Egocentric Social Network Analysis of Cardiovascular Disease in South Asians: Preliminary evidence from urban India

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ABSTRACT

Long considered a "disease of the affluent," cardiovascular disease (CVD) and related risk factors rank among the leading causes of morbidity and mortality globally. Life expectancy is increasing worldwide, driving the CVD epidemic forward as cardio-metabolic risk escalates with age. Evidence from upper-middle and high-income countries reveals elevated risk in lower socioeconomic groups, suggesting the inverse income-risk relationship expected from the affluent disease paradigm. Indeed the majority of the current global CVD burden occurs in low to middle income countries where widespread infectious disease persists. Over time, such global health inequalities are expected to widen further. India is experiencing an unprecedented and alarming rise in CVD, exhibiting a unique and controversial pathogenesis. A changing epidemiological profile in India is occurring concurrently with a shifting demographic landscape through the breakup of traditional joint family structure and large rural to urban migration. Recent evidence from the field of social network analysis suggests the importance of social ties for chronic disease risk and incidence. Social ties may promote behavior norms or access to informational or instrumental healthcare support. Social network analysis is particularly relevant in India to assess the effect of the changing demographic conditions on the CVD epidemic. The few available studies of social support and networks in Indian communities strengthen evidence of the importance of social engagement, family structure, and network size on health. This study examines the role of social networks in the context of CVD among urban Indian adults using a cross-sectional social network pilot in conjunction with an ongoing cardio-metabolic surveillance system. Our objectives are twofold. First, we will quantify and characterize egocentric social networks in a representative adult sample of the urban community in Delhi. Second, we will analyze the patterns and extent of CVD risk within the observed social networks. To address

these objectives, we combine extensive cardio-metabolic risk profiles of participants in the CARRS (**C**entre for c**A**rdiometabolic **R**isk **R**eduction in **S**outh-Asia) Surveillance Study with comprehensive social network information captured in the pilot instrument. The analysis is based on 208 residents aged 20 years or older interviewed in urban Delhi. Preliminary analysis reveals variability in network size across several individual attributes: including gender, marital status, education, and alcohol use. The average network size of urban Asian Indians is 3.8 persons. Alcohol use is concentrated to a small proportion (17%) of respondents, and alcohol users reported significantly smaller networks than non-users. Higher education also corresponded to smaller networks, as did the male gender and married status. As expected, Indian networks consisted of primarily family ties, with female relatives named more often than males. Neighborhood relationships comprised only 5% of nominated networks on average, indicating the relevance of social space over physical space in personal networks. We will model the cardiovascular risk of respondents, using anthropometric and behavior indicators, against network measurements. Regression models will adjust for covariates that may confound the relationship. Our conclusions will set a precedent of social network structure among urban Indians and illuminate patterns of CVD risk within these social networks. This study will provide insight into the relevance of social ties on cardio-metabolic health among urban Indians and in less developed settings globally.

INTRODUCTION

India is experiencing dramatic epidemiological and demographic transitions. While infectious diseases once dominated the national health burden, non-communicable diseases have recently surpassed their levels. In 2004, the Indian age-standardized mortality rate for non-communicable diseases was 713 per 100,000 persons, compared to the communicable disease age-standardized mortality rate of only 377 per 100,000 persons [1]. Cardiovascular disease is the leading cause of mortality in India. 2030 estimates indicate CVD accounting for 35% of national mortality, compared to 22% in China and 12% in the United States [2,3]. Annual deaths attributable to CVD are expected to increase from 2.7 million to an estimated 4.0 million between 2004 and 2030 [4].

CVD complications appear greater in Indian urban and migrant populations, suggesting CVD risk correlates with India's developmental transition from rural, traditional practices towards urbanization and globalization [5,6]. Rapid changes in lifestyle may compound health complications such that traditional CVD risk factors interact with emerging risk factors particular to urban areas. Urban risk factors may include relatively rapid transitions to crowded living conditions, decreased physical activity, and consumption of novel, unhealthy diets [7]. Targeted interventions for India's growing urban societies are essential to curb the nation's alarming CVD epidemic.

In the past few decades, health scientists have exploited social network analysis, a powerful methodology modeling health determinants within the framework of social constructs, to advance understanding of health behavior and chronic disease risk. Application of social network analytics to the Framingham heart study, a multigenerational CVD surveillance system, revealed the association of social network connections with several CVD risk factors: loneliness [11];

happiness [12]; obesity [13]; tobacco use and cessation [14]; and alcohol consumption [15]. A recent review of 35 studies on social networks and CVD found that social network size, or number of social contacts, reduces CVD mortality and incidence such as including stroke, myocardial infarction, and congestive heart failure [16].

Kinship and community ties are historically valued in Indian communities. While many studies equate social support measures to social network research, only two identified studies from India have employed formal network analysis to Indian communities. Both demonstrated the importance of social engagement and network size on individual health. Family, friendship, or community ties may establish social norms of health behaviors or influence access to health-related information.

