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A social network analysis of psychological morbidity in an urban slum of Bangladesh: a cross-sectional study based on a community census

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Abstract

Objectives To test whether social ties play any roles in mitigating depression and anxiety, as well as fostering mental health among young men living in a poor urban community.

Setting A cohort of all young men living in an urban slum in Dhaka, the capital of Bangladesh.

Participants All 18 to 29 years old men (N = 824) living in the low income urban community at the time of the survey.

Primary and secondary outcome measures Unspecified psychological morbidity measured by Generalized Health Questionnaire (GHQ 12).

Results The GHQ scores (mean = 9.2, SD = 4.9) suggest significant psychological morbidity among the respondents. However, each additional friend is associated with 0.063 SD lower GHQ score (95% CI -0.106 to -0.021). Between centrality measuring relative importance of the respondent within his social network is also associated with 0.103 SD lower GHQ score (95% CI -0.155 to -0.051), as are other measures of social network ties. Among other factors, married respondents and recent migrants also report better mental health status.

Conclusions Our results underscore the importance of social connection in providing buffer against stress and anxiety through psychosocial support from one's peer in a resource constraint urban setting. Our findings also suggest incorporating social network and ties in designing mental health policies and interventions.

Keywords: Mental health outcomes; social network; urban young men; regression analyses.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Our analyses take advantage of a census of young men in a resource constraint low-income urban community in Bangladesh.
- The measurement of social network is based on roster-based approach where friendship connections for all possible pairs of respondents are carefully assessed and validated.
- We take advantage of a locally adopted GHQ-12 to assess unspecified mental health outcomes along with detailed socioeconomic characteristics of our respondents.
- Our study underscores the importance of social connection within a community in determining mental health outcomes for urban young men in developing countries.
- Cross sectional data limits causal interpretations of the otherwise robust relationships and our measure of social network captures limited community ties through friendship relations only.

INTRODUCTION

Mental illness and disorders generally refer to "abnormal thoughts, perceptions, emotions, behaviour and relationships with others."[1] Mental illness contributes about 7.1 percent to global disease burden and the cost of mental disorders such as depression can be enormous.[2,3] Over lifetime, mental disorder can adversely affect one-third of the global population.[4] As of 2010, close to nine hundred million people were estimated to suffer from certain mental health issues including depression, anxiety and substance abuse.[5] The burden of mental health is also likely to increase with growing urbanization in the developing countries.[6] The poor neighborhoods and low-income communities can potentially offer more stressful environments for the urban citizens.[7] Hence, one can potentially infer a larger share of the global mental health burden will be borne by the lower income population living in challenging environments in the newly urbanized developing countries. This will further be compounded by social stigma and general misinformation associated with mental health symptoms and resulting low psychosocial care seeking in the developing countries.[8]

Social capital can be multifaceted and the definitions vary in the literature as they aim to capture the different aspects of social engagements for an individual.[9] Social capital encompasses civic engagement, trust, reciprocity and certain norms. Moreover, it can both be a structural feature of the community or a group and owned by individual to rely and exploit to command over resources to ensure his or her wellbeing.[10,11] Horizontal nature of the ties, for example, friendship network and community embeddedness are considered a defining feature of one's social capital and prior literature typically associate resulting social capital with socially desirable health outcomes.[12]

There is a growing consensus that the quality of social ties and deeper social embeddedness are important determinants of mental health.[13,14,15] Lack of social ties has been found to be a risk factor for a number of mental health indicators.[16,17,18,19] Through providing attachment and buffer, social network and ties can have both extrinsic and intrinsic values for an individual's mental or psychological wellbeing.[20,21] Prior studies have shown the positive roles social connection can play in lowering depressive episodes.[19,22] Depressive symptoms are also less likely to manifest themselves for people who are more central within the group they belong to.[3] Mental state of mind, like happiness, can also proliferate for people with social networks that are closer in terms of geographic distance.[18]

In the context of Bangladesh, social network has been found to contribute towards health service delivery in both rural and urban areas.[23,24] However, we have limited information on how social ties and network properties can determine mental health outcomes in urban Bangladesh and similar other low-income contexts. Social network has been found to have strong association with positive mental health outcomes. However, these studies have taken place mostly in the developed contries by taking advantage of large, often longitudinal, cohort studies and population level data.[3,18,19,22] We intend to contribute to the growing literature on social network as a determinant of mental health by exploiting a community level census of young men in a slum of Dhaka.

METHOD

Study Design

We follow a cross-sectional study design based on individual respondents from a census of young men living in an urban slum at the time of the survey (N = 824). Census allows us to

enumerate friendship ties along with directions between any two respondents among possible 339,076 ties. We also collect mental health outcome measures along with detailed socio-economic characteristics of the respondents.

Study Setting

We have carried out our study in a particular but otherwise typical urban community in Dhaka, namely *Vashantek*. The entire *Vashantek* slum is geographically divided into four subdivisions with a total population of around 31 thousand or about 5.5 thousand households. We choose to work in a particular subdivision and carry out a census of all men between the age of 18 and 29 years. We collect baseline information on a number of socioeconomic variables and detailed social network information for all the targeted respondents. The site and the setting meet the necessary criteria for usual social network analyses.[25]

Sample and sampling technique

We collect information for all men between the ages of 18 and 29 in our targeted site. Initially we list all the households in the study community with men who fit the age criteria. We ask each household if it has an 18-29 year old man living in the household. Then we follow up with their full names, contact information and their availability for a more detailed survey. From the household list, we select a total of 942 potential respondents. After thorough training of the data collectors and questionnaire pretesting, we send our data collectors to collect information on demographic, economic, sexual practice and friendship related information using a structured questionnaire. Some of the respondents moved out of the slum between the initial household listing and the follow up survey. We also find households with a potential respondent living outside the community but previously listed as a household member. The final cohort consists of

824 young men of 18 to 29 years of age living in our study area. We have carried out all analyses on this sample.

Measures of Mental Wellbeing

We use the 12-question version of the General Health Questionnaire (GHQ-12) to assess the mental wellbeing of individuals. It is an often-used survey based tool to measure the population morbidity of non-psychotic and minor psychiatric disorders. GHQ-12 has been implemented and validated widely in different contexts in both developed and developing countries, including Bangladesh.[26,27] Due to its precise and concise nature and validity in the context of Bangladesh, we consider this tool to be appropriate for our study to assess any non-specific psychiatric morbidity among the respondents.[28] We estimate *Cronbach's α,* and a value of 0.83 suggests high internal consistency. We further carry out exploratory factor analysis and high individual variance for each factor suggests high reliability of the score in our sample.

Social Network Analysis (SNA) Parameters

For the social network analysis, we ask each respondent to name the close friend(s) within the community and where they live (particular landmark/household identifier within the slum). After confirming the proper identification of all the close friends mentioned by the respondents, we construct a 824×824 square *sociomatrix* showing direct friendship ties with value 1 or 0.[29] We then use network analysis software *Pajek* to analyze this dataset. We estimate different social network parameters for each of our respondents such as different measures of embeddedness, and centrality of each respondent within the friendship network. These measures capture richer aspects of social network of the respondents.[20,30] For robustness check and sensitivity analyses, we use non-linear versions of some of our centrality measures, due to the overrepresentation of zeros in our sample, which indicates absence of any ties between

individuals.[19] We also estimate some additional measures of the nature of the social network at individual levels to carry out further sensitivity analyses (see Appendix).

Socioeconomic Characteristics

Given the observational nature of our study, we control for various socio-economic characteristics of the respondents. These factors can potentially confound our results and we include them all in our multivariable analyses. Some of these factors are also important and can capture community embeddedness and social support aspects of a person's life that can influence psychosocial wellbeing, such as marital status and being born in the same community. We further collect information on age of the respondent as well as his education and current occupation. We have also profiled the wealth status of the respondents' households. We have used a wealth index or *Equity Tool*, which is generally comparable across different contexts.[31] This tool has been validated for Bangladesh and consists of seven questions according to its latest update as of 2014. We have chosen the urban wealth scores and urban wealth quintile for our study.

Statistical Analyses

To assess the relationship between mental wellbeing and social ties, we run different regression models with different social network measures. We include the socioeconomic characteristics in all the regression models and separately analyze the coefficients on these additional controls. For the multivariate analyses, we use robust regression models to correct the possible violation of the standard Gauss-Markov assumptions.[32] We standardized both the mental health outcomes and also the continuous variables on the right-hand side in the regression models and estimate the beta-coefficients. We further use ordered probit analyses for some additional robustness checks (see Appendix). The outcome variable, GHQ-12 scores are discrete

in nature, hence, are prone to violate the basic normality conditions. Ordered probit models relax these assumptions. All econometric analyses are done using Stata™/MP 15.0.

Table 1: Summary Statistics

	Mean (SD)
Age, years	23.6 (3.6)
Currently Married, percent	52.2 (50.0)
Born in *Vashantek*, percent	44.2 (49.7)
Education, percent	
No formal education	83 (10.1)
Primary incomplete	290 (35.2)
Primary complete	106 (12.9)
Secondary incomplete	206 (25.0)
Secondary complete/Above	139 (16.9)
Equity Score	-0.016 (0.230)
Wealth Quintile, percent	
First	61 (7.4)
Second	325 (39.4)
Third	418 (50.7)
Fourth	16 (1.9)
Fifth	4 (0.5)
Occupations, percent	
Driver	138 (16.8)
Service Sector	125 (15.2)
Student	109 (13.2)
Business/Shop owner	100 (12.1)
Construction worker/Carpenter/Wall painter	88 (10.9)
Daily labor	58 (7.0)
Rickshaw puller/Van puller	43 (5.2)

Notes: Based on surveys of 824 respondents. Equity score is based on ownership of selected assets (namely, refrigerator, TV, almirah/wardrobe and electric fan) and household building materials. The wealth quintiles are based on equity scores with Bangladesh urban specific cutoffs. For occupations, other category is not included in the table.

FINDINGS

Socioeconomic Characteristics

We present the basic socioeconomic and demographic characteristics of the respondents in Table 1. The average age of the respondents is 23.6 with a SD of 3.6. About 44 percent of the respondents reported living in the study community since the time of their births. Interestingly, 52 percent of the respondents were married at the time of the survey. The respondent group also exhibits generally low education level as 45 percent reports having either no or less than primary level of education. The average schooling is about the same as nationally representative household surveys.[33]

According to the generalizable equity score, with a mean of -0.016 and SD of 0.230, the majority of our respondents come from second and third wealth quintiles, with very few (only 2.5 percent) from the upper two wealth quintiles. We find a considerable variation in occupations the respondents are engaged in, namely driving, service in construction sectors and running small businesses. About 13 percent of the respondents also reported being students at tertiary level educational institutions.

Mental Health Status

We present both distribution and some summary statistics for mental health status of the respondents in Figure 1. We find a considerable variation in GHQ-12 outcomes that ranged from 0 to 25. The average GHQ-12 score is about 9.2 with a SD of 4.9. We have further tested for normality using Shapiro-Wilk test and the results basically reject the null hypothesis of normality. This is natural given the discrete nature of GHQ-12 scoring and we further test the robustness of our results using an ordered probit model that take into account the discrete nature of our scoring (see Appendix).

[FIGURE 1 ABOUT HERE]

Social Network Analyses

A visual inspection of the social network suggests that the respondents can belong to one of the three broad types of components (see Figure 2): the largest component (N = 452 or 55 percent), one of the 37 smaller self-contained components of sizes between 2 to 7 friends (N = 105 or 13 percent) and 267 respondents (32 percent) who have not mentioned anybody in the community as a friend or nobody else in the community has mentioned them as a friend (see Table 2). They are completely isolated individuals within our target population with zero friendship ties within the community. On average, our sample has 1.6 ties per respondent, including the ones that report no friendship tie within the community.

Table 2: Social Network Characteristics of the Respondents

	Mean	SD
Respondents in each component, percent		
Large connected group	54.6	
Smaller groups	12.7	
Isolated with no referrals in any direction	32.4	
Number of friends, percent		
0	32.4	
1	26.3	
2	17.1	
3	11.0	
4	6.4	
5	3.9	
6 or more	2.8	
Average number of friendship ties	1.6	1.6
Average Centrality Scores		
All-closeness centrality	0.034	0.031
Betweenness centrality	0.00000662	0.000024
Eigenvector centrality	0.004	0.034

Notes: Based on 824 respondents. Each respondent reports the friendship ties within the community. The large connected group includes the biggest component where all subjects are connected with intermediate ties. Centrality measures are estimated using Pajek.

The average all-closeness centrality score is 0.034 for this network of 824 men (with a SD of 0.031, see Table 2). The average betweenness centrality score for this network of 824 men is 6.6 $\times 10^{-6}$ (with a SD of 24.0 $\times 10^{-6}$) with an overall betweenness centralization of 0.0003. We further estimate the average eigenvector centrality for the respondents, which is equal to 0.004 (with a SD of 0.034). The overall eigenvector centralization of the network is 0.0071. An average eigenvector (Bonacich power) centrality of 0.004 suggests that on average, men in this network do not hold very prestigious position with fairly low variation.

[FIGURE 2 ABOUT HERE]

Association between mental wellbeing and social networks

The results from our multivariate analyses to assess the association between mental health outcome (standardized GHQ scores) and individuals' social network parameters are presented in Table 3. All the continuous variables are standardized. In column (1) of Table 3, we find that compared to an isolated respondent with no community friendship tie, a respondent belonging to a small component has 0.098 SD lower GHQ score (95% Confidence Interval [CI] -0.327 to 0.131) and a respondent belonging to the larger component has 0.117 SD lower GHQ score (95% CI -0.274 to 0.041).

In the next model in Column (2) of Table 3, we find mental health outcomes are systematically better with higher degrees of ties or number of friends. Having an additional friend is associated with 0.063 SD lower GHQ score (95% CI -0.106 to -0.021). In the next three columns, we include different measures of centralities retaining all the controls. We find that a one SD higher all-closeness centrality of a respondent is associated with 0.053 SD lower GHQ score (95% CI -0.124 to 0.018, see Columns [3] in Table 3). We find similar results and more precise estimates for betweenness and eigenvalue centralities. Respondents with one SD higher

betweenness centrality report about 0.103 SD lower GHQ score (95% CI -0.155 to -0.051) and one SD higher eigenvalue centrality report about 0.068 SD lower SHQ score (95% CI -0.103 to -0.033) controlling for other factors.

