, and perhaps more importantly, we can directly test for additive and synergistic effects of these social connection components. Although there are currently not enough of these studies to examine meta-analytically, there are a few studies that can provide preliminary insight. For instance, when researchers examined the influence of loneliness and social network size on immune response, both were significant predictors, but the poorest immune response was found among individuals who both were high in loneliness and had a small social network (i.e., were isolated) (Pressman et al. 2005); however, in another study with mortality as an outcome, no synergistic effect was found (Tanskanen & Anttila 2016). Additional studies have measured both social isolation or social network size and loneliness in the same sample; however, most only tested for independent effects and not for synergistic effects. Of course, these findings have important implications for research, risk assessment, and, ultimately, the development of effective interventions.

DEVELOPING EFFECTIVE INTERVENTIONS

In the realm of public health, it is important to determine risk for the purposes of predicting and identifying those who are most vulnerable to potential poor health, as well as the factors that can be modified to reduce that risk. Despite strong epidemiological and experimental evidence establishing a direct influence of social connection on health, the major challenge has been developing effective interventions. Early work suggested that medical patient participation in peer support groups could significantly increase survival (Spiegel et al. 1989). For instance, in the landmark study by Spiegel et al. (1989), metastatic breast cancer patients who participated in support groups in addition to receiving standard care lived twice as long as patients who only received standard care. However, attempts to replicate this study have led to debate, as subsequent interventions have been less effective (Boesen & Johansen 2008, Kissane & Li 2008).

There are now multiple reviews of the intervention literature, including evaluations of social support interventions (Hogan et al. 2002) and interventions aimed specifically at reducing loneliness (Cacioppo et al. 2015) and isolation (Franck et al. 2016, Gardiner et al. 2017) among older adults. These reviews indicate a variety of implementation strategies, including individual and group interventions and peer-led and professionally delivered interventions, as well as differing social foci (e.g., perceptions of support, network size, social skills) and presenting problems (e.g., cancer, substance abuse, loneliness). These reviews also reveal varying levels of effectiveness among existing interventions, with some being successful and some unsuccessful. Despite robust evidence of the influence of social connections on health, when we attempt to intervene to reduce risk, there is no clear indication of what works best for whom.

Examining the characteristics of the intervention studies highlights several important limitations of the existing literature that may explain why interventions fail. For example, most interventions intervene too late—when the health condition is advanced (at the tertiary level). Many do not take relationship quality into account. Some may be intervening to increase social contact or interaction or the receipt of resources without regard to more subjective aspects of social connections, such as perceived support and relationship quality. Most interventions, due to logistical constraints, are limited to acute treatments, when the time course of the influence of relationships is likely chronic. Importantly, most interventions have been at the individual level and have not utilized existing close relationships or community.

Multilevel (Systems) Approach to Prevention and Interventions

There appears to be a disconnect between implementation efforts and the science that established the importance of social connections. When taking a social ecological approach to addressing social connection (or lack thereof), we need to consider intervening upon the potential causal mechanisms across these levels and to recognize that these levels are embedded within each other and may influence each other. Examples of how interventions have been or could be applied across social system levels highlight the need for additional efforts in this area.

Potential Interventions Across Social Systems

At the individual level, intervention strategies have included those aimed at reducing perceptions of loneliness (Cacioppo et al. 2015, Masi et al. 2011). Although there are a variety of approaches, one review determined that interventions that address maladaptive thinking via cognitive behavioral therapy were associated with the greatest success (Cacioppo et al. 2015). Despite this success, it should be noted that these effects were relatively small. Furthermore, among interventions dealing with individual-level contributory factors, most have targeted cognitive and psychological factors, with few interventions specifically targeting biological or personality factors. Certainly, some factors may be more modifiable than others, but advancements in biologically based treatments suggest potential for intervention.

Prevention efforts should also be considered. We know from other behavioral and lifestyle risk factors (e.g., smoking, obesity) that individual-based interventions have not had as much success as preventative efforts and interventions aimed at the societal and population level. It is difficult and costly to design interventions that reach every individual; thus, interventions at the individual level tend to target those at highest risk (i.e., isolated older adults or chronically ill patients; see **Figure 3**). Individual-based interventions rarely capture others along the risk trajectory and miss the opportunity to prevent risk. Unfortunately, very little systematic research has been aimed at evaluating the efficacy of preventative efforts in the realm of social connection. Prevention strategies may be designed to promote attitudes, beliefs, and behaviors that ultimately prevent isolation and loneliness (Saito et al. 2012).

