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An exploratory study on the influence of social networks on the care seeking behavior, treatment adherence and outcomes of Tuberculosis patients in Chennai, India.

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Title: An exploratory study on the influence of social networks on the care seeking behavior, treatment adherence and outcomes of Tuberculosis patients in Chennai, India

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Abstract :

Introduction :

Poor treatment adherence and outcomes of TB patients is a key issue which leads to morbidity, mortality and transmission of the disease in the community. Patients level psychological , behavioral factors risk factors along with structural social and health system determinants which lead to poor treatment adherence and outcomes have got wider research attention in tuberculosis context in India. There is a evidence gap in terms of how TB patient's care seeking behavior, treatment adherence and outcomes gets influenced by the social network structure of TB patients and different supports they receive from social network members.

Methods and Analysis

We propose an exploratory cross sectional social network study to assess the social network structure of 380 TB patients in Chennai, who have recently completed their treatment under the Revised National Tuberculosis Program(RNTCP) in India. We will employ ego centric social network survey to generate the social network names and relationships from randomly selected patients and will assess the type of support they have received from different network members retrospectively. Supports received will be categorized as emotional supports, resource support, appraisal support, informational support, spiritual support, and instrumental support. Social network size, composition, density, centrality and cohesion for the individual TB patient with larger networks will be calculated and sociograms will be developed. Multiple logistic regressions will be used to assess the relationship between the "structure of social network members" and "social network supports" on the differential treatment seeking behavior , treatment adherence and outcomes among TB patients.

Ethics and Dissemination : The proposal was approved by the Institutional Review Board and Ethics Committee of School of Public Health, SRM University Kancheepuram. A manuscript with the key findings of study will be published in a peer-reviewed journal and will also be disseminated to the tuberculosis program and research stakeholders.

Keywords : Social Network , Tuberculosis, India , Social Support, Ego centric, Treatment adherence, Treatment completion.

Article Summary

Strengths and limitations of this study:

- The study will generate evidence on the social network characteristics of TB patients and the different social supports enabled by the network members.
- The study evidences will complement the existing evidences on individual behavioral determinants and structural determinants of tuberculosis treatment adherence and completion.
- The findings will lead to developing and testing individualized intervention for TB patients based on the different social network support which they are in need to complete treatment and adherence.
- The retrospective design of the study may lead to recall bias and respondent bias among participants in accurately reporting their social network support they received during treatment period.

Introduction:

Anti tuberculosis treatment (ATT) through Directly Observed Treatment Short course (DOTS) remained an effective strategy for Tuberculosis treatment in India, which have saved millions of lives so far since implementation [1,2]. Inspite of effective treatment regimen available, TB patient's poor adherence to anti tuberculosis medication remains a key barrier in program settings [3]. The failure to take TB medication properly leads to poor treatment outcomes among TB patients which leads to the risks of morbidity, mortality ,transmission and drug of the disease in the community. Patient level factors for poor treatment adherence are, "relief from symptoms" at the initiation of treatment , "adverse reactions or side effects" to drugs, "alcoholism", psycho social problems like "depression" and "stigma", familial and occupational problems, lack of money and loss of wages, non supportive health staffs , lack of awareness and knowledge about the treatment etc. [4–7]

While the psycho- social , behavioral, economical and health system related risk factors have been assessed of their TB treatment adherence and outcomes widely in India, still there is a paucity of research on how the social network of TB patients influence and affect the treatment status of TB patients through impacting their behavior, access and utilization of individual patients. There needs a focused research on how the social networks of TB patients enable them in receiving different types of social psychological , economical and emotional support which they received during their treatment period .