Table 3: Multivariate Association between Mental Health Outcomes and Social Network

	(1)	(2)	(3)	(4)	(5)
Component type					
Disconnected	Base				
Small	-0.098 (-0.327 - 0.131)				
Large	-0.117 (-0.274 - 0.041)				
Number of friend(s)		-0.063*** (-0.106 - -0.021)			
All closeness centrality (standardized)			-0.053 (-0.124 - 0.018)		
Betweenness centrality (standardized)				-0.103*** (-0.155 - -0.051)	
Eigenvalue centrality (standardized)					-0.068*** (-0.103 - -0.033)
Age (years)	0.012 (-0.013 - 0.037)	0.011 (-0.014 - 0.035)	0.012 (-0.013 - 0.037)	0.011 (-0.014 - 0.035)	0.014 (-0.011 - 0.038)
Education					
No formal education	Base	Base	Base	Base	Base
Primary incomplete	-0.333** (-0.622 - -0.043)	-0.315** (-0.602 - -0.027)	-0.326** (-0.616 - -0.037)	-0.320** (-0.609 - -0.030)	-0.339** (-0.631 - -0.048)
Primary complete	-0.450*** (-0.777 - -0.124)	-0.437*** (-0.763 - -0.112)	-0.443*** (-0.771 - -0.115)	-0.447*** (-0.774 - -0.120)	-0.444*** (-0.773 - -0.115)
Secondary incomplete	-0.269* (-0.574 - 0.035)	-0.267* (-0.570 - 0.035)	-0.267* (-0.572 - 0.037)	-0.272* (-0.576 - 0.033)	-0.277* (-0.583 - 0.029)
Secondary complete or above	-0.114 (-0.452 - 0.223)	-0.105 (-0.441 - 0.230)	-0.114 (-0.452 - 0.223)	-0.125 (-0.462 - 0.211)	-0.131 (-0.470 - 0.208)
= 1 if born outside Vashantek	0.169** (0.025 - 0.312)	0.184** (0.041 - 0.328)	0.167** (0.024 - 0.311)	0.182** (0.040 - 0.325)	0.163** (0.022 - 0.305)
= 1 if currently married	-0.190** (-0.367 - -0.013)	-0.198** (-0.375 - -0.022)	-0.188** (-0.364 - -0.011)	-0.179** (-0.353 - -0.004)	-0.171* (-0.346 - 0.004)
Equity Score (standardized)	-0.030 (-0.108 - 0.048)	-0.028 (-0.106 - 0.049)	-0.030 (-0.108 - 0.048)	-0.029 (-0.107 - 0.048)	-0.031 (-0.108 - 0.047)
Occupation Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	824	824	824	824	824
R-squared	0.036	0.047	0.036	0.043	0.038

Notes: The outcome variable is the standardized GHQ score in all five specifications. The robust 95% CIs are reported in parentheses. We also control for occupations, which are not reported here. *** p<0.01, ** p<0.05, * p<0.1.

In all five specifications, we include the socio-economic characteristics of the respondents as controls or possible confounding factors. The association between mental health outcomes and other covariates are quite suggestive. We find mental health to get worse with age, about 0.012 SD higher with each additional year, however, while the point estimates are quite robust across

different models, they are not very precise. More educated respondents generally report lower GHQ score, so more educated respondents typically have better mental health outcomes. Interestingly, respondents born outside the community have better mental health outcomes. Respondents who are currently married have 0.17-0.20 SD lower GHQ scores and coefficient values are typically significant. We also find higher wealth as measured by equity score is associated with lower GHQ score or better mental health outcomes.

DISCUSSION

Our findings signify the importance of social relationship in determining mental wellbeing in resource-constrained contexts. Social ties are important components of a much broader idea of social capital and observed outcomes can be associated with both the cognitive aspect of social bonding and constructivist dimension of local social institutions.[34] Hence, our results further illuminate the importance of social determinants of health in the context of mental health, a topic that has garnered importance in both academic and policy literature in recent time.[12,17,35]

Our results show young men with better social ties and higher community embeddedness and network report better mental health. We have used a number of different measures of social network parameters at individual level that are typical of a person's connectedness within his immediate community. While this captures a particular aspect of a person's position within a broad spectrum of social capital he can accumulate over time, our estimates are mostly robust and suggest that the connection with the peer of one's community is a strong predictor of his mental health outcomes.

Additionally we should also highlight the overall high average GHQ-12 score for our sample. While clinical diagnoses of disorder require closer scrutiny and assessment by mental health

professionals, such high score suggests potentially high psychosocial morbidity associated with high level of stress, anxiety and possibly depression. Though we have focused on only one neighborhood in Dhaka, the study area is not peculiar or remarkable in any observational way suggesting wider implication and generalizability. In general, urban areas and youth population are particularly prone to isolation and can suffer from psychological distresses and psychosis.[36]

Social capital can influence the psychological wellbeing in a number of different ways and our study can only speculate the possible channels through which social ties can affect mental health for our study population.[21] A social network can help individuals to access material resources such as loans, grants or health services.[11] We have found the respondents in our sample primarily rely on family members for financial needs and community practitioners and informal care providers such as salespersons in local pharmacies for health services. This suggests, in our context, social network is contributing towards better mental health primarily through socio-emotional supports and recreational needs. However, identifying the exact nature of different channels will require further study and specific tools to measure different pathways through which social ties can alter mental health outcomes.

Given the cross-sectional nature of our study, we cannot claim causality in our findings. More specifically, it is possible that the association is primarily picking up selection bias where people with certain psychosocial traits are self-selected into the social structure typified by higher social ties and centrality.[3,18] We are also limited by using GHQ-12 to measure mental health outcomes, which is not a clinical tool. We are also capturing, while important, very specific types of social ties, namely friends within the community and a specific age group.

Obviously, our respondents can have social ties and network outside the community and also through online social media.

Despite these limitations, the findings presented here further enhance our understanding of social network determinants of mental health for a very interesting population. The post-adolescent young population is particularly important because, Bangladesh, like many low-middle income countries of the world, remains and will remain largely young for another generation or so. High youth unemployment and underemployment can put strain on men due to traditional gender expectations.[37] In this context, isolation and social disconnectedness can contribute to lower mental health luring male youth to violence, which has become a concern locally in the recent time. Thus, our findings have important implications for understanding mental health outcomes and policies addressing psychosocial health issues for young men and highlight the importance of social connection and ties in determining mental health among post-adolescent population in the context of developing countries.

Contributorship

AR1 and MS conceived the study. AR led the analysis with guidance from NRB, AR2 and MS. NRB led the social network data collection and analyses with guidance from AR1. AR2 managed the overall data collection and preliminary analyses with guidance from AR1 and MS. AR1 wrote the first draft and the final manuscript with contribution from MS. All authors have seen and approved the final version of the manuscript.

Conflicts of interests

All authors declare no conflicts of interest.

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Data sharing

All the data used in the preparation of this paper has been properly deidentified and no personal identification information was retained in the final data sets. The data used in the paper can be made available upon request and as per the policy of the journal.

Ethical approval

The Institutional Review Board at the BRAC School of Public Health, BRAC University reviewed and approved both the proposal and the data collection protocols.

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1

Figure 1: Distribution of GHQ-12 score

Notes. Based on 824 respondents. Here we report the non-standardized GHQ scores. The mean is shown as the vertical red line and the median is shown as the vertical blue line. GHQ is the aggregate of 12 questions with possible values of 0, 1, 2 and 3. The scores of all 12 questions are added to measure the composite score for a respondent.

Figure 2: Visualization of the friendship network of the 824 young men of Vashantek

Notes: Here we show the socio network graph for 824 respondents. Each node represents an individual respondent. The connector shows the friendship ties between two respondents. There are 267 respondents who are completely isolated (represented by v100 in the figure). The largest component consists of 450 respondents who are all connected with each other through intermediate ties. We also have 37 smaller components with smaller networks.

A social network analysis of psychological morbidity in an urban slum of Bangladesh: a cross-sectional study based on a community census

APPENDIX: ROBUSTNESS CHECKS

To test the validity of our statistical findings, we carry out some additional robustness checks to see whether our estimates are sensitive to the models we have determined. The results are presented in Appendix Table 1. We first restrict our models by dropping the 267 isolated respondents. It is possible that our centrality measures can pick up the outcome differences between these two groups. However, results in row (1) of Appendix Table 1 suggest this is not the case. The estimate on the sub-sample is -0.098 (95% CI -0.151 to -0.044), which is very similar to the value we found in column (4) in Table 3. The estimated coefficient on betweenness centrality is not sensitive to excluding the isolated nodes. We also find that betweenness centrality has too many zeros, hence, we define a dummy for respondents with non zero values and re-estimate the model. We find negative association between mental health outcomes of the respondents and those with non-zero betweenness centrality (-0.163, 95% CI -0.321 to -0.004, see row [2]). The results are very similar for eigenvector centrality as well (see rows [3] and [4] in Appendix Table 1). We also use a new measure of being influential within a network namely input proximity prestige index. We find that one SD higher value in this index is associated with 0.06 SD lower GHQ score (95% CI -0.124 to 0.010, see row [5]), suggesting better mental health outcomes.

As we noted earlier, GHQ scores are essentially discrete in nature and we could actually reject null hypothesis of normality distribution in GHQ scores. So we have re-estimated the models with three centrality scores using ordered probit models and relaxed the normality

assumption in the outcome variables. The results are presented in rows (6-8). We find that both the point estimates and also the second moments are generally not sensitive to the alternative regression models.

Appendix Table 1: Robustness Checks

		Coefficient	(95% CI)	N	R^2
(1)	Betweeness Centrality (standardized) excluding isolated respondents	-0.098***	(-0.151 to -0.044)	557	0.058
(2)	= 1 if Betweenness Centrality > 0	-0.163**	(-0.321 to -0.004)	824	0.038
(3)	Eigenvector Centrality (standardized) excluding isolated respondents	-0.060***	(-0.098 to -0.023)	557	0.051
(4)	= 1 if Eigenvector Centrality > 0	-0.117	(-0.257 to 0.023)	824	0.037
(5)	Input Proximity Prestige (standardized)	-0.057*	(-0.124 to 0.010)	824	0.036
Results from ordered probit models					
(6)	All closeness centrality (standardized)	-0.052	(-0.124 to 0.019)	824	
(7)	Betweenness centrality (standardized)	-0.106***	(-0.177 to -0.034)	824	
(8)	Eigenvalue centrality (standardized)	-0.064*	(-0.133 to 0.006)	824	

Note: The outcome variable is the standardized GHQ score in all specifications. In specifications (1) and (3), we drop the respondents who do not have any friendship tie. In specifications (2) and (4), we use an indicator variable for respondents with non-zero centrality values. In specifications (6-8), we use ordered probit models for the discrete standardized GHQ score as the outcome variables. In all specifications, we have retained the control variables that we include in Table 3. The robust p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

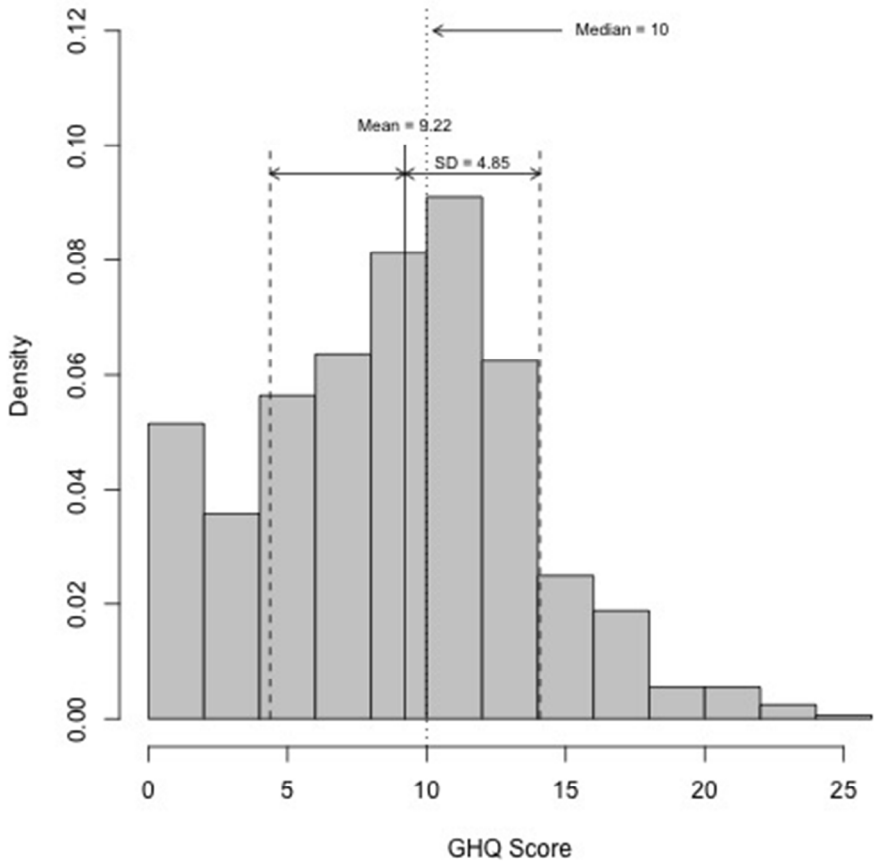

Figure 1: Distribution of GHQ-12 score

169x169mm (72 x 72 DPI)

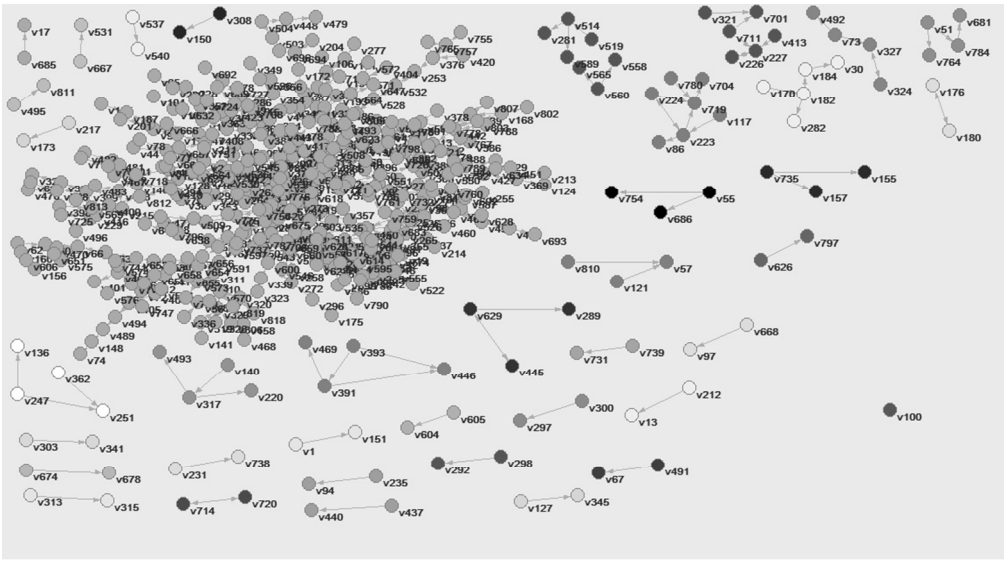

Figure 2: Visualization of the friendship network of the 824 young men of Vashantek

404x224mm (72 x 72 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-11
		(b) Indicate number of participants with missing data for each variable of interest	N/A

Outcome data	15*	Report numbers of outcome events or summary measures	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-13
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	See Appendix
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15,16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A social network analysis of psychological morbidity in an urban slum of Bangladesh: a cross-sectional study based on a community census

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Abstract – 219

Abstract

Objectives To test whether social ties play any roles in mitigating depression and anxiety, as well as fostering mental health among young men living in a poor urban community.