At the relationship or family level, prevention and intervention strategies may include parenting or family-focused prevention programs and mentoring and peer programs designed to reduce conflict, foster social skills, and promote healthy relationships. Current intervention approaches aimed at reducing social isolation have often utilized one-on-one strategies such as befriending (Mead et al. 2010) or mentoring (Dickens et al. 2011). Although these approaches may be aimed at creating relationships, the use of strangers or hired personnel may have limited impact relative to approaches that include existing relationships (e.g., friends or family). Furthermore, approaches that target couples and families may increase in efficacy when attention is paid to the quality of

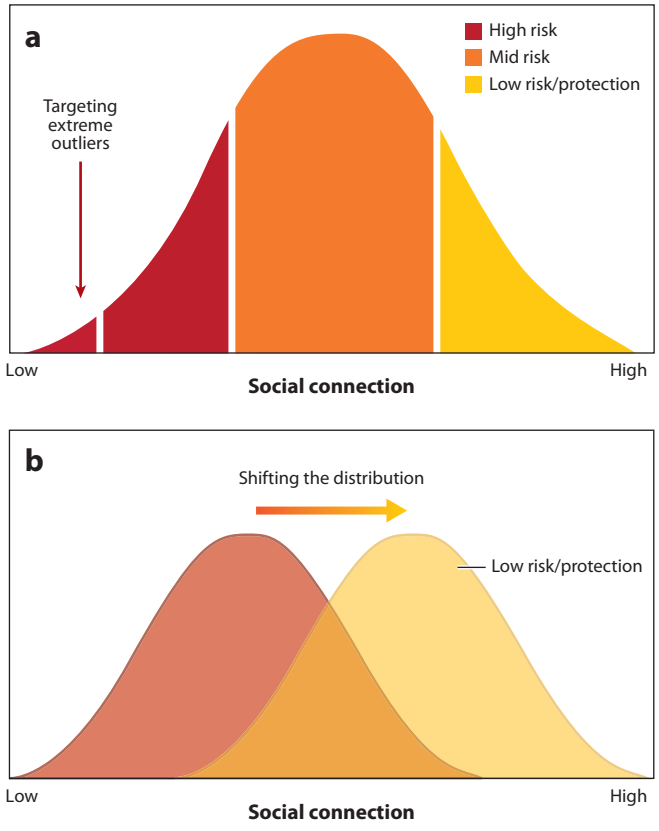

Figure 3

Conceptual representations of social connection and potential influence of prevention and intervention efforts at individual and population levels. (*a*) Individual-level interventions typically only target those on the extreme low end. (*b*) Population-based interventions may shift the distribution.

these relationships (Martire et al. 2010, Robles et al. 2014), as increasing contact with one's spouse or family may have unintended negative effects if conflict or strain is present.

At the community level, prevention and intervention strategies may be designed to influence the social and physical environments. This might include improving opportunities in neighborhoods, as well as improving the social climate, processes, and policies within school, workplace, and health care settings. One community-based intervention, the Blue Zones Project (**https://www.bluezonesproject.com/**), is based on factors identified to be characteristic among rare longevity hotspots around the world—where a disproportionate segment of the population live well into their 90s, 100s, and beyond. They identified nine factors that contribute to longer, healthier, and happier lives—three of which are social (i.e., family first, right tribe, belong). The Blue Zone Project includes multiple social components among its guiding principles of longevity in hopes of transforming several US cities into healthier and happier communities. Other community-based interventions include anti-bullying programs within schools (Lee et al. 2015) and buddy benches (**http://buddybench.org/**) to promote social inclusion. Communities are building infrastructure to make cities more walkable and safe. Hospitals and clinics can provide early assessments to refer high-risk individuals to community resources. Nonetheless, clear data demonstrating the effectiveness of these interventions in increasing both social connectedness and physical health

outcomes are still needed; in some cases, the interventions have been shown to be less effective than expected (Hatzenbuehler et al. 2017, Oishi et al. 2015), suggesting that greater refinement is needed.

At the society level, we can consider normative, structural, institutional, and policy approaches. For example, strategies may target social and cultural norms that place a higher value on independence than on connection. Normative messaging can be effectively used in mass media campaigns, as well as in subtle messaging in the mainstream media, such as television shows and movies (Schultz et al. 2007). Other large societal factors to consider include the health, economic, educational, and social policies that help to promote social equality and minimize inequalities between groups. Family-friendly policies, such as guaranteed (or paid) parental leave to encourage connection at critical periods and tax incentives for living with or near an aging parent or providing direct care, may be instituted. Governments or national and international health organizations may establish consensus reports that establish guidelines and recommendations for social activity, similar to recommendations on how much physical activity one should get per week. Regardless of the exact approach, interventions should be evidence based and subject to periodic review and revision based on emerging evidence over time. Whereas individual-level interventions target only those at highest risk, society-level interventions have the capability to shift the entire population (see **Figure 3**).