Social network analysis (SNA) is the study of social structure which connects individuals. Social network has three sub components, which are i) the network relationships i.e. the characteristics or attributes of the individuals , ii) network structures which is the positions of individuals within the network, and iii)

the network functions which is the influence of network members between each other[8] . Social network as a novel research discipline has been utilized for diverse purposes in the health research settings. Many social network studies have provided unconventional data which haven throws insights into the relationship dynamics between members of a social group. A study which examined the association between network diversity and health behaviors among cancer patients showed that low network diversity was significantly associated with sedentary and risky health behaviors like lack of physical exercise, increased weight & obesity, smoking, and alcohol intake [9].A study in Ethiopia utilized data which included use of modern contraception among rural residents and assessed the duration of adoption of modern contraception. It was found that the of person-to-person contact through either friendship or spatial networks is minimal in influencing contraception use [10]. A study was conducted among aboriginal communities on their patterns of social interactions in receiving health information and awareness which showed that specific community members were having higher betweenness, degree and closeness centrality and thus were facilitating the flow of health information to other members of the social network. [11]. A study in Bangladesh highlighted the importance of social networks as a medium and mean to support the needy and vulnerable mother in changing their health care behavior and to effectively access appropriate maternal health service [12]. Social network analysis has been successfully employed to identify social structure and key individuals who influence the sexual behavioras of key populations (like sex workers, MSM and IDUs) such as condom use, HIV prevention, client management etc.[13] Social network analysis describe how critical social partnerships help to increase their social support and social capital [14].

While Social network as a novel research discipline has been employed for understanding of tuberculosis transmission in the community, still the potential of social network in influencing the

health care seeking behavior and treatment status of individual patients within their familial and social context has not been given sufficient research focus so far.

Rational for the study

We define the social network of TB patients as those individuals with whom the TB patients have lived, socialized, worked, shared resources and reciprocal relationships during the time of their treatment period. diagnosis or symptoms identification at least. The network members were of different types, whom could be family members, relatives, friends, occupational contacts, neighborhood contacts etc.Social support for TB patients though their social networks is of different types which include the following supports- with respects to their needs in terms of diagnosis , treatment and care for their tuberculosis disease .Emotional support (motivation, care, sympathy and understanding); resources (money, food , transport help, job support and other economic and related needs); appraisal (support in decision-making); informational (advice, knowledge ,referrals), spiritual support (trust and value) and instrumental support (helping in services like accompanying to hospital or sharing house works etc)

Social networks impacts the health behavior and status of the individuals by acting as medium for generating social capital, enabling social learning, experiencing social influences and impacts , through which the individual values, norms and behavioral patterns are reinforced or new ones are diffused. Individuals who are densely interconnected, highly cohesive and centrally located within local social networks are more likely to hear about new information's, access resources', and have newer experience.

Social network research evidences show that some features of network relations like reciprocity is correlated with better psychological status of the individuals and they are again influencing the health behavior and health status of the individuals. Increased density and cohesiveness may help individuals

receive emotional supports. Alternatively social network may also have negative impacts for the individuals, like peer network for alcohol and smoking may have deleterious effect on the health status and health behavior of the patients.

Understanding social network of TB patients in these multiple dimensions would help to understand how the social network relationships play role in the patient's course of TB treatment. With this background this study proposes to assess the influence of social network of TB patients on their adherence to tuberculosis treatment and its outcomes.

Study Objectives :

a) To assess the social network structure of TB patients with varying treatment seeking behavior, treatment adherence and outcomes

b) To assess the different supports needed, perceived by TB patients from their social network members (resources, information's, emotional supports, spiritual support, appraisal support and instrumental support) in the context of their care seeking behavior, treatment adherence and outcomes

c) To assess how the personal social network size, composition and functions mediates the TB patients care seeking behavior, treatment adherence and outcomes

Hypothesis

- There is a significant difference between the social network size and composition of TB patients with favorable and unfavorable treatment outcomes
- There is a significant difference between the social network supports received by TB patients, with favorable and unfavorable treatment outcomes

- There is a significant difference between the social network size and composition of TB patients with regular and irregular adherence
- There is a significant difference between the social network supports received by TB patients with regular and irregular adherence

Methodology

This study would be of exploratory in nature since, there are no studies done on the social network of the TB patients and their influence on the health behaviors. The evidence generated by this study would be of first line in this domain and would lead to designing novel interventions based on this.

A cross sectional e social network survey would be conducted among randomly selected 380 TB patients in Chennai who have recently completed their "treatment period" of 6 months under RNTCP. The **type of Social Network would** be ego centric personal social network [15,16] and the **study settings would be** Treatment Units in Chennai, Tamilnadu. As there were no studies on personal social network of TB patients in India, we assume a 50% prevalent network difference (Review of TB Social Networks, Journal of Social Structure, 2017).Considering this at 95% CI, precision 5%, the expected sample size to identify any differences in the social network structure of TB patients was calculated as **380.**Formula used for calculating the sample was. Z^2 P (1-P)/d^2.