Social network analysis in the context of CVD has yet to be applied to India. To address this empirical need, this study addressed two research questions: (1) What do social networks of urban Indians look like? (2) To what extent do social ties influence individual cardio-metabolic risk? This study is the first to quantify and characterize social networks in a representative urban adult population in India and to comprehensively analyze network association to cardiovascular risk.

BACKGROUND

Social networks and health

Social network analysis analyzes health patterns within social constructs, namely the relationships (ties) between and among a set of network members (actors). An egocentric or personal social network concerns a focal actor (ego) and actors with ties to the ego (alters).

The quantity and quality of social connections are important for health. The key network attributes of network size and network heterogeneity can be predictive of health outcomes and patterns [17]. *Network size*, a measure of social integration, predicts multiple health outcomes with smaller social networks generally associated with negative health events, such as susceptibility to rhinovirus exposure [18], stroke events [19], depression scores [20], self-esteem and quality of life measurements [21], and overall mortality risk [22-25]. *Network heterogeneity* predicts psychosocial and physical health. Persons with more heterogeneous networks, in terms of number of different types of tie relationships, exhibit lower overall mortality risk [26,27], higher survival following a stroke [28], lower recurrence of cancer events [29], lower ischemic heart disease risk [27], and less susceptibility to rhinovirus exposure [18].

Social networks and cardiovascular disease

Network size and heterogeneity have been shown to independently predict cardiovascular disease. Studies using longitudinal analysis of the networks constructed from Framingham Heart Study, a US multi-generational study capturing dynamic longitudinal social ties [30], found that social network measures were associated with several CVD risk factors: loneliness [11]; happiness [12]; obesity [13]; tobacco use and cessation [14]; and alcohol consumption. Network size inversely associates with cardiovascular mortality risk [19,23,25]. Significantly, clusters of the CVD risk factors obesity [13] and smoking behavior [14] were discernable up to three degrees of separation, or the distance of three social ties, within the Framingham Study suggesting the association of CVD risk with social integration. A review of 35 social network studies found that network size benefits both CVD mortality and incidence, including stroke, myocardial infarction, and congestive heart failure [16]. In other words, network composition and structure predicts CVD risk, of both the individual and his/her social ties. These findings hold significant implications for CVD risk assessment, prevention and management.

Cardiovascular disease in India

Traditional CVD risk factors such as hyperlipidemia, tobacco use, and hypertension do not account for increased CVD mortality rates observed in South Asians compared to other ethnicities [31-33]. A growing body of evidence attributes the disparity in CVD burden to a theorized "Asian Indian Phenotype" of the metabolic syndrome (MetS) and a premature onset of MetS-associated diseases, type-2 diabetes and CVD [34,35]. The Asian Indian phenotype is primarily characterized by excess visceral adiposity, defined as intra-abdominal body fat, despite low body mass indexes (BMI) compared to other ethnic groups.

Asian Indian CVD occurs at younger ages and with higher case-fatality rates than equivalent countries, leading to increased burdens on healthcare systems and greater cumulative loss of productive years of life [4,5,36]. In India, life years lost in persons younger than 60 years is estimated to increase from 7.1 million in 2004 to 17.9 million in 2030, a projection higher than USA, Russia, and Chinese estimates combined [4]. As a result, coronary heart disease in Asian Indian populations presents particular concern as the disease manifests in younger populations.

Urban Indian context

In post-independence India, urban population growth exceeds rural growth, with upwards of 580 million persons projected to live in urban areas by 2030 [6]. The urban population in India accounts for approximately 30% of the country's population, with an annual urban population growth of 2.4% according to 2010-2015 estimates [37]. CVD incidence and complications are higher for urban and migrant Indian populations. Indian urban and migrant populations exhibit a higher percent body fat at lower body mass index (BMI) and higher waist to hip ratio (WHR) compared to other ethnic groups [35]. Insufficient physical activity and obesity prevalence are highest among urban residents, elderly persons, and higher SES [4]. Recent evidence suggests that approximately 40% of deaths in urban areas are attributable to CVD compared to only 30% in rural areas [10]. In urban Indian adult populations, prevalence estimates of coronary artery disease (CAD) have increased six-fold over the half century, with recent estimates around 8-10% [5,10]. The increased CVD risk of urban Indian populations is thought to be evidence of the country's transition from traditional, rural lifestyles to those characterized by modern urban risk factors such as physical inactivity and unhealthy diet [5,6].

METHODS

Sample

Our social network pilot was implemented as an amendment to the cardio-metabolic risk profiles of participants in the CARRS (**C**entre for c**A**rdiometabolic **R**isk **R**eduction in **S**outh-Asia) Surveillance Study. CARRS comprehensively collected sociodemographic and cardio-metabolic health data, including anthropometric evaluation. CARRS captured a representative sample (n=4,000) within the urban Delhi population using a multistage, cluster random sampling methodology derived from the WHO STEPwise methodology [38]. One female and one male above 20 years of age were recruited per household. Detailed methodology of CARRS has been published elsewhere [39]. CARRS participants identified between May – October 2011 were administered the social networks pilot instrument.