Of course, intervention approaches need not be targeted specifically at one level. A recent innovative intervention approach suggests that we can target individuals within a social network that can have profound effects at the population level. For example, in a public health (nutrition) intervention that included 5,773 individuals within 32 villages in Honduras, it was found that targeting influential individuals within a social network was associated with increased behavioral change in the social network more generally relative to targeting individuals who were randomly chosen (Kim et al. 2015). These results suggest that, by utilizing such approaches, we may be able to capitalize on the distributive properties of social networks, thereby utilizing fewer resources and more effectively intervening in the population.

As is the case with other multiply determined risk factors for mortality, some levels may be more modifiable than others. Although social norms may be difficult and slow to change, attitudes toward smoking are a prime indicator that it can be done. The CDC (2016) estimates that 15.1% of US adults currently smoke, whereas in 1965, the smoking rate was 42.4% (US Dep. Health Hum. Serv. 2014). Attitudes toward smoking have mirrored this dramatic shift; in 1966, only 40% of Americans recognized smoking as a major cause of cancer, compared to 71% in 2001 (Cummings & Proctor 2014). We can see how rates of smoking have shifted over time as normative attitudes have changed. This shift can also be illustrated using smoking rates that differ across countries, with the accompanying different cultural views of smoking. It is not difficult to see parallels in the social norms and trends that may be contributing to the increases in social isolation and loneliness seen across many nations. Could a shift in our social norms and attitudes from independence toward interdependence and connection lead to a reduction in health risks similar to the shifts seen in the case of smoking?

CONCLUSION AND FUTURE DIRECTIONS

We now have substantial evidence that social connection has a protective effect on health and longevity and, conversely, that lacking connection is linked to risk. A systems approach provides a framework to advance our understanding of the mechanisms linking social connection to health risk, develop effective strategies for reducing risk, and take into account future developments.

A systems approach can potentially provide a substantially broader impact on public health than individual-based interventions. As depicted in **Figure 3**, most individual-based interventions only target those deemed at high risk, i.e., those at the extreme end of the risk continuum. This approach

adopts the "theory of bad apples" rather than the "theory of continuous improvement" (Berwick 1989). Although these theories were originally applied to productivity in workplace settings, they can be and have been applied to improvements in public health. The "bad apples" approach seeks out precise tools to identify statistical outliers. Those at the extreme end are identified and labeled as deficient and in need of fixing to eliminate the problem. Although we should not ignore those on the extreme end of the risk continuum, exclusively focusing on this group has important limitations. First, it assumes that there is a dichotomous threshold effect of risk, meaning that below a certain threshold one is at risk, and above it one is not. However, the cumulative data do not support this (Holt-Lunstad et al. 2010). Rather, it is imperative that we recognize that there is a continuous dose-response risk trajectory (Yang et al. 2016) and that we do not focus attention and efforts entirely on one extreme end. Second, this approach may contribute to stigmatizing the lack of social connection. Stigmatization may lead to defensive responses to assessment tools (e.g., individuals denying that there is a problem) and potential exacerbation of the problem. Indeed, there is considerable social stigma associated with loneliness, such that, in one study, individuals labeled lonely were viewed as less likable, less attractive, and less preferred as a friend (Lau & Gruen 1992). In contrast, an approach of continuous improvement would promote the idea that we can all benefit from establishing and maintaining healthy social relationships. Finally, and perhaps most importantly, focusing efforts on the extreme end of the risk continuum ignores a significant portion of the population. Instead, interventions aimed at the community and society levels that reach the entire risk spectrum may result in population-level shifts—thereby effecting a greater degree of change in risk (see **Figure 3**).

Social trends in most Western cultures suggest that individuals are becoming more socially disconnected (McPherson et al. 2006, Perissinotto et al. 2012, Pew Res. Cent. 2009). Widespread use of technology (Pew Res. Cent. 2015) as a primary means of connecting socially has important implications. Future research must consider the mechanisms by which technology may influence social connection for both good and bad and how technology can be utilized as a tool to improve assessment and intervention. Whereas previous assessment attempts, particularly those that are population based, were designed with brevity in mind, we now have the capability to use big data to identify those who may be at greatest risk (Bates et al. 2014). Just as advertisers use big data to identify and advertise specific products to target customers, we can use the myriad of sensors (e.g., audio, visual, physiological responses, activity, location) already included in existing devices, both wearable and within the environment, to identify those at risk (e.g., those who do not leave the house, have not spoken with others, or are distressed), as well as to nudge individuals to make corrections. Technology is also increasingly used as an intervention tool, but a review of existing data suggests that careful attention is needed to address nuances in what will be effective for different people (Chen & Schulz 2016). Of course, technology is ever changing, and at an exponentially rapid pace; thus, we are on the verge of having the ability to make larger changes than ever before. The capabilities to assess and intervene in a multifactorial and social ecological manner are within our reach.

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