Study participants

Inclusion criteria:

1) TB patients who have completed six months of treatment without any default (n=127)

2) TB patients who have defaulted and further completed their treatment(n=127)

3) TB patients who have defaulted during their treatment period and were loss to follow up(n=127)

Exclusion criteria: 1) TB patients with HIV confection. 2) Pediatric TB patients. 3) MSM, TG and other key population with dense social networks

Method of survey: An ego centric social network design will be used through which the egos (TB patients) will probe sing name generator methods. The social networks survey will use an ego-centric design in which only the egos (TB patients) information of social network will be elicited by name generation methods but the alters (social network contacts) will not be interviewed for reciprocity. The questions will be unprompted and will be based on recall.

The social network survey will include three fours major steps.

1. Collection of demographic, treatment and other background information from the patient.
2. Information on the needs of the TB patients throughout the period of diagnosis and treatment will be inquired. Needs in terms of resources, information, livelihood support, emotional & spiritual support, instrumental support, occupational support etc will be listed and asked.
3. List of social network members of the TB patients and the kind of support they have received (against which they needed) from them from the time of TB symptoms to treatment end /or last treatment point. This will done using name generator methods where the participants will probe to list the names of the social network members. The social network members who have

contributed to the TB patients in terms of resource support, information support, emotional support, spiritual support, appraisal support, instrumental support will be listed separately. The network members may be individuals or institutions like NGO themselves or some social events/meetings.

4. Information on the type and nature of relationships between the network members and the TB patients will be collected. Network relations will be broadly classified as family, friendship, neighborhood, community, occupational, and occasional. The characteristics and closeness of relation between the network members within themselves and with the TB patients and the frequency of their interaction will also be gathered.

Variables to be used in the study:

1) Dependent Dichotomous variables :
2) TB patients who have completed treatment without any default and those with default
3) TB patients who have failed to complete treatment and who didn't

Social network Independent variables:

1) Proportion of alters by demographic and behavioral characteristics
2) Proportion of supportive alters/ with risky behaviors
3) Proportion of alters that provide resource support
4) Proportion of alters that provide information support
5) Proportion of alters that provide emotional support
6) Proportion of alters that provide instrumental support
7) Proportion of alters that provide spiritual support

8) Proportion of alters that provide spiritual Support

Metrics to be used for measuring independent variables : Average Network size, Average Number of components/, Average Weak and Strong ties, Average Betweenness centralization, Average Networks density, Average centrality, Average number of isolates/Subgroups, Average cohesion

Personal Social Network characteristics will be described as below.

Information on the type and nature of relationships between the network members and the TB patients will be collected. Network relations will be broadly classified as family, friendship, neighborhood, community, occupational, and occasional. The characteristics and closeness of relation between the network members within themselves and with the TB patients and the frequency of their interaction will also be gathered.

Data Analysis:

Proportion of network members of TB patients will be calculated using descriptive statistics. Socio grams will be generated to assess the structure of TB patients network. Social network metrics including network size, density, centrality and cohesion for the individual TB patient with larger networks will be calculated. Proportion of network members by characteristics of interest will be calculated using descriptive statistics. Socio grams will be generated to assess the structure of TB patient's network. Cluster analysis will used to group networks of similar kinds. Multiple logistic regressions will be used to assess "structure of social network members" and "social network supports" on the differential treatment seeking behavior , treatment adherence and outcomes among TB patients.

Ethics and Dissemination :

The proposal was approved by the Institutional Review Board and Ethics Committee of School of Public Health, SRM University Kancheepuram Chennai. The ethics committee assessed and judged about the protection of confidentiality of patients social network information, analysis methods, ethical issues involved. The study is about to be initiated in Chennai. A manuscript with the key findings of this exploratory study will be published in a peer-reviewed journals. We will also be disseminating our findings to the Programme and research stakeholders involved in Tuberculosis Programme in India. After completion of the study, and after the key findings are published data requests could be submitted to the researchers at the School of Public Health SRM University.