Setting A cohort of all young men living in an urban slum in Dhaka, the capital of Bangladesh.

Participants All 18 to 29 years old men (N = 824) living in the low income urban community at the time of the survey.

Primary and secondary outcome measures Unspecified psychological morbidity measured by Generalized Health Questionnaire (GHQ 12), where lower scores suggest better mental status.

Results The GHQ scores (mean = 9.2, SD = 4.9) suggest significant psychological morbidity among the respondents. However, each additional friend is associated with 0.063 SD lower GHQ score (95% CI -0.106 to -0.021). Between centrality measuring relative importance of the respondent within his social network is also associated with 0.103 SD lower GHQ score (95% CI -0.155 to -0.051), as are other measures of social network ties. Among other factors, married respondents and recent migrants also report better mental health status.

Conclusions Our results underscore the importance of social connection in providing buffer against stress and anxiety through psychosocial support from one's peer in a resource constraint urban setting. Our findings also suggest incorporating social network and ties in designing mental health policies and interventions.

Keywords: Mental health outcomes; social network; urban young men; regression analyses.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Our analyses take advantage of a census of young men in a resource constraint low-income urban community in Bangladesh to establish the roles social network and community ties may play in determining better mental health outcomes.
- The measurement of social network is based on roster-based approach where friendship connections for all possible pairs of respondents are carefully assessed and validated.
- We take advantage of a locally adopted GHQ-12 to assess unspecified mental health outcomes along with detailed socioeconomic characteristics of our respondents.
- Cross sectional data limits causal interpretations and cannot rule out reverse causality of otherwise robust relationships and community ties through friendship relations can capture only limited aspects of respondents' social network.

INTRODUCTION

Mental illness and disorders generally refer to "abnormal thoughts, perceptions, emotions, behaviour and relationships with others." [1] Mental illness contributes about 7.1 percent to global disease burden and the cost of mental disorders such as depression can be enormous. [2,3] Over lifetime, mental disorder can adversely affect one-third of the global population. [4] As of 2010, close to nine hundred million people were estimated to suffer from certain mental health issues including depression, anxiety and substance abuse. [5] The burden of mental health is also likely to increase with growing urbanization in the developing countries. [6,7] The poor neighborhoods and low-income communities can potentially offer more stressful environments for the urban citizens. [8] Hence, one can potentially infer a larger share of the global mental health burden will be borne by the lower income population living in challenging environments in the newly urbanized developing countries. This will further be compounded by social stigma and general misinformation associated with mental health symptoms and resulting low psychosocial care seeking in the developing countries. [9]

Social capital can be multifaceted and the definitions vary in the literature as they aim to capture the different aspects of social engagements for an individual. [10] Social capital encompasses civic engagement, trust, reciprocity and certain norms. Moreover, it can both be a structural feature of the community or a group and owned by individual to rely and exploit to command over resources to ensure his or her wellbeing. [11,12] Horizontal nature of the ties, for example, friendship network and community embeddedness are considered a defining feature of one's social capital and prior literature typically associate resulting social capital with socially desirable health outcomes. [13]

There is a growing consensus that the quality of social ties and deeper social embeddedness are important determinants of mental health. [14,15,16] Lack of social ties has been found to be a risk factor for a number of mental health indicators. [17,18,19,20] Through providing attachment and buffer, social network and ties can have both extrinsic and intrinsic values for an individual's mental or psychological wellbeing. [21] Prior studies have shown the positive roles social connection can play in lowering depressive episodes. [20,22] Depressive symptoms are also less likely to manifest themselves for people who are more central within the group they belong to. [23] Mental state of mind, like happiness, can also proliferate for people with social networks that are closer in terms of geographic distance. [19]

In the context of Bangladesh, social network has been found to contribute towards health service delivery in both rural and urban areas. [24,25] However, we have limited information on how social ties and network properties can determine mental health outcomes in urban Bangladesh and similar other low-income contexts. Social network has been found to have strong association with positive mental health outcomes. However, these studies have taken place mostly in the developed contries by taking advantage of large, often longitudinal, cohort studies and population level data. [19,20,22,23] We intend to contribute to the growing literature on social network as a determinant of mental health by exploiting a community level census of young men in a slum of Dhaka.

METHOD

Study Design

We follow a cross-sectional study design based on individual respondents from a census of young men living in an urban slum at the time of the survey (N = 824). Census allows us to

enumerate friendship ties along with directions between any two respondents among possible 339,076 ties. We also collect mental health outcome measures along with detailed socio-economic characteristics of the respondents.

Study Setting

We have carried out our study in a particular but otherwise typical urban community in Dhaka, namely *Vashantek*. The entire *Vashantek* slum is geographically divided into four subdivisions with a total population of around 31 thousand or about 5.5 thousand households. We choose to work in a particular subdivision and carry out a census of all men between the age of 18 and 29 years. The study is part of a larger project, which focuses on gender norms, risky sexual behavior and mental health within this particular population. These topics have often focused on adolescent or female population. Hence, we chose post-adolescent young men in low-income urban community as study population to provide some novel and unique perspectives to the relevant literature. We collect baseline information on a number of socioeconomic variables and detailed social network information for all the targeted respondents. The site and the setting meet the necessary criteria for usual social network analyses. [26]

Sample and sampling technique

We collect information for all men between the ages of 18 and 29 in our targeted site. Initially we list all the households in the study community with men who fit the age criteria. We ask each household if it has an 18-29 year old man living in the household. Then we follow up with their full names, contact information and their availability for a more detailed survey. We find a total of 942 potential respondents from 790 households through this initial listing process. After thorough training of the data collectors and questionnaire pretesting, we send nine data collectors to carry out the surveys. All enumerators were experienced data collectors and also

had experience in mobile based the quantitative survey through Survey CTO. The enumerators carry out the interviews over 26 days during the month of December 2016.

We collect information on demographic, economic, sexual practice and friendship related information using a structured questionnaire. Some of the respondents moved out of the slum between the initial household listing and the follow up survey. We also find households with a potential respondent living outside the community but previously listed as a household member. We also exclude individuals who have communication impairments and not agreeing to provide written consents. The final cohort consists of 824 young men of 18 to 29 years of age living in our study area. We have carried out all analyses on this sample.

Patient and Public Involvement statement

No patients were involved in designing the study or developing the research questions, nor they were involved in analyzing or interpreting the findings. The study is based on a community based sample of individuals who meet the pre-specific criteria. We have plans to discuss some of general implications of the study findings through workshops as well as through a series of radio shows aiming to address mental health problems affecting young men in Dhaka.

Measures of Mental Wellbeing

We use the 12-question version of the General Health Questionnaire (GHQ-12) to assess the mental wellbeing of individuals where a higher score generally suggests a worse mental health outcome. It is an often-used survey based tool to measure the population morbidity of non-psychotic and minor psychiatric disorders. GHQ-12 has been implemented and validated widely in different contexts in both developed and developing countries, including Bangladesh. [27,28] Due to its precise and concise nature and validity in the context of Bangladesh, we consider this tool to be appropriate for our study to assess any non-specific psychiatric morbidity among the

respondents. [29] We estimate *Cronbach's α,* and a value of 0.83 suggests high internal consistency. We further carry out exploratory factor analysis and high individual variance for each factor suggests high reliability of the score in our sample. The detailed item-wise responses are reported in Appendix A.

Social Network Analysis (SNA) Parameters

For the social network analysis, we ask each respondent to name the close friend(s) within the community and where they live (particular landmark/household identifier within the slum). After confirming the proper identification of all the close friends mentioned by the respondents, we construct a 824×824 square *sociomatrix* showing direct friendship ties with value 1 or 0. [30] We then use network analysis software *Pajek* to analyze this dataset. We estimate different social network parameters for each of our respondents measuring embeddedness, and centrality of each respondent within the friendship network. These measures capture richer aspects of social network of the respondents (for definitions of the different social network parameters, see Appendix B). [31,32] For robustness check and sensitivity analyses, we use non-linear versions of some of our centrality measures, due to the overrepresentation of zeros in our sample, which indicates absence of any ties between individuals. [20] We also estimate some additional measures of the nature of the social network at individual levels to carry out further sensitivity analyses (see Appendix C).

Socioeconomic Characteristics

Given the observational nature of our study, we control for various socio-economic characteristics of the respondents. These factors can potentially confound our results and we include them all in our multivariable analyses. Some of these factors are also important and can capture community embeddedness and social support aspects of a person's life that can influence

psychosocial wellbeing, such as marital status and being born in the same community. We further collect information on age of the respondent as well as his education and current occupation. We have also profiled the wealth status of the respondents' households. We have used a wealth index or *Equity Tool*, which is generally comparable across different contexts. [33] This tool has been validated for Bangladesh and consists of seven questions according to its latest update as of 2014. We have chosen the urban wealth scores and urban wealth quintile for our study.

Statistical Analyses

To assess the relationship between mental wellbeing and social ties, we run different regression models with different social network measures. We include the socioeconomic characteristics in all the regression models and separately analyze the coefficients on these additional controls. For the multivariable analyses, we use robust regression models to correct the possible violation of the standard Gauss-Markov assumptions (see Appendix D. [34] We standardized both the mental health outcomes and also the continuous variables on the right-hand side in the regression models and estimate the beta-coefficients. We further use ordered probit analyses for some additional robustness checks (see Appendix C). The outcome variable, GHQ-12 scores are discrete in nature, hence, are prone to violate the basic normality conditions. Ordered probit models relax these assumptions (see Appendixes C and D). All econometric analyses are done using Stata™/MP 15.0.

Table 1: Summary Statistics

	Mean (SD)
Age, years	23.6 (3.6)
Currently Married, percent	52.2 (50.0)
Born in *Vashantek*, percent	44.2 (49.7)
Education, percent	
No formal education	83 (10.1)
Primary incomplete	290 (35.2)
Primary complete	106 (12.9)
Secondary incomplete	206 (25.0)
Secondary complete/Above	139 (16.9)
Equity Score	-0.016 (0.230)
Wealth Quintile, percent	
First	61 (7.4)
Second	325 (39.4)
Third	418 (50.7)
Fourth	16 (1.9)
Fifth	4 (0.5)
Occupations, percent	
Driver	138 (16.8)
Service Sector	125 (15.2)
Student	109 (13.2)
Business/Shop owner	100 (12.1)
Construction worker/Carpenter/Wall painter	88 (10.9)
Daily labor	58 (7.0)
Rickshaw puller/Van puller	43 (5.2)

Notes: Based on surveys of 824 respondents. Equity score is based on ownership of selected assets (namely, refrigerator, TV, almirah/wardrobe and electric fan) and household building materials. The wealth quintiles are based on equity scores with Bangladesh urban specific cutoffs. For occupations, other category is not included in the table.

FINDINGS

Socioeconomic Characteristics

We present the basic socioeconomic and demographic characteristics of the respondents in Table 1. The average age of the respondents is 24 with a SD of 3.6 About 44 percent of the

respondents reported living in the study community since the time of their births. Interestingly, 52 percent of the respondents were married at the time of the survey. The respondent group also exhibits generally low education level as 45 percent reports having either no or less than primary level of education. The average schooling is about the same as nationally representative household surveys. [35]

According to the generalizable equity score, with a mean of -0.016 and SD of 0.230, the majority of our respondents come from second and third wealth quintiles, with very few (only 2.5 percent) from the upper two wealth quintiles. We find a considerable variation in occupations the respondents are engaged in, namely driving, service in construction sectors and running small businesses. About 13 percent of the respondents also reported being students at tertiary level educational institutions.

Mental Health Status

We present both distribution and some summary statistics for mental health status of the respondents in Figure 1. We find a considerable variation in GHQ-12 outcomes that ranged from 0 to 25. The average GHQ-12 score is about 9.2 with a SD of 4.9. We have further tested for normality using Shapiro-Wilk test and the results basically reject the null hypothesis of normality. This is natural given the discrete nature of GHQ-12 scoring and we further test the robustness of our results using an ordered probit model that take into account the discrete nature of our scoring (see Appendix C).

[FIGURE 1 ABOUT HERE]

Social Network Analyses

A visual inspection of the social network suggests that the respondents can belong to one of the three broad types of components (see Figure 2): the largest component (N = 452 or 55 percent), one of the 37 smaller self-contained components of sizes between 2 to 7 friends (N = 105 or 13 percent) and 267 respondents (32 percent) who have not mentioned anybody in the community as a friend or nobody else in the community has mentioned them as a friend (see Table 2). They are completely isolated individuals within our target population with zero friendship ties within the community. On average, our sample has 1.6 ties per respondent, including the ones that report no friendship tie within the community.

Table 2: Social Network Characteristics of the Respondents

	Mean	SD
Respondents in each component, percent		
Large connected group	54.6	
Smaller groups	12.7	
Isolated with no referrals in any direction	32.4	
Number of friends, percent		
0	32.4	
1	26.3	
2	17.1	
3	11.0	
4	6.4	
5	3.9	
6 or more	2.8	
Average number of friendship ties	1.6	1.6
Average Centrality Scores		
All-closeness centrality	0.034	0.031
Betweenness centrality	0.00000662	0.000024
Eigenvector centrality	0.004	0.034

Notes: Based on 824 respondents. Each respondent reports the friendship ties within the community. The large connected group includes the biggest component where all subjects are connected with intermediate ties. Centrality measures are estimated using Pajek.

The average all-closeness centrality score is 0.034 for this network of 824 men (with a SD of 0.031, see Table 2). The average betweenness centrality score for this network of 824 men is 6.6

$\times 10^{-6}$ (with a SD of 24.0 $\times 10^{-6}$) with an overall betweenness centralization of 0.0003. We further estimate the average eigenvector centrality for the respondents, which is equal to 0.004 (with a SD of 0.034). The overall eigenvector centralization of the network is 0.0071. An average eigenvector (Bonacich power) centrality of 0.004 suggests that on average, men in this network do not hold very prestigious position with fairly low variation.