Measures

Ego demographic and health measures were taken from the CARRS questionnaire. Demographic measures include: age; gender; birthplace state, dichotomized into "Delhi" or "Other"; marital status, dichotomized into "Married" or "Not married"; employment status, dichotomized into "Employed" or "Unemployed"; and household income (rupees) per month, split into "Median or below" or "Above median" using the sample median of the 10,001-20,000 rupees/month. Health measures include: current or past alcohol use; current or past tobacco use; psychical activity; anxiety/depression; and prescribed diets, dichotomized into those on a "Special diet" of diabetic, low-fat, high-fiber, low-salt, or weight-reducing diet vs. those not on a health-oriented diet. Two composite cardio-metabolic history variables were created for ego CMD disease history and family CMD disease history. Any self-reported CMD ego-history comprised a history of any of the following diseases: Hypertension, Diabetes, Hyperlipidemia, Heart Disease, Stroke, or Kidney Disease. Any self-reported CMD family history consisted of a family member with a history of any of the following diseases: Hypertension, Heart Disease, Diabetes, or Stroke. Anthropometric measures include blood pressure, height, weight, mid-arm circumference, waist circumference, and hip circumference.

Personal networks were captured in terms of size, composition, and ego-perceived network attributes relevant to cardiovascular health: health communication, diet, shared physical activity, weight, tobacco, and alcohol use. Network size quantified the number of nominated alters. Network composition included alter gender and relationship to the ego. Shared activities relevant to CVD or CMD risk (exercise with the aim of health, completion of small task, preparing a meal, smoking, or sharing a drink) were captured within the same time frame of the previous fourteen days.

Several covariates were considered for the second research question. *Network covariates* considered were tie strength and geographic distance. Tie strength, in terms of frequency of contact, was captured within the time frame of the previous fourteen days. Geographic distance between the alter and ego was determined using the scale of same household, building, neighborhood, ward, city, or another city/village. *Ego covariates* included religion and caste.

Religion was dichotomized into “Hindu” or “Other.” Caste/Tribe was dichotomized into those identifying with a caste or tribe and those who did not.

Analysis

To address *research question one*, we summarize univariate analysis of all network variables. Bivariate analysis will be used to analyze the association between ego sociodemographic characteristics (age, gender, education, marital status) characteristics and network size and composition (percentage of the network composed of family members, friends, same-sex members, or male members). Similarly, the association between CVD-related ego health behaviors (physical activity, alcohol, tobacco use) and network size and composition.

To address the *research question two*, the anthropometric ego variables of waist circumference, BMI, and waist-to-hip ratio will be our measures of ego cardiovascular risk. Preliminary binary logistic regression analysis will be used to test the key network variables of size and health behaviors as predictors of ego cardiovascular risk. Network demographic characteristics will be tested as potential mediators of the association between network measures and ego cardiovascular outcomes. Multivariate models will incorporate network variables identified through binary regression analysis in addition to theoretical covariates. For model selection, variable inclusion will be based on inflation of the coefficient of determination (R^2), the Akaike Information Criterion (AIC), the Bayesian Information Criterion BIC), and the resultant variance inflation factors (VIFs).

Preliminary Results

Preliminary analysis indicate high variability in network size across several individual attributes, including gender, marital status, education, and alcohol use. Ego gender, marital status, education status, and alcohol use (past and current) were significantly associated with network size. Males had smaller networks (μ=3.6, SD=1.1) than females (μ=, SD=) (Table 1). Unmarried individuals had significantly larger networks: Single (μ=4.0, SD=1.2) and Widow/Widower (μ=4.4, SD=1.0) vs. Married (μ=3.7, SD=1.1). Illiterate respondents reported significantly smaller networks (μ=3.4, SD=1.2). Respondents reporting occasional alcohol use nominated significantly smaller networks (μ=2.4, SD=1.7).

Table 1: Significant bivariate associations between ego risk factors and network size

Ego Risk Factors	**Network Size (n=208) μ(SD)**	**p-value**
Male	3.6 (1.1)	0.0379**
Composite marital status		0.0125**
Married	3.5 (1.4)	
Not married	4.3 (1.0)	
Education Status		0.0257**
Professional Degree/Postgraduate	3.7 (0.9)	
Graduate	3.7 (1.0)	
Secondary School/Intermediary	3.7 (1.2)	
High School	4.2 (1.1)	
Primary School	4.7 (0.6)	
Literate with no Formal Education	4.3 (1.3)	
Illiterate	3.4 (1.2)	
Other	1.0 (N/A)°	
Ever used alcohol	3.3 (1.2)	0.0090**
Composite current alcohol use		0.0245**
Currently using alcohol	3.1 (1.4)	
Not currently using alcohol	3.8 (1.3)	

** Significant at α=0.10 ** Significant at α=0.05 ° Only one observation*

Indian networks lack heterogeneity, consisting primarily of family ties (81% of named alters). Female relatives named more often than male relatives: 42% of those named were female relatives, and 38% of named alters were male relatives. Friendship ties contributed the highest proportion of non-familial ties, with 18% of overall ties being friendship contacts. Interestingly, while the majority of alters (91%) lived in the same city as the ego, only 5% of named ties were neighbor contacts.

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