Discussion

This exploratory social network analysis will highlight on the size and composition of social network of TB patients and the flow of different kind of supports they received for the purpose of their TB treatment. The study will throw light on the complexity of the needs of the TB patients and the network relations which have enabled them . Study will highlight whether the social network supports received by TB patients influence favorable treatment outcomes and adherence. Identifying the gaps in the social network support between different groups of TB patients will lead to designing interventions and further test the effectiveness of social network intervention through larger trials. The findings from such larger trials could be used to identify the kind of social support which is lacking for the TB patients with poor treatment outcomes and based on the linkages or referrals could be made on individual basis for them. Social network information on TB patients would thus enable to address the individual level support mechanisms.

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Authors Contribution: KN reviewed the literature, conceptualized and developed the proposal. BD provided the critical inputs on sampling and methodology of the study and revised the manuscript.

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Keywords:	Social Network, Tuberculosis < INFECTIOUS DISEASES, India, Social Support, Ego centric, Treatment adherence

Title: An exploratory study on the influence of social networks on the care seeking behavior, treatment adherence and outcomes of Tuberculosis patients in Chennai, India

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Abstract

Introduction

Poor treatment adherence and outcomes of tuberculosis (TB)patients leads to drug resistance, increased chances for morbidity, mortality, and transmission of the disease in the community. Individual level psychological, behavioral factors risk factors of patients and structural level social and health system determinants of treatment adherence and outcomes had been studied widely in India and other countries. There is an evidence gaps on how the TB patient's care seeking behavior, treatment adherence and outcomes are influenced by the social network structure of TB patients and the different supports they received from social network members.

Methods and Analysis

We propose an exploratory cross-sectional social network study to assess the social network structure of TB patients in Chennai, who recently completed their treatment under the Revised National Tuberculosis Program (RNTCP) in India. We will employ ego centric personal social network survey to 380 TB patients to generate their social network relationships and will retrospectively assess the type of supports they received from different network members re. Supports received will be categorized as emotional support, resources support, appraisal support, informational support, spiritual support, occupational support and practical support. Social network size, composition, density, centrality and cohesion for the individual TB patient will be calculated and sociograms will be developed. Multinomial logistic regressions will be used to assess the relationship between the "structure of social network members" and "social network supports" on the differential treatment seeking behavior , treatment adherence and outcomes among TB patients.

Ethics and Human protection : The proposal was approved by the Institutional Review Board and Ethics Committee of School of Public Health, SRM University Kancheepuram. Confidentiality and privacy of participants will be protected. Duty of care for patients who have not completed treatment will be ensured by taking all possible measures to bring them back for treatment.

Keywords: Social Network, Tuberculosis, India, Social Support, Ego centric, Treatment adherence, Treatment completion.

Article Summary

Strengths and limitations of this study:

- The study will generate evidence on the social network characteristics of TB patients and the different social supports enabled by the network members.
- The study evidences will complement the existing evidences on individual behavioral determinants and structural determinants of tuberculosis treatment adherence and completion.
- The findings of this study will lead to further develop and test individual patient centric intervention's for addressing barriers and challenges faced by TB patients to complete treatment with adherence.
- The retrospective collection of information may lead to recall bias and respondent bias among participants in accurately reporting their social network support they received during treatment period.

Introduction

Antituberculotic treatment (ATT) through Directly Observed Treatment Short course (DOTS) as an effective strategy for Tuberculosis(TB) treatment , had saved millions of lives in India [1,2]. Inspite of

effective treatment available, challenges in adherence to medication remains a key barrier in program settings [3]. Improper TB medication leads to poor treatment outcomes among patients leading to drug resistance, morbidity, mortality, and disease transmission in the community. Studies have identified individual patient level factors leading to poor treatment adherence which are, "relief from symptoms" at the initiation of treatment , "adverse reactions or side effects" to drugs, "alcoholism", psycho social problems like "depression" and "stigma", familial and occupational problems, lack of money and loss of wages, nonsupportive health staff lack of awareness and knowledge about the treatment etc. [4–7]

Psycho- social and behavioral factors of TB patients and structurally determining economical and health system related factors had been widely studied for their impact on the TB treatment adherence and outcomes in India and other countries. But still there is a paucity of research on how the social networks of TB patients influence their health care seeking behavior, treatment access, adherence and completion. There is a need to assess how the social networks of TB patients enable them to receive the different types of social, psychological, economical and practical supports during their treatment period.