[FIGURE 2 ABOUT HERE]

Association between mental wellbeing and social networks

The results from our multivariable regression analyses to assess the association between mental health outcome (standardized GHQ scores) and individuals' social network parameters are presented in Table 3. All the continuous variables are standardized. In column (1) of Table 3, we find that compared to an isolated respondent with no community friendship tie, a respondent belonging to a small component has 0.098 SD lower GHQ score (95% Confidence Interval [CI] -0.327 to 0.131) and a respondent belonging to the larger component has 0.117 SD lower GHQ score (95% CI -0.274 to 0.041).

In the next model in Column (2) of Table 3, we find mental health outcomes are systematically better with higher degrees of ties or number of friends. Having an additional friend is associated with 0.063 SD lower GHQ score (95% CI -0.106 to -0.021). In the next three columns, we include different measures of centralities retaining all the controls. We find that a one SD higher all-closeness centrality of a respondent is associated with 0.053 SD lower GHQ score (95% CI -0.124 to 0.018, see Columns [3] in Table 3). We find similar results and more precise estimates for betweenness and eigenvalue centralities. Respondents with one SD higher betweenness centrality report about 0.103 SD lower GHQ score (95% CI -0.155 to -0.051) and

one SD higher eigenvalue centrality report about 0.068 SD lower SHQ score (95% CI -0.103 to -0.033) controlling for other factors.

Table 3: Multivariable Association between Mental Health Outcomes and Social Network

	(1)	(2)	(3)	(4)	(5)
Component type					
Disconnected	Base				
Small	-0.098 (-0.327 to 0.131)				
Large	-0.117 (-0.274 to 0.041)				
Number of friend(s)		-0.063*** (-0.106 to -0.021)			
All closeness centrality (standardized)			-0.053 (-0.124 to 0.018)		
Betweenness centrality (standardized)				-0.103*** (-0.155 to -0.051)	
Eigenvalue centrality (standardized)					-0.068*** (-0.103 to -0.033)
Age (years)	0.012 (-0.013 to 0.037)	0.011 (-0.014 to 0.035)	0.012 (-0.013 to 0.037)	0.011 (-0.014 to 0.035)	0.014 (-0.011 to 0.038)
Education					
No formal education	Base	Base	Base	Base	Base
Primary incomplete	-0.333** (-0.622 to -0.043)	-0.315** (-0.602 to -0.027)	-0.326** (-0.616 to -0.037)	-0.320** (-0.609 to -0.030)	-0.339** (-0.631 to -0.048)
Primary complete	-0.450*** (-0.777 to -0.124)	-0.437*** (-0.763 to -0.112)	-0.443*** (-0.771 to -0.115)	-0.447*** (-0.774 to -0.120)	-0.444*** (-0.773 to -0.115)
Secondary incomplete	-0.269* (-0.574 to 0.035)	-0.267* (-0.570 to 0.035)	-0.267* (-0.572 to 0.037)	-0.272* (-0.576 to 0.033)	-0.277* (-0.583 to 0.029)
Secondary complete or above	-0.114 (-0.452 to 0.223)	-0.105 (-0.441 to 0.230)	-0.114 (-0.452 to 0.223)	-0.125 (-0.462 to 0.211)	-0.131 (-0.470 to 0.208)
= 1 if born at Vashantek	-0.169** (-0.312 to -0.025)	-0.184** (-0.328 to -0.041)	-0.167** (-0.311 to -0.024)	-0.182** (-0.325 to - 0.040)	-0.163** (-0.305 to -0.022)
= 1 if currently married	-0.190** (-0.367 to -0.013)	-0.198** (-0.375 to -0.022)	-0.188** (-0.364 to -0.011)	-0.179** (-0.353 to -0.004)	-0.171* (-0.346 to 0.004)
Equity Score (standardized)	-0.030 (-0.108 to 0.048)	-0.028 (-0.106 to 0.049)	-0.030 (-0.108 to 0.048)	-0.029 (-0.107 to 0.048)	-0.031 (-0.108 to 0.047)
Occupation Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	824	824	824	824	824
R-squared	0.036	0.047	0.036	0.043	0.038

Notes: The outcome variable is the standardized GHQ score in all five specifications. A higher GHQ score suggests worse mental health outcomes. The robust 95% CIs are reported in parentheses. We also control for occupations, which are not reported here. *** p<0.01, ** p<0.05, * p<0.1.

In all five specifications, we include the socio-economic characteristics of the respondents as controls or possible confounding factors. The association between mental health outcomes and other covariates are quite suggestive. We find mental health to get worse with age, about 0.012 SD higher with each additional year, however, while the point estimates are quite robust across

different models, they are not very precise. More educated respondents generally report lower GHQ score, so more educated respondents typically have better mental health outcomes. Interestingly, respondents born inside the community have better mental health outcomes. Respondents who are currently married have 0.17-0.20 SD lower GHQ scores and coefficient values are typically significant. We also find higher wealth as measured by equity score is associated with lower GHQ score or better mental health outcomes.

DISCUSSION

Our findings signify the importance of social relationship in determining mental wellbeing in resource-constrained contexts. Social ties are important components of a much broader idea of social capital and observed outcomes can be associated with both the cognitive aspect of social bonding and constructivist dimension of local social institutions. [20] Hence, our results further illuminate the importance of social determinants of health in the context of mental health, a topic that has garnered importance in both academic and policy literature in recent time. [13,18,36]

Our results show young men with better social ties and higher community embeddedness and network report better mental health. We have used a number of different measures of social network parameters at individual level that are typical of a person's connectedness within his immediate community. While this captures a particular aspect of a person's position within a broad spectrum of social capital he can accumulate over time, our estimates are mostly robust and suggest that the connection with the peer of one's community is a strong predictor of his mental health outcomes.

Additionally we should also highlight the overall high average GHQ-12 score for our sample from a general population. For example, in the context of Bangladesh, previously researchers

have found GHQ-12 score of 20 with a SD of 3 among the diagnosed mental patients. [27] While clinical diagnoses of disorder require closer scrutiny and assessment by mental health professionals, such high score suggests potentially high psychosocial morbidity associated with high level of stress, anxiety and possibly depression. Though we have focused on only one neighborhood in Dhaka, the study area is not peculiar or remarkable in any observational way suggesting wider implication and generalizability. In general, urban areas and youth population are particularly prone to isolation and can suffer from psychological distresses and psychosis. [36]

Social capital can influence the psychological wellbeing in a number of different ways and our study can only speculate the possible channels through which social ties can affect mental health for our study population. [21] A social network can help individuals to access material resources such as loans, grants or health services. [12] We have found the respondents in our sample primarily rely on family members for financial needs and community practitioners and informal care providers such as salespersons in local pharmacies for health services. This suggests, in our context, social network is contributing towards better mental health primarily through socio-emotional supports and recreational needs. However, identifying the exact nature of different channels will require further study and specific tools to measure different pathways through which social ties can alter mental health outcomes.

Given the cross-sectional nature of our study, we cannot claim causality in our findings. More specifically, it is possible that the association is primarily picking up selection bias where people with certain psychosocial traits are self-selected into the social structure typified by higher social ties and centrality, resulting in reverse causality that we cannot completely rule out given the observational nature of the study. However, we include a set of socio-economic factors

that might have back-door influences on the mental health outcomes and we block those influences by controlling them in all our empirical models. [37]

We are also limited by using GHQ-12 to measure mental health outcomes, which is not a clinical tool and captures uni-dimensional unspecified psychological morbidity. [29] Hence, this scale will only measure the true mental health status with some measurement errors. This will limit total variation we will be able explain with our empirical models. We are also capturing, while important, very specific types of social ties, namely friends within the community and a specific age group. Obviously, our respondents can have social ties and network outside the community and also through online social media. Such measurement errors will lead to downward bias and smaller coefficients (in absolute terms), as one can observe in all our models. So our estimates can be considered as lower bounds for the true effects of social ties on mental well being of the respondents.

Despite these limitations, the findings presented here further enhance our understanding of social network determinants of mental health for a very interesting population. The post-adolescent young population is particularly important because, Bangladesh, like many low-middle income countries of the world, remains and will remain largely young for another generation or so. High youth unemployment and underemployment can put strain on men due to traditional gender expectations. [38] In this context, isolation and social disconnectedness can contribute to lower mental health luring male youth to violence, which has become a concern locally in the recent time. Thus, our findings have important implications for understanding mental health outcomes and policies addressing psychosocial health issues for young men and highlight the importance of social connection and ties in determining mental health among post-adolescent population in the context of developing countries.

Contributorship

AR1 and MS conceived the study. AR led the analysis with guidance from NRB, AR2 and MS. NRB led the social network data collection and analyses with guidance from AR1. AR2 managed the overall data collection and preliminary analyses with guidance from AR1 and MS. AR1 wrote the first draft and the final manuscript with contribution from MS. All authors have seen and approved the final version of the manuscript.

Conflicts of interests

All authors declare no conflicts of interest.

Role of funding source

The study was funded by WOTRO Science for Global Development of Netherlands Organization for Scientific Research (NWO) under grant number W 08,560.007. Funding source did not play any role in designing of the study or collecting, analyzing or interpreting the data or preparing this manuscript and deciding to submit the paper for publication.

Data sharing

All the data used in the preparation of this paper has been properly deidentified and no personal identification information was retained in the final data sets. The data used in the paper can be made available upon request and as per the policy of the journal.

Ethical approval

The Institutional Review Board at the BRAC School of Public Health, BRAC University reviewed and approved both the proposal and the data collection protocols. All the participants provided written informed consent prior to the survey. Data collectors at first explained the research objective and the confidentiality that would be maintained after gathering the

information from the young men. Moreover, entirely voluntary nature of the participation in the survey was carefully explained and the participant could withdraw himself at any point of the survey even after signing the consent form. One copy of the written consent form was given to the participant and another copy was retained for the official record.

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1

Figure 1: Distribution of GHQ-12 scores

Notes. Based on 824 respondents. Here we report the non-standardized GHQ scores. The mean is shown as the vertical red line and the median is shown as the vertical blue line. GHQ is the aggregate of 12 questions with possible values of 0, 1, 2 and 3. The scores of all 12 questions are added to measure the composite score for a respondent.

Figure 2: Visualization of the friendship network of the 824 young men of Vashantek

Notes: Here we show the socio network graph for 824 respondents. Each node represents an individual respondent. The connector shows the friendship ties between two respondents. There are 267 respondents who are completely isolated (not included in the figure). The largest component consists of 450 respondents who are all connected with each other through intermediate ties. We also have 37 smaller components with smaller networks.

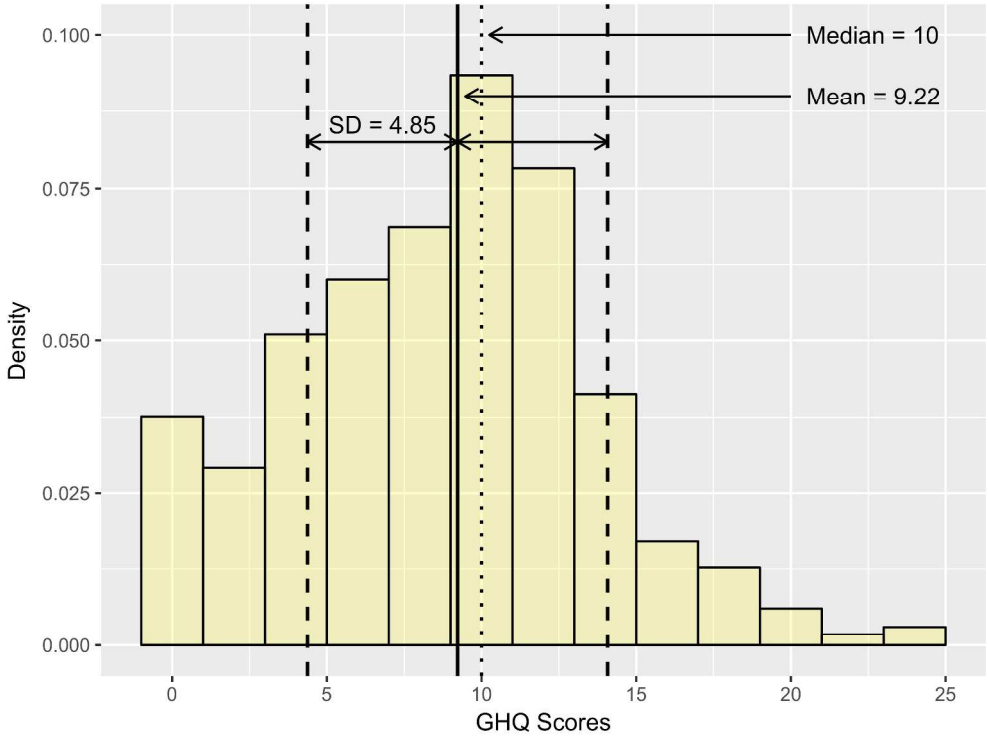

Figure 1: Distribution of GHQ-12 scores

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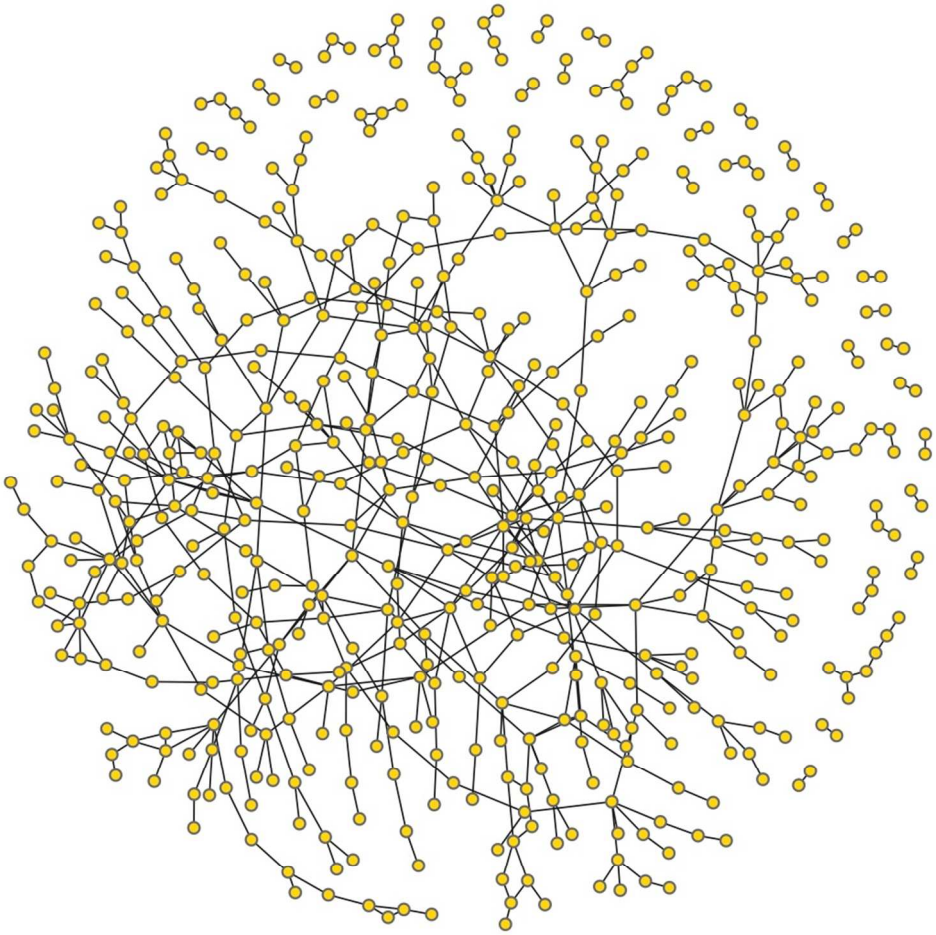


Figure 2: Visualization of the friendship network of the 824 young men of Vashantek

A social network analysis of psychological morbidity in an urban slum of Bangladesh: a cross-sectional study based on a community census

APPENDIX A: DETAILED ITEM ANALYSES OF GHQ-12

Here we present the detailed item-wise report from the Generalized Health Questionnaire we have implemented among our respondents (see Appendix Table 1). We have used a version of the GHQ-12 that has been previously translated and adopted in Bangladeshi context (Hossain, Siddique and Habib 2017, Islam and Iqbal 2008).

Appendix Table 1: GHQ-12 Responses by Each Item

	Reponses (fraction of total)				Mean	95% CI	
	Never	Sometimes	Often	Always			
	0	1	2	3			
Have you recently been able to; concentrate on what you are doing?	0.347	0.489	0.157	0.007	0.824	0.776	0.872
Have you recently lost much sleep over worry?	0.417	0.485	0.085	0.012	0.692	0.646	0.738
Have you recently felt you were playing important part in things?	0.369	0.468	0.159	0.004	0.797	0.749	0.846
Have you recently felt capable of making decisions about things?	0.214	0.567	0.211	0.008	1.015	0.968	1.061
Have you recently felt consistently under strain?	0.280	0.511	0.184	0.024	0.953	0.901	1.004
Have you recently felt you couldn't overcome your difficulties?	0.227	0.552	0.205	0.016	1.010	0.962	1.058
Have you recently been able to enjoy your normal day to day activity?	0.291	0.522	0.180	0.007	0.903	0.855	0.951
Have you recently been able to face up to your problems?	0.209	0.542	0.242	0.007	1.047	1.000	1.095
Have you recently been unhappy and depressed?	0.471	0.453	0.069	0.007	0.613	0.569	0.657
Have you recently been losing confidence in yourself?	0.715	0.221	0.028	0.036	0.386	0.337	0.435
Have you recently been thinking of yourself as a worthless person?	0.733	0.237	0.017	0.013	0.311	0.271	0.350
Have you recently been feeling reasonably happy, all things considered?	0.451	0.437	0.097	0.015	0.675	0.626	0.723
Overall GHQ-12					9.225	8.893	9.556

There are two suggested methods of scoring for GHQ-12. We have used the 'four point response scale' or Likert method, which should allow more variation in the scores (see Hankins 2008). GHQ-12 typically captures the unidimensional nature of unspecified psychological morbidity and commonly used in survey based instruments to measure the mental wellbeing in different populations.

APPENDIX B: CENTRALITY MEASURES

While intuitive, just focusing on the number of friendship ties can mask the deeper structure of social power or popularity within a network. We focus on a number of more sophisticated measures of centrality which gauge one's position in the entire network by analyzing not just the number of people they are connected to but also the type of people they are connected to and reveals to what extent that person is central/peripheral in his social network by analyzing their network positions (Freeman 1978). While 'node degree' shows the extent of connectedness, centrality shows how well and centrally each node is connected and we focus on a number of them.

Degree Centrality

Degree centrality is simply the number of degrees each person has. In-degree centrality is the number of referrals each person gets, out-degree centrality is the number of referrals each person gives and all-degree centrality is the number of total referrals (summing both the referrals he gives and the ones he gets). Hence, degree centrality is just the number of friendship ties each respondent has normalized by the possible total number of ties ($N - 1$).

Closeness Centrality

Closeness centrality is the inverse of the average distance within a network. It measures how distant a node is from the rest of the nodes and how many times it has to be crossed by other

nodes to reach some other node using the shortest path. Applying this in the context of our friendship network, we can measure how many stages a person requires to get connected to another random person or node in the network.

$$\text{Closeness Centrality}_i = \frac{n-1}{\sum_{j \neq i} l(i,j)}$$

where, $l(i,j)$ denotes the number of links node i needs to reach to node j using the shortest path. Input closeness centrality and output closeness centrality take into account of the direction of referral while all closeness centrality does not.

Betweenness Centrality

Betweenness centrality is a measure of centrality based on how well situated a person is in terms of the paths he lies on (see Freeman 1978, Jackson 2010). This takes into account the number of shortest links connecting each node to all other nodes that pass through a particular node.

Let $P_i(j,k)$ denote the number of shortest paths between any two nodes j and k that pass through node i and, let $P(j,k)$ represent the number of shortest paths between these two nodes . Then,

$$\text{Betweenness Centrality}_i = \sum_{k \neq j,k,j} \frac{P_i(k,j)/P(k,j)}{(n-1)(n-2)/2}$$

where, n is total number of nodes. So in short, betweenness centrality of a node is equal to the number of geodesics passed through that particular node divided by the number of all the geodesics of any two other nodes.

Eigenvector Centrality

Eigenvector centrality measures a person's centrality based on the centrality of his direct connections. Letting $C^e(g)$ denote the eigenvector centrality associated with a network g, then the centrality of a node is proportional to the sum of the centrality of its neighbors. So, eigenvector centrality, $\tau C_j e(g) = \sum_j g_{ij} C_j^e(g)$. And in terms of matrix, $\tau C^e(g) = gC^e(g)$ where $C^e(g)$ is an eigenvector of g and τ is the corresponding eigenvalue.

Eigenvector centrality is a better measure of social prestige as it takes account of the position of the direct friends of each person (Bonacich, 2007). As a result, a person having very few but centrally positioned friends will not be under-estimated to a person having a lot of almost isolated or peripherally positioned friends. Eigenvector centrality is closely related to Bonacich centrality and is a variant of Bonacich centrality. They are also used as a proxy for each other (Bonacich, 1987, Bonacich, 1991).

APPENDIX C: ROBUSTNESS CHECKS

To test the validity of our statistical findings, we carry out some additional robustness checks to see whether our estimates are sensitive to the models we have determined. The results are presented in Appendix Table 2. We first restrict our models by dropping the 267 isolated respondents. It is possible that our centrality measures can pick up the outcome differences between these two groups. However, results in row (1) of Appendix Table 2 suggest this is not the case. The estimate on the sub-sample is -0.098 (95% CI -0.151 to -0.044), which is very similar to the value we found in column (4) in Table 3. The estimated coefficient on betweenness centrality is not sensitive to excluding the isolated nodes. We also find that betweenness centrality has too many zeros, hence, we define a dummy for respondents with non zero values and re-estimate the model. We find negative association between mental health outcomes of the

respondents and those with non-zero betweenness centrality (-0.163, 95% CI -0.321 to -0.004, see row [2]). The results are very similar for eigenvector centrality as well (see rows [3] and [4] in Appendix Table 1). We also use a new measure of being influential within a network namely input proximity prestige index. We find that one SD higher value in this index is associated with 0.06 SD lower GHQ score (95% CI -0.124 to 0.010, see row [5]), suggesting better mental health outcomes.

Appendix Table 2: Robustness Checks

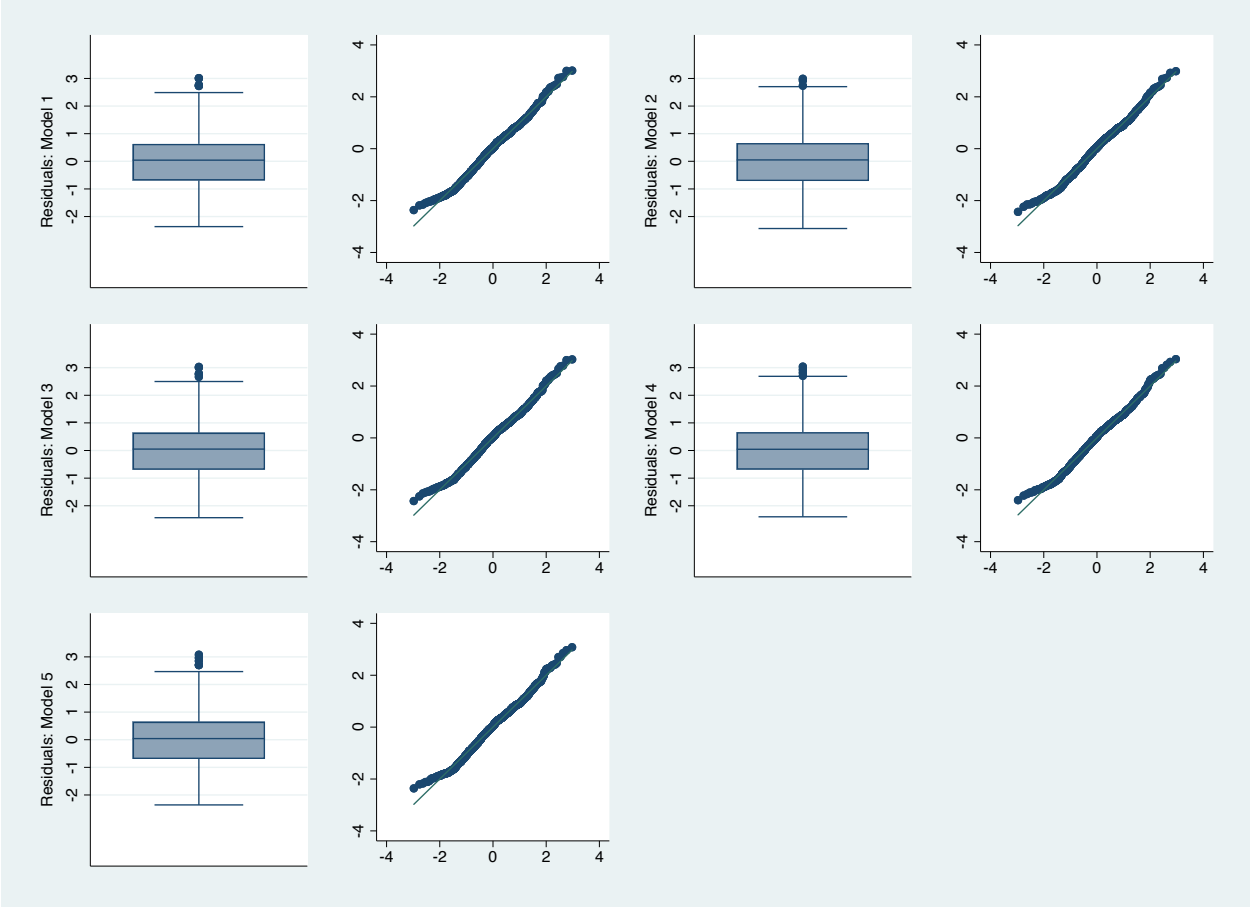
		Coefficient	(95% CI)	N	R^2
(1)	Betweeness Centrality (standardized) excluding isolated respondents	-0.098***	(-0.151 to -0.044)	557	0.058
(2)	= 1 if Betweenness Centrality > 0	-0.163**	(-0.321 to -0.004)	824	0.038
(3)	Eigenvector Centrality (standardized) excluding isolated respondents	-0.060***	(-0.098 to -0.023)	557	0.051
(4)	= 1 if Eigenvector Centrality > 0	-0.117	(-0.257 to 0.023)	824	0.037
(5)	Input Proximity Prestige (standardized)	-0.057*	(-0.124 to 0.010)	824	0.036
Results from ordered probit models					
(6)	All closeness centrality (standardized)	-0.052	(-0.124 to 0.019)	824	
(7)	Betweenness centrality (standardized)	-0.106***	(-0.177 to -0.034)	824	
(8)	Eigenvalue centrality (standardized)	-0.064*	(-0.133 to 0.006)	824	

Note: The outcome variable is the standardized GHQ score in all specifications. In specifications (1) and (3), we drop the respondents who do not have any friendship tie. In specifications (2) and (4), we use an indicator variable for respondents with non-zero centrality values. In specifications (6-8), we use ordered probit models for the discrete standardized GHQ score as the outcome variables. In all specifications, we have retained the control variables that we include in Table 3. The robust p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

As we noted earlier, GHQ scores are essentially discrete in nature and we could actually reject null hypothesis of normality distribution in GHQ scores. So we have re-estimated the models with three centrality scores using ordered probit models and relaxed the normality assumption in the outcome variables. The results are presented in rows (6-8). We find that both

the point estimates and also the second moments are generally not sensitive to the alternative regression models.

Appendix Figure 1: Testing for Outliers in Residuals and QQ Plots



Note: In each panel, on the left we plot the box-plot for the residuals from each model reported in Table 3. On the right, we show the QQ plots for the same residuals.

APPENDIX D: DIAGNOSTIC TESTS FOR REGRESSION RESULTS IN TABLE 3

We present some diagnostic tests for the basic Gauss-Markov assumptions here (see Wooldridge 2002). Our outcome variable is discrete in nature so it is important test for normality. We also check for outliers in our models. We box plot the residuals for all five models from Table 3 and also plot the QQ chart to visually inspect the distributions for the residuals from the same models. We present the charts in different panels in Appendix Figure 1.

Simple visual inspections suggest there are few outliers in the residuals from all five models; however, the frequency does not warrant much concern. We also look at the quintile normal figures and residuals generally lie on the lines. While they may suggest that misspecifications may not be an issue we further use statistical tests to check the normality of the residuals. We show the results in Appendix Table 2.

Appendix Table 2: Normality Tests

	p-value	
Model	**Shapiro-Wilk**	**Shapiro –Francia**
1	0.00041	0.00121
2	0.00077	0.00213
3	0.00059	0.00163
4	0.00062	0.00172
5	0.00042	0.00119

Note. We report the p-values from Shapiro-Wilk and Shapiro-Francia tests for residuals from each model reported in Table 3.