Social network analysis (SNA) is the study of social structure which connects individuals. Social network has three sub components, which are i) the network relationships i.e. the characteristics or attributes of the individuals , ii) network structures which is the positions of individuals within the network, and iii) the network functions which is the influence of network members between each other[8]. Social network is a novel research discipline which is increasingly applied for diverse purposes in the health research settings. Social network studies have generated data which are different from the conventional data in providing insights into the relationship dynamics between members of a social group and its impact on health behaviors. A study which examined the association between network diversity and health behaviors among cancer patients showed that low network diversity was significantly associated with sedentary and risky health behaviors (lack of physical exercise, increased weight & obesity, smoking, and

alcohol intake) [9].A study in Ethiopia utilized social network data to understand the duration and adoption of modern contraception among rural residents and found that friendship or spatial networks is minimal in influencing contraception use [10]. A study conducted among aboriginal communities assessed their social interaction patterns showed that specific community members were having higher betweenness, degree and closeness centrality and thus were facilitating the flow of health information to members of the social network[11]. A study in Bangladesh highlighted the importance of social networks as a medium and mean to support the needy and vulnerable mother in changing their health care seeking behavior to effectively access maternal health service [12]. Social network analysis had been successfully employed to identify the social structure and key individuals who influence the safe condom use and client management of key populations (like sex workers, Men who have sex with men(MSM) and Injecting Drug Users(IDUs) [13]. Social network research had been used to describe how critical social partnerships helped these key populations to increase their social support and social capital [14].

Social network as a novel research discipline had been used in many countries for understanding the tuberculosis transmission dynamics in the community. Still the potential of social networks in influencing the health care seeking behavior and treatment status of individual tuberculosis patients within their familial and social context has not been given sufficient research focus..

Rational for the study

We define the social network of TB patients as “those individuals with whom the TB patients had lived, socialized, worked, shared resources and had reciprocal relationships during their treatment period". The social network members are inclusive of family members, relatives, friends, occupational relations, neighborhood relations, community relations etc. Social support for TB patients enabled through their social networks are of different types with respect to their needs during treatment and care for their

disease. The broad domains of support are : Emotional supports (motivation, care, sympathy and understanding received); resources supports (money, food , transportation help, job support, economic and related needs); appraisal supports (decision-making in terms of treatment continuation and completion); informational supports (advice, knowledge ,referrals), spiritual supports (building trust and value in life) and instrumental supports (helping in daily activities like accompanying to hospital, sharing house works, child care)

Social networks impact the health behavior and health status of the individuals by acting as a medium for generating social capital and supports. Social network of individuals enables social learning, and to experience social influences through which the values, norms and behavioral patterns of individuals are reinforced or new one's are diffused. Individuals who have densely network connections have highly cohesive networks and individuals who are centrally located within social networks are more likely to learn about new information's, access resource's, and have newer experiences.

Social network research evidences highlight that some network property like "reciprocity" (relationship being reciprocated by network members is correlated with better psychological status of the individuals and also influence the health behavior and health status of the individuals. Increased "density" and "cohesiveness" (meaning more ties between network members) may help individuals receive emotional supports. Alternatively social network may also have risky impacts for individuals, when network members with risky behaviors (like alcohol and smoking)may have deleterious peer effect on their health status and health behaviors.. With this background this study proposed to assess the social networks of TB patients to help understand how social networks could impact treatment adherence and outcomes among the TB patients.