The normality tests reported in Appendix Table 2 suggest that in all five models null of hypotheses of normality are rejected. Hence, we carry out further robustness checks with alternate specifications as reported in Appendix D below.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-11
		(b) Indicate number of participants with missing data for each variable of interest	N/A

Outcome data	15*	Report numbers of outcome events or summary measures	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-13
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	See Appendix
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15,16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A social network analysis of psychological morbidity in an urban slum of Bangladesh: a cross-sectional study based on a community census

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A social network analysis of psychological morbidity in an urban slum of Bangladesh: a cross-sectional study based on a community census

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Abstract – 225

Abstract

Objectives To test whether social ties play any roles in mitigating depression and anxiety, as well as in fostering mental health among young men living in a poor urban community.

Setting A cohort of all young men living in an urban slum in Dhaka, the capital of Bangladesh.

Participants All 18- to 29-year-old men (N = 824) living in a low-income urban community at the time of the survey.

Primary and secondary outcome measures Unspecified psychological morbidity measured using the Generalized Health Questionnaire (GHQ-12), where lower scores suggest better mental status.

Results The GHQ scores (mean = 9.2, SD = 4.9) suggest a significant psychological morbidity among the respondents. However, each additional friend is associated with a 0.063 SD lower GHQ score (95% CI -0.106 to -0.021). Between centrality measuring the relative importance of the respondent within his social network is also associated with a 0.103 SD lower GHQ score (95% CI -0.155 to -0.051), as are other measures of social network ties. Among other factors, married respondents and recent migrants also report a better mental health status.

Conclusions Our results underscore the importance of social connection in providing a buffer against stress and anxiety through psychosocial support from one's peers in a resource-constraint urban setting. Our findings also suggest incorporating a social network and community ties in designing mental health policies and interventions.

Keywords: Mental health status, social network, young men, urban slum

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Our analyses take advantage of a census of young men in a resource-constraint low-income urban community in Bangladesh to establish the roles a social network and community ties play in determining better mental health outcomes.
- The measurement of the social network is based on a roster-based approach where friendship connections for all possible pairs of respondents are carefully assessed and validated.
- We take advantage of a locally adopted GHQ-12 to assess unspecified mental health outcomes along with detailed socioeconomic characteristics of our respondents.
- Cross-sectional data limit causal interpretations and cannot rule out the reverse causality of otherwise robust relationships, and community ties through friendships can capture only limited aspects of the respondents' social network.

INTRODUCTION

Mental illness and disorders refer to "abnormal thoughts, perceptions, emotions, behaviour, and relationships with others." [1] Mental illness contributes about 7.1 percent to global disease burden, and the cost of mental disorders such as depression can be enormous. [2,3] Over a person's lifetime, psychological disorders can adversely affect one-third of the global population. [4] As of 2010, close to 900 million people were estimated to suffer from certain mental health issues, including depression, anxiety, and substance abuse. [5] The burden of mental health is also likely to increase with growing urbanization in developing countries. [6,7] Poor neighborhoods and low-income communities potentially offer more stressful environments for urban citizens. [8] Hence, one can infer that a larger share of the global mental health burden will be borne by lower-income populations living in challenging environments in newly urbanized developing nations. This is further compounded by the social stigma and general misinformation associated with mental health symptoms, resulting in low psychosocial care seeking in developing countries. [9]

Social capital can be multifaceted, and its definitions vary in the literature as they aim to capture the different aspects of social engagements for an individual. [10] Social capital encompasses civic engagement, trust, reciprocity, and certain norms. Moreover, it can both be a structural feature of the community or group and be owned by an individual to rely on and exploit to command over resources to ensure his or her well-being. [11,12] The horizontal nature of ties, for example, friendship network and community embeddedness, is considered a defining feature of one's social capital, and prior literature typically associates resulting social capital with socially desirable health outcomes. [13]

A growing consensus reveals that the quality of social ties and deeper social embeddedness are important determinants of mental health. [14,15,16] Lack of social ties has been found to be a risk factor for some mental health indicators. [17,18,19,20] By ensuring attachment and buffer, a social network and community ties can have both extrinsic and intrinsic values for an individual's mental or psychological well-being. [21] Prior studies have shown the positive roles social connection can play in lowering depressive episodes. [20,22] Depressive symptoms are also less likely to manifest in people who are more central within the group they belong. [23] Mental state of mind, like happiness, can also better in people with social networks that are closer in terms of geographical distance. [19]

In the context of Bangladesh, social networks have been found to contribute to health service delivery in both rural and urban areas. [24,25] However, we have limited information on how social ties and network properties can determine mental health outcomes in urban Bangladesh and similar other low-income contexts. One's social network has been found to have a strong association with positive mental health outcomes. However, these studies have been conducted mostly in developed countries by taking advantage of large, often longitudinal, cohort studies and population level data. [19,20,22,23] We intend to contribute to the growing literature on social network as a determinant of mental health by exploiting a community-level census of young men in a slum in Dhaka.

METHOD

Study Design

We followed a cross-sectional study design based on individual respondents from a census of young men living in an urban slum at the time of the survey (N = 824). The census allowed us to

enumerate friendship ties along with directions between any two respondents among possible 339,076 ties. We also collected mental health outcome measures along with the detailed socioeconomic characteristics of the respondents.

Study Setting

We conducted our study in a particular but otherwise typical urban community in Dhaka, namely, Vashantek. The entire Vashantek slum was geographically divided into four subdivisions with a total population of around 31,000 or about 5,500 households. We chose to work in a particular subdivision and conducted a census of all men aged between 18 and 29 years. The study was part of a larger project, which focused on gender norms, risky sexual behavior, and mental health within this particular population. These topics often focused on adolescent or female populations. Hence, we chose post-adolescent young men in a low-income urban community as the study population to provide some novel and unique perspectives to the relevant literature. We collected baseline information on a number of socioeconomic variables and detailed social network information on all the targeted respondents. The site and the setting met the necessary criteria for usual social network analyses. [26]

Sample and Sampling Technique

We collected information on all men aged between 18 and 29 in our targeted site. Initially, we listed all the households in the study community with men who fit the age criteria. We asked each household whether an 18- to 29-year-old man lived in that household. We followed up with their full names, contact information, and availability for a more detailed survey afterward. We found a total of 942 potential respondents from 790 households through this initial listing process. After thoroughly training the data collectors and pretesting the questionnaire, we sent nine data collectors to conduct the surveys. We used skilled enumerators who had prior

experience in a mobile-based quantitative survey through SurveyCTO. The enumerators conducted the interviews in 26 days during the month of December 2016.

We collected demographic, economic, sexual practice, and friendship information using a structured questionnaire. We excluded some of the respondents who moved out of the slum between the initial household listing and the follow-up survey. We also found households that had a potential respondent who lived outside the community but was previously listed as a household member. We also excluded individuals with communication impairments and two respondents who refused to provide a written consent. The final cohort consisted of 824 young men aged 18 to 29 years living in our study area. We performed all analyses on this sample.

Patient and Public Involvement Statement

No patients were involved in designing the study or developing the research questions, nor were they involved in analyzing or interpreting the findings. The study was conducted on a community-based sample of individuals who met the pre-specified criteria. We would discuss some of the general implications of the study findings through workshops as well as through a series of radio shows to help address mental health problems affecting young men in Dhaka.

Measures of Mental Well-Being

We used the 12-question version of the General Health Questionnaire (GHQ-12), an often-used survey-based tool that measures the population morbidity of nonpsychotic and minor psychiatric disorders, to assess the mental well-being of individuals, where a higher score generally suggests a poor mental health outcome. GHQ-12 was implemented and validated widely in different contexts in both developed and developing countries, including Bangladesh. [27,28] Because of its precise and concise nature and validity in the context of Bangladesh, we considered this tool to be appropriate for our study to assess any nonspecific psychiatric

morbidity among the respondents. [29] We estimated Cronbach's α, and a value of 0.83 suggests high internal consistency. We further performed exploratory factor analysis, and high individual variance for each factor suggested high reliability of the score in our sample. The detailed item-wise responses are reported in Appendix A.

Social Network Analysis (SNA) Parameters

For the social network analysis, we asked each respondent to name his close friend(s) in the community and state where they lived (particular landmark/household identifier in the slum). After confirming the proper identification of all the close friends mentioned by the respondents, we constructed a 824 × 824 square *sociomatrix* showing direct friendship ties with a value of 1 or 0. [30] We then used the network analysis software Pajek to analyze the data set. We estimated different social network parameters for each of our respondents to measure the embeddedness and centrality of each respondent within the friendship network. These measures captured richer aspects of the social network of the respondents (for definitions of the different social network parameters, see Appendix B). [31,32] For robustness check and sensitivity analyses, we used nonlinear versions of some of our centrality measures because of the overrepresentation of zeros in our sample, which indicates the absence of any ties between individuals. [20] We also estimated some additional measures of the nature of the social network at individual levels to perform further sensitivity analyses (see Appendix C).

Socioeconomic Characteristics

Given the observational nature of our study, we controled for various socioeconomic characteristics of the respondents. These factors could potentially confound our results, and we included them all in our multivariable analyses. Some of these factors were also important and can capture community embeddedness and social support aspects of a person's life that could

influence psychosocial well-being, such as marital status and birth in the same community. We further collected information on the age of the respondent as well as his education and current occupation. We also profiled the wealth status of the respondent's households. We used a wealth index called Equity Tool, which generated comparable results across different contexts. [33] This tool was validated for Bangladesh and consists of seven questions in its latest update as of 2014. We chose the urban wealth scores and urban wealth quintile for our study.

Statistical Analyses

To assess the relationship between mental well-being and social ties, we ran different regression models with different social network measures. We included the socioeconomic characteristics in all the regression models and separately analyzed the coefficients on these additional controls. For the multivariable analyses, we used robust regression models to correct the possible violation of the standard Gauss-Markov assumptions (see Appendix D). [34] We standardized both the mental health outcomes and the continuous variables on the right-hand side in the regression models and estimated the beta-coefficients. We further used ordered probit analyses for some additional robustness checks (see Appendix C). In the outcome variable, GHQ-12 scores were discrete in nature and hence were prone to violation of the basic normality conditions. Ordered probit models relaxed these assumptions (see Appendixes C and D). All econometric analyses were performed using Stata™/MP 15.0.

Table 1: Summary Statistics

	Mean (SD)
Age, years	23.6 (3.6)
Currently Married, percent	52.2 (50.0)
Born in *Vashantek*, percent	44.2 (49.7)

Education, percent	
No formal education	83 (10.1)
Primary incomplete	290 (35.2)
Primary complete	106 (12.9)
Secondary incomplete	206 (25.0)
Secondary complete/Above	139 (16.9)
Equity Score	-0.016 (0.230)
Wealth Quintile, percent	
First	61 (7.4)
Second	325 (39.4)
Third	418 (50.7)
Fourth	16 (1.9)
Fifth	4 (0.5)
Occupations, percent	
Driver	138 (16.8)
Service Sector	125 (15.2)
Student	109 (13.2)
Business/Shop owner	100 (12.1)
Construction worker/Carpenter/Wall painter	88 (10.9)
Daily labor	58 (7.0)
Rickshaw puller/Van puller	43 (5.2)

Notes: Based on surveys of 824 respondents. Equity index is based on ownership of selected assets (namely, refrigerator, TV, almirah/wardrobe and electric fan) and household building materials. The wealth quintiles are based on equity scores with Bangladesh urban specific cutoffs. For occupations, "other" category is not included in the table.

FINDINGS

Socioeconomic Characteristics

We present the basic socioeconomic and demographic characteristics of the respondents in Table 1. The average age of the respondents is 24, with an SD of 3.6. About 44 percent of the respondents report living in the study community since birth. Interestingly, 52 percent of the respondents are married at the time of the survey. The respondent group also has low educational level as 45 percent report that they have achieved either not the primary educational level or lower. Their average schooling is about the same as those found in nationally representative household surveys. [35]

According to the generalizable equity score, with a mean of -0.016 and SD of 0.230, majority of our respondents come from second and third wealth quintiles, with very few (only 2.5 percent) from the top 2 wealth quintiles. We find a considerable variation in occupations that the respondents are engaged in, namely, driving, service in construction sectors, and running small businesses. About 13 percent of the respondents report being students at tertiary-level educational institutions.

Mental Health Status

We present both distribution and summary statistics for the mental health status of the respondents in Figure 1. We have found a considerable variation in GHQ-12 outcomes, which range from 0 to 25. The average GHQ-12 score is about 9.2 with an SD of 4.9. We have further assessed for normality using the Shapiro-Wilk test, and the results reject the null hypothesis of normality. This result is natural given the discrete nature of GHQ-12 scoring, and we have further tested the robustness of our results using an ordered probit model that takes into account the discrete nature of our scoring (see Appendix C).

[FIGURE 1 ABOUT HERE]

Social Network Analyses

A visual inspection of the social network suggests that the respondents can belong to one of the three broad types of components (see Figure 2): the largest component (N = 452 or 55 percent), 37 smaller self-contained components with sizes between 2 to 7 friends (N = 105 or 13 percent), and 267 respondents (32 percent) who have not mentioned anybody in the community as a friend, or nobody in the community has mentioned them as a friend (see Table 2). They are entirely isolated individuals in our target population with zero friendship ties in the community.

On average, our sample has 1.6 ties per respondent, including those who have reported no friendship tie in the community.

Table 2: Social Network Characteristics of the Respondents

	Mean	SD
Respondents in each component, percent		
Large connected group	54.6	
Smaller groups	12.7	
Isolated with no referrals in any direction	32.4	
Number of friends, percent		
0	32.4	
1	26.3	
2	17.1	
3	11.0	
4	6.4	
5	3.9	
6 or more	2.8	
Average number of friendship ties	1.6	1.6
Average Centrality Scores		
Closeness centrality	0.034	0.031
Betweenness centrality	0.00000662	0.000024
Eigenvector centrality	0.004	0.034

Notes: Based on 824 respondents. Each respondent reports the friendship ties within the community. The large connected group includes the biggest component where all subjects are connected with intermediate ties. Centrality measures are estimated using Pajek.

The average closeness centrality score is 0.034 for this network of 824 men (with an SD of 0.031, see Table 2). The average betweenness centrality score for this network of 824 men is 6.6 $\times 10^{-6}$ (with an SD of 24.0 $\times 10^{-6}$) with an overall betweenness centralization of 0.0003. We further estimate the average eigenvector centrality for the respondents, which is equal to 0.004 (with an SD of 0.034). The overall eigenvector centralization of the network is 0.0071. An average eigenvector (Bonacich power) centrality of 0.004 suggests that, on average, men in this network do not hold very prestigious positions with fairly low variation.

[FIGURE 2 ABOUT HERE]

Association between Mental Well-Being and Social Networks

The results from our multivariable regression analyses, which assess the association between mental health outcome (standardized GHQ scores) and individuals' social network parameters, are presented in Table 3. All the continuous variables are standardized. In column 1 of Table 3, we find that compared with an isolated respondent with no community friendship tie, a respondent belonging to a small component has a 0.098 SD lower GHQ score (95% confidence interval [CI] -0.327 to 0.131). Moreover, a respondent belonging to the larger component has a 0.117 SD lower GHQ score (95% CI -0.274 to 0.041).

In the next model in column 2 of Table 3, we find that mental health outcomes are systematically better with higher degrees of ties or number of friends. Having an additional friend is associated with a 0.063 SD lower GHQ score (95% CI -0.106 to -0.021). In the next three columns, we include different measures of centralities that retain all the controls. We find that a 1 SD higher all-closeness centrality score of a respondent is associated with a 0.053 SD lower GHQ score (95% CI -0.124 to 0.018, see column 3 in Table 3). We find similar results for betweenness and eigenvalue centralities. Respondents with a 1 SD higher betweenness centrality score report about a 0.103 SD lower GHQ score (95% CI -0.155 to -0.051), and respondents with a 1 SD higher eigenvalue centrality score report about a 0.068 SD lower SHQ score (95% CI -0.103 to -0.033), controlling for other factors.

In all the five specifications, we include the socioeconomic characteristics of the respondents as controls or possible confounding factors. The association between mental health outcomes and other covariates is quite suggestive. We find that mental health worsens with age, about 0.012 SD higher with each additional year; however, while the point estimates are quite robust across different models, they are not very precise. More educated respondents report a lower GHQ

score, so more educated respondents typically have better mental health status. Interestingly, respondents born in the community have better mental health status. Respondents who are currently married have 0.17–0.20 SD lower GHQ scores, and coefficient values are typically significant. We also find higher wealth as measured by the equity score, which is associated with a lower GHQ score or better mental health status.

Table 3: Multivariable Association between Mental Health Outcomes and Social Network

	(1)	(2)	(3)	(4)	(5)
Component type					
Disconnected	Base				
Small	-0.098 (-0.327 to 0.131)				
Large	-0.117 (-0.274 to 0.041)				
Number of friend(s)		-0.063*** (-0.106 to -0.021)			
Closeness centrality (standardized)			-0.053 (-0.124 to 0.018)		
Betweenness centrality (standardized)				-0.103*** (-0.155 to -0.051)	
Eigenvalue centrality (standardized)					-0.068*** (-0.103 to -0.033)
Age (years)	0.012 (-0.013 to0.037)	0.011 (-0.014 to 0.035)	0.012 (-0.013 to 0.037)	0.011 (-0.014 to 0.035)	0.014 (-0.011 to 0.038)
Education					
No formal education	Base	Base	Base	Base	Base
Primary incomplete	-0.333** (-0.622 to -0.043)	-0.315** (-0.602 to -0.027)	-0.326** (-0.616 to -0.037)	-0.320** (-0.609 to -0.030)	-0.339** (-0.631 to -0.048)
Primary complete	-0.450*** (-0.777 to -0.124)	-0.437*** (-0.763 to -0.112)	-0.443*** (-0.771 to -0.115)	-0.447*** (-0.774 to -0.120)	-0.444*** (-0.773 to -0.115)
Secondary incomplete	-0.269* (-0.574 to 0.035)	-0.267* (-0.570 to 0.035)	-0.267* (-0.572 to 0.037)	-0.272* (-0.576 to 0.033)	-0.277* (-0.583 to 0.029)
Secondary complete or above	-0.114 (-0.452 to 0.223)	-0.105 (-0.441 to 0.230)	-0.114 (-0.452 to 0.223)	-0.125 (-0.462 to 0.211)	-0.131 (-0.470 to 0.208)
= 1 if born atVashantek	-0.169** (-0.312 to -0.025)	-0.184** (-0.328 to -0.041)	-0.167** (-0.311 to -0.024)	-0.182** (-0.325 to - 0.040)	-0.163** (-0.305 to -0.022)
= 1 if currently married	-0.190** (-0.367 to -0.013)	-0.198** (-0.375 to -0.022)	-0.188** (-0.364 to -0.011)	-0.179** (-0.353 to -0.004)	-0.171* (-0.346 to 0.004)
Equity Score (standardized)	-0.030 (-0.108 to 0.048)	-0.028 (-0.106 to 0.049)	-0.030 (-0.108 to 0.048)	-0.029 (-0.107 to 0.048)	-0.031 (-0.108 to 0.047)
Occupation Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	824	824	824	824	824
R-squared	0.036	0.047	0.036	0.043	0.038

Notes: The outcome variable is the standardized GHQ score in all five specifications. A higher GHQ score suggests worse mental health outcomes.The robust 95% CIs are reported in parentheses. We also control for occupations, which are not reported here. *** p<0.01, ** p<0.05, * p<0.1.

DISCUSSION

Our findings indicate the importance of social relations in determining mental well-being in resource-constrained contexts. Social ties are important components of a much broader idea of social capital, and observed outcomes can be associated with both the cognitive aspect of social bonding and the constructivist dimension of local social institutions. [20] Hence, our results further highlight the importance of the social determinants of health in the context of mental health, a topic that has gained importance in both academic and policy literature in recent times. [13,18,36]

Our results show that young men with better social ties and higher community embeddedness and network report better mental health. We have used a number of different measures of social network parameters at an individual level that are typical of a person's connectedness in his immediate community. While this captures a particular aspect of a person's position in a broad spectrum of social capital that he can accumulate over time, our estimates are robust and suggest that connection with one's peer from his community is a strong predictor of his mental health status.

Additionally, we should highlight the overall high average GHQ-12 score for our sample from the general population. For example, in the context of Bangladesh, previous researchers have found a GHQ-12 score of 20 with an SD of 3 among diagnosed mental patients. [27] While clinical diagnoses of disorders require closer scrutiny and assessment by mental health professionals, such high score suggests a potentially high psychosocial morbidity associated with a high level of stress, anxiety, and possibly depression. Although we have focused on only one neighborhood in Dhaka, the study area is not peculiar or remarkable in any observational way, suggesting a broader implication and generalizability. In general, urban areas and youth

populations are prone to isolation and can suffer from psychological distresses and psychoses. [36]

Social capital can influence one's psychological well-being in a number of ways, and our study can only speculate the possible channels through which social ties can affect mental health in our study population. [21] A social network can help individuals access material resources, such as loans, grants, and health services. [12] We have found that the respondents in our sample primarily rely on family members for their financial needs and community practitioners and informal care providers such as salespersons in local pharmacies for health services. This result suggests, within our context, that the social network promotes mental health primarily through socioemotional supports and recreational activities. However, identifying the exact nature of different channels requires further study and specific tools to measure different pathways through which social ties can alter mental health outcomes.

Given the cross-sectional nature of our study, we cannot claim causality in our findings. More specifically, it is possible that the association primarily picks up selection bias, where people with certain psychosocial traits are self-selected into the social structure typified by higher social ties and centrality, resulting in reverse causality that we cannot completely rule out given the observational nature of the study. However, we include a set of socioeconomic factors that are possible confounders of the mental health outcomes in our empirical models and we block these influences by controlling them in all our empirical models. [37]

Also, using GHQ-12 to measure mental health outcomes limits our study, as this questionnaire is not a clinical tool and captures a unidimensional unspecified psychological morbidity. [29] Hence, this scale measures only the respondents' actual mental health status with some measurement errors. This limits the total variation that we are able to explain using our

empirical models. We also capture important social ties, namely, friends in the community and age-group. The respondents can have social ties and a network outside the community as well as through social media. Such measurement errors lead to downward bias and smaller coefficients (in absolute terms), as one can see in all our models. So our estimates can be considered lower bounds for the true effects of social ties on the mental well-being of the respondents.

Despite these limitations, the findings presented here enhance our understanding of the social network determinants of mental health in an exciting population. The postadolescent young population is particularly important because, Bangladesh, like many low-middle-income countries in the world, remains and will remain largely young for another generation or so. High youth unemployment and underemployment rates can put a strain on men owing to traditional gender expectations. [38] In this context, isolation and social disconnectedness can contribute to poorer mental health, luring male youth to violence, which has become a concern locally in recent times. Thus, our findings have important implications in understanding mental health outcomes and policies that address psychosocial health issues of young men and highlight the importance of social connection and ties in determining mental health in the post-adolescent population in developing countries.

Contributorship

AR1 and MS conceived this study. AR led the analysis with guidance from NRB, AR2, and MS. NRB led the collection and analyses of social network data with guidance from AR1. AR2 managed the overall data collection and preliminary analyses with guidance from AR1 and MS. AR1 wrote the first draft and the final manuscript with contribution from MS. All authors have seen and approved the final version of the manuscript.

Conflicts of Interests

All authors declare no conflicts of interest.

Role of Funding Source

The study was funded by WOTRO Science for Global Development of the Netherlands Organization for Scientific Research (NWO) under grant number W 08,560.007. The funding source did not play any role in designing the study or collecting, analyzing, or interpreting the data or preparing this manuscript and deciding to submit the paper for publication.

Data Sharing

Extra data can be accessed via the Dryad data repository at http://datadryad.org/ with the doi: 10.5061/dryad.320bv7b

Ethical Approval

The Institutional Review Board at the BRAC School of Public Health at BRAC University reviewed and approved both the proposal and the data collection protocols. All the participants provided written informed consent prior to the survey. The data collectors explained first the research objective and the confidentiality that would be maintained after the gathering of information from young men. Moreover, the entirely voluntary nature of participation in the survey was carefully explained, and the participants could withdraw their participation at any point of the survey, even after they signed the consent form. One copy of the written consent form was given to the participant, and another copy was retained for official records.

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1

Figure 1: Distribution of GHQ-12 scores

Notes. Based on 824 respondents. Here we report the non-standardized GHQ scores. The mean is shown as the vertical red line, and the median is shown as the vertical blue line. GHQ is the aggregate of 12 questions with possible values of 0, 1, 2 and 3. The scores of all 12 questions are added to measure the composite score for a respondent.

Figure 2: Visualization of the friendship network of the 824 young men of Vashantek

Notes: Here we show the socio network graph for 824 respondents. Each node represents an individual respondent. The connector shows the friendship ties between two respondents. There are 267 respondents who are completely isolated (not included in the figure). The largest component consists of 450 respondents who are all connected with each other through intermediate ties. We also have 37 smaller components with smaller networks.

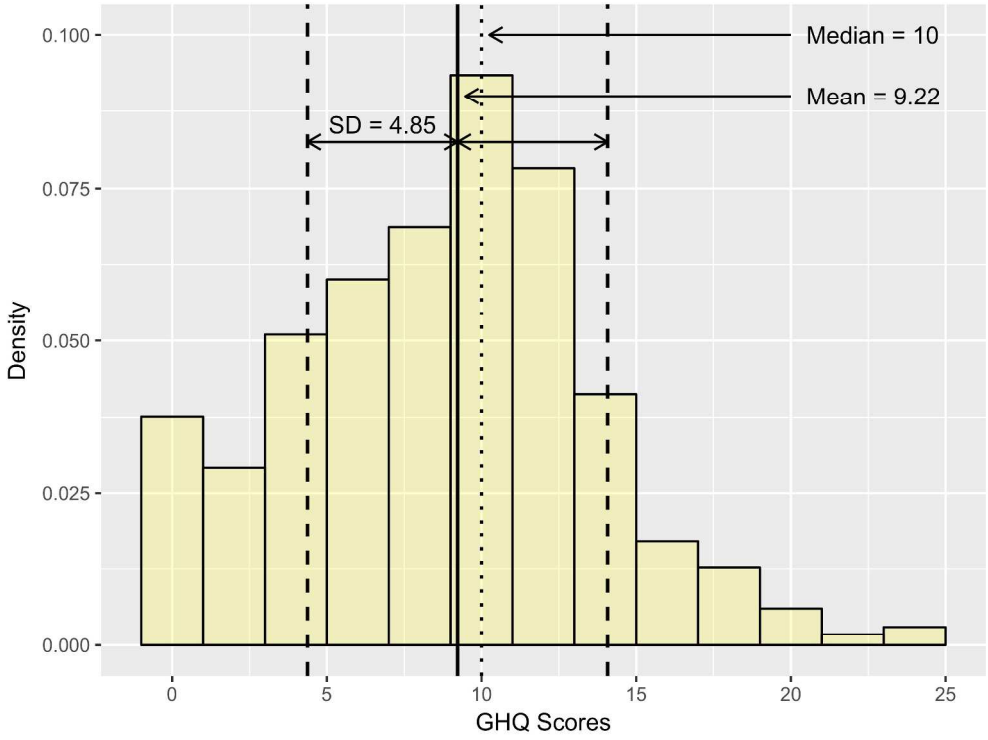

Figure 1: Distribution of GHQ-12 scores

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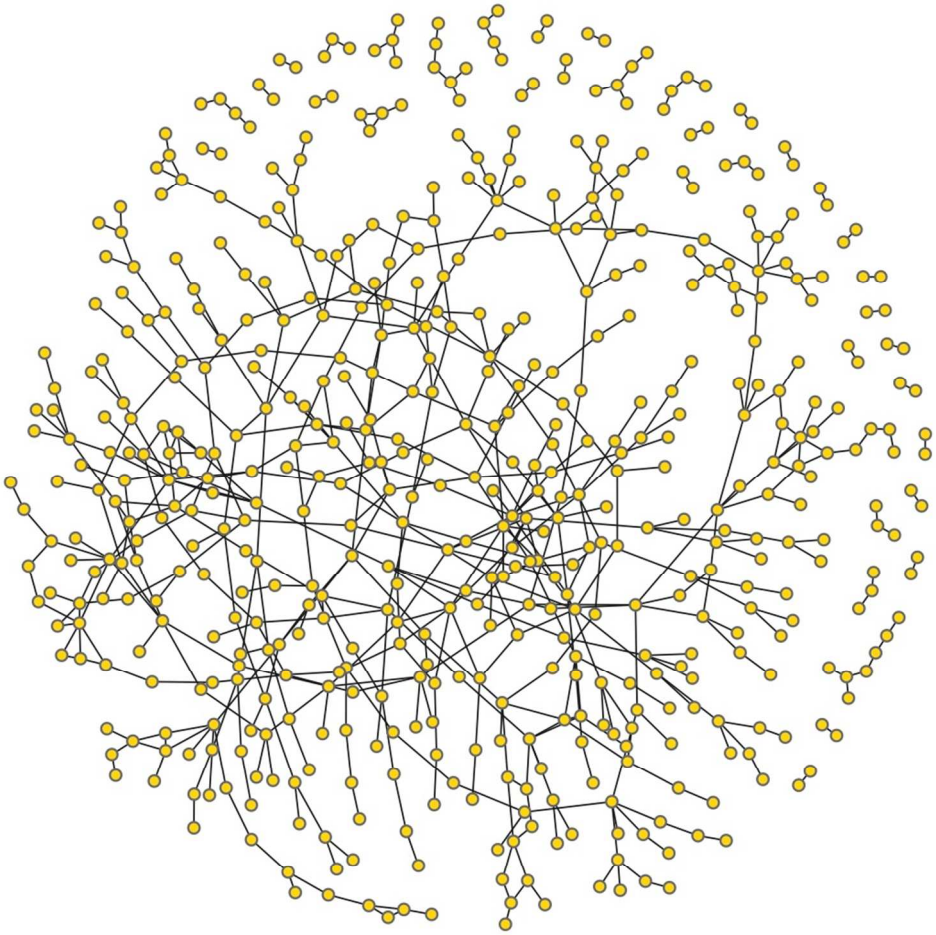


Figure 2: Visualization of the friendship network of the 824 young men of Vashantek

A social network analysis of psychological morbidity in an urban slum of Bangladesh: a cross-sectional study based on a community census

APPENDIX A: DETAILED ITEM ANALYSES OF GHQ-12

Here we present the detailed item-wise report from the Generalized Health Questionnaire we have implemented among our respondents (see Appendix Table 1). We have used a version of the GHQ-12 that has been previously translated and adopted in Bangladeshi context (Hossain, Siddique and Habib 2017, Islam and Iqbal 2008).

Appendix Table 1: GHQ-12 Responses by Each Item

	Reponses (fraction of total)				Mean	95% CI	
	Never	Sometimes	Often	Always			
	0	1	2	3			
Have you recently been able to; concentrate on what you are doing?	0.347	0.489	0.157	0.007	0.824	0.776	0.872
Have you recently lost much sleep over worry?	0.417	0.485	0.085	0.012	0.692	0.646	0.738
Have you recently felt you were playing important part in things?	0.369	0.468	0.159	0.004	0.797	0.749	0.846
Have you recently felt capable of making decisions about things?	0.214	0.567	0.211	0.008	1.015	0.968	1.061
Have you recently felt consistently under strain?	0.280	0.511	0.184	0.024	0.953	0.901	1.004
Have you recently felt you couldn't overcome your difficulties?	0.227	0.552	0.205	0.016	1.010	0.962	1.058
Have you recently been able to enjoy your normal day to day activity?	0.291	0.522	0.180	0.007	0.903	0.855	0.951
Have you recently been able to face up to your problems?	0.209	0.542	0.242	0.007	1.047	1.000	1.095
Have you recently been unhappy and depressed?	0.471	0.453	0.069	0.007	0.613	0.569	0.657
Have you recently been losing confidence in yourself?	0.715	0.221	0.028	0.036	0.386	0.337	0.435
Have you recently been thinking of yourself as a worthless person?	0.733	0.237	0.017	0.013	0.311	0.271	0.350
Have you recently been feeling reasonably happy, all things considered?	0.451	0.437	0.097	0.015	0.675	0.626	0.723
Overall GHQ-12					9.225	8.893	9.556

There are two suggested methods of scoring for GHQ-12. We have used the 'four point response scale' or Likert method, which should allow more variation in the scores (see Hankins 2008). GHQ-12 typically captures the unidimensional nature of unspecified psychological morbidity and commonly used in survey based instruments to measure the mental wellbeing in different populations.

APPENDIX B: CENTRALITY MEASURES

While intuitive, just focusing on the number of friendship ties can mask the deeper structure of social power or popularity within a network. We focus on a number of more sophisticated measures of centrality which gauge one's position in the entire network by analyzing not just the number of people they are connected to but also the type of people they are connected to and reveals to what extent that person is central/peripheral in his social network by analyzing their network positions (Freeman 1978). While 'node degree' shows the extent of connectedness, centrality shows how well and centrally each node is connected and we focus on a number of them.

Degree Centrality

Degree centrality is simply the number of degrees each person has. In-degree centrality is the number of referrals each person gets, out-degree centrality is the number of referrals each person gives and all-degree centrality is the number of total referrals (summing both the referrals he gives and the ones he gets). Hence, degree centrality is just the number of friendship ties each respondent has normalized by the possible total number of ties ($N - 1$).

Closeness Centrality

Closeness centrality is the inverse of the average distance within a network. It measures how distant a node is from the rest of the nodes and how many times it has to be crossed by other

nodes to reach some other node using the shortest path. Applying this in the context of our friendship network, we can measure how many stages a person requires to get connected to another random person or node in the network.

$$\text{Closeness Centrality}_i = \frac{n-1}{\sum_{j \neq i} l(i,j)}$$

where, $l(i,j)$ denotes the number of links node i needs to reach to node j using the shortest path. Input closeness centrality and output closeness centrality take into account of the direction of referral while all closeness centrality does not.

Betweenness Centrality

Betweenness centrality is a measure of centrality based on how well situated a person is in terms of the paths he lies on (see Freeman 1978, Jackson 2010). This takes into account the number of shortest links connecting each node to all other nodes that pass through a particular node.

Let $P_i(j,k)$ denote the number of shortest paths between any two nodes j and k that pass through node i and, let $P(j,k)$ represent the number of shortest paths between these two nodes . Then,

$$\text{Betweenness Centrality}_i = \sum_{k \neq j,k,j} \frac{P_i(k,j)/P(k,j)}{(n-1)(n-2)/2}$$

where, n is total number of nodes. So in short, betweenness centrality of a node is equal to the number of geodesics passed through that particular node divided by the number of all the geodesics of any two other nodes.

Eigenvector Centrality

Eigenvector centrality measures a person's centrality based on the centrality of his direct connections. Letting $C^e(g)$ denote the eigenvector centrality associated with a network g, then the centrality of a node is proportional to the sum of the centrality of its neighbors. So, eigenvector centrality, $\tau C_j e(g) = \sum_j g_{ij} C_j^e(g)$. And in terms of matrix, $\tau C^e(g) = gC^e(g)$ where $C^e(g)$ is an eigenvector of g and τ is the corresponding eigenvalue.

Eigenvector centrality is a better measure of social prestige as it takes account of the position of the direct friends of each person (Bonacich, 2007). As a result, a person having very few but centrally positioned friends will not be under-estimated to a person having a lot of almost isolated or peripherally positioned friends. Eigenvector centrality is closely related to Bonacich centrality and is a variant of Bonacich centrality. They are also used as a proxy for each other (Bonacich, 1987, Bonacich, 1991).

APPENDIX C: ROBUSTNESS CHECKS

To test the validity of our statistical findings, we carry out some additional robustness checks to see whether our estimates are sensitive to the models we have determined. The results are presented in Appendix Table 2. We first restrict our models by dropping the 267 isolated respondents. It is possible that our centrality measures can pick up the outcome differences between these two groups. However, results in row (1) of Appendix Table 2 suggest this is not the case. The estimate on the sub-sample is -0.098 (95% CI -0.151 to -0.044), which is very similar to the value we found in column (4) in Table 3. The estimated coefficient on betweenness centrality is not sensitive to excluding the isolated nodes. We also find that betweenness centrality has too many zeros, hence, we define a dummy for respondents with non zero values and re-estimate the model. We find negative association between mental health outcomes of the

respondents and those with non-zero betweenness centrality (-0.163, 95% CI -0.321 to -0.004, see row [2]). The results are very similar for eigenvector centrality as well (see rows [3] and [4] in Appendix Table 1). We also use a new measure of being influential within a network namely input proximity prestige index. We find that one SD higher value in this index is associated with 0.06 SD lower GHQ score (95% CI -0.124 to 0.010, see row [5]), suggesting better mental health outcomes.

Appendix Table 2: Robustness Checks

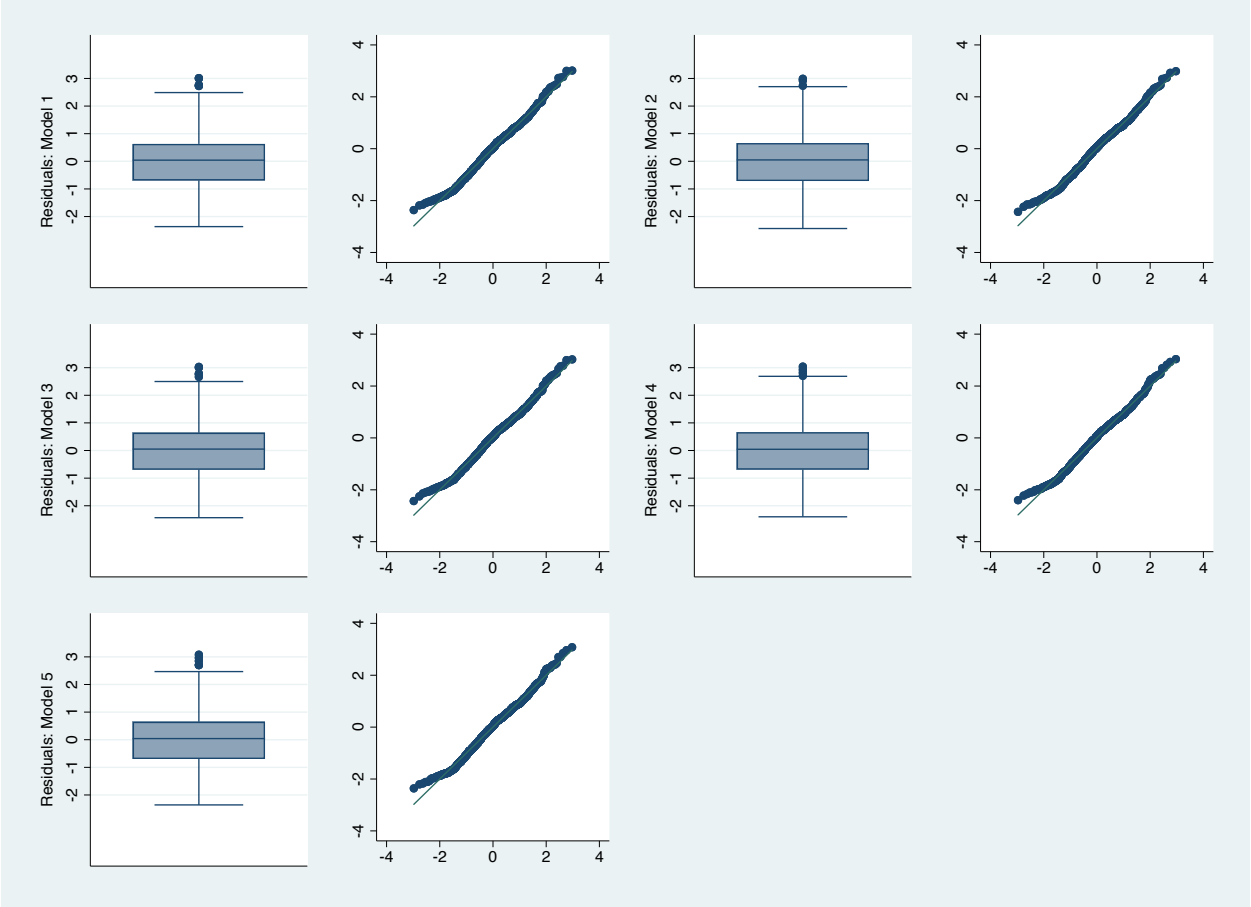
		Coefficient	(95% CI)	N	R^2
(1)	Betweeness Centrality (standardized) excluding isolated respondents	-0.098***	(-0.151 to -0.044)	557	0.058
(2)	= 1 if Betweenness Centrality > 0	-0.163**	(-0.321 to -0.004)	824	0.038
(3)	Eigenvector Centrality (standardized) excluding isolated respondents	-0.060***	(-0.098 to -0.023)	557	0.051
(4)	= 1 if Eigenvector Centrality > 0	-0.117	(-0.257 to 0.023)	824	0.037
(5)	Input Proximity Prestige (standardized)	-0.057*	(-0.124 to 0.010)	824	0.036
Results from ordered probit models					
(6)	All closeness centrality (standardized)	-0.052	(-0.124 to 0.019)	824	
(7)	Betweenness centrality (standardized)	-0.106***	(-0.177 to -0.034)	824	
(8)	Eigenvalue centrality (standardized)	-0.064*	(-0.133 to 0.006)	824	

Note: The outcome variable is the standardized GHQ score in all specifications. In specifications (1) and (3), we drop the respondents who do not have any friendship tie. In specifications (2) and (4), we use an indicator variable for respondents with non-zero centrality values. In specifications (6-8), we use ordered probit models for the discrete standardized GHQ score as the outcome variables. In all specifications, we have retained the control variables that we include in Table 3. The robust p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

As we noted earlier, GHQ scores are essentially discrete in nature and we could actually reject null hypothesis of normality distribution in GHQ scores. So we have re-estimated the models with three centrality scores using ordered probit models and relaxed the normality assumption in the outcome variables. The results are presented in rows (6-8). We find that both

the point estimates and also the second moments are generally not sensitive to the alternative regression models.

Appendix Figure 1: Testing for Outliers in Residuals and QQ Plots



Note: In each panel, on the left we plot the box-plot for the residuals from each model reported in Table 3. On the right, we show the QQ plots for the same residuals.

APPENDIX D: DIAGNOSTIC TESTS FOR REGRESSION RESULTS IN TABLE 3

We present some diagnostic tests for the basic Gauss-Markov assumptions here (see Wooldridge 2002). Our outcome variable is discrete in nature so it is important test for normality. We also check for outliers in our models. We box plot the residuals for all five models from Table 3 and also plot the QQ chart to visually inspect the distributions for the residuals from the same models. We present the charts in different panels in Appendix Figure 1.

Simple visual inspections suggest there are few outliers in the residuals from all five models; however, the frequency does not warrant much concern. We also look at the quintile normal figures and residuals generally lie on the lines. While they may suggest that misspecifications may not be an issue we further use statistical tests to check the normality of the residuals. We show the results in Appendix Table 2.

Appendix Table 2: Normality Tests

	p-value	
Model	**Shapiro-Wilk**	**Shapiro –Francia**
1	0.00041	0.00121
2	0.00077	0.00213
3	0.00059	0.00163
4	0.00062	0.00172
5	0.00042	0.00119

Note. We report the p-values from Shapiro-Wilk and Shapiro-Francia tests for residuals from each model reported in Table 3.

The normality tests reported in Appendix Table 2 suggest that in all five models null of hypotheses of normality are rejected. Hence, we carry out further robustness checks with alternate specifications as reported in Appendix D below.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-11
		(b) Indicate number of participants with missing data for each variable of interest	N/A

Outcome data	15*	Report numbers of outcome events or summary measures	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-13
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	See Appendix
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15,16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.