Study Objectives

a) To assess the social network structure of TB patients with varying treatment seeking behavior, treatment adherence and outcomes

b) To assess the different supports needed and perceived by TB patients from their social network members (resources, information's, psychological supports, spiritual supports, appraisal supports , occupational and practical supports) in the context of their care seeking behavior, treatment adherence and outcomes

c) To assess the influence of TB patients personal social network structure and social network enabled supports on their care seeking behavior, treatment adherence and outcomes

Hypothesis

- There is a significant difference between the social network size and composition of TB patients with favorable and unfavorable treatment outcomes
- There is a significant difference between the social network supports received by TB patients, with favorable and unfavorable treatment outcomes
- There is a significant difference between the social network size and composition of TB patients with regular and irregular adherence
- There is a significant difference between the social network supports received by TB patients with regular and irregular adherence

Methodology

Study setting: Treatment Units of Revised National Tuberculosis Control Program (RNTCP) of Chennai City, Tamil Nadu, India.

Study design

This study would be of exploratory in nature which will first time explore the social networks of the TB patients and its influence on treatment outcome. A cross sectional social network survey will be conducted among TB patients in Chennai city who have recently completed their treatment under the Revised National Tuberculosis Control Program (RNTCP)of Tamil Nadu, India. The type of Social Network would be ego centric personal social network [15,16] and the study settings would be Treatment Units in Chennai, Tamilnadu. By ego centric, we refer our study participant of interest (TB patients) as "Ego". The individuals whom the TB patient is nominating as his/her social network member– relatives, friends, workplace relations, neighbors, advisors, etc., are referred to as alter.

Sample size and sampling method

As there were no studies on personal social network of TB patients in India, we assume a 50% prevalent network difference[17].Considering this at 95% Confidence Interval , with precision of 5%, and 10% drop outs or missing treatment details of patients**,** the expected sample size to identify any differences in the social network structure of TB patients was calculated as 380 **.**Formula used for calculating the sample was Z^2 P (1-P)/d^2 in which "Z" denotes Z Statistic for a level of confidence, "P" denotes expected prevalence or proportion and "d" denotes precision

These 380 TB patients will be recruited from the RNTCP Treatment Units of Chennai Corporation. Out of the 36 TUs of Chennai corporation with varying caseloads, the study TUs will be selected using probability proportional to size (PPS) sampling method. Further individual patient who completed treatment with adherence, completed without adherence and patients who were Lost to follow-up will be recruited consecutively from the treatment registers of all the selected TU's till the required sample size is reached.

Our study will include patients who have initiated treatment in the past six months before the study commences.

Study Duration: The study is planned to be conducted for a period of one year between January 2019 to December 2019. Piloting of study tools has been completed.

Study participants

Inclusion criteria:

1) TB patients who have completed treatment with adherence (n=127)

2) TB patients who have completed their treatment without adherence(n=127)

3) TB patients who were Loss to Follow Up (LFU) during treatment (n=127)

Exclusion criteria: 1) TB patients with HIV confection. 2) Drug resistant TB patients 3) TB patients aged less than 18 years 4) Men Who Have Sex with Men (MSM), Transgender (TG) and other key population with TB. 5) Participants registered for treatment under private sector.

Method of survey: Eligible patient's name, contact details and treatment related information will be listed for every selected TU. Further with the help of program staff at treatment center we will be communicating the eligible patients to inform about the study purposes and request them for their willingness and appointment. Telephonic contact will be made wherever phone numbers are available or home visits will be made with the help of health visitor (HV) of the treatment center. We will be making home visits only to those patients who were earlier visited by the Health visitor for household contact tracing or for treatment follow up purposes. Based on patient's convenience and willingness, an appointment will be made for meeting at the respective treatment center or in their own house. Further informed consent will be obtained from them after explaining the purpose and details of the study. Patients who are in the near completion of treatment will also be contacted during their visits to

treatment centers and appointments will be fixed. For patients who are loss to follow up, the contact details of the support person of the LFU patient will be obtained and they will be contacted to reach the patients. We will plan our home visits to LFU patients along with the health visitor to make an attempt to initiate treatment.

Study variables, methods of collection and sources

1. Socio -demographic information including age, sex, marital status, education, personal and family income occupation status will be collected. treatment related information including: Treatment type, patient type, co infections, dates of treatment initiation and completion, missed dosses of medication and treatment outcomes will be collected from treatment register and cards of patients. Information on risky behaviors like alcohol and smoking habits and comorbidities will be collected.
2. Information on the needs and challenges of the TB patients throughout the period of treatment will be inquired initially. The patients will be asked to free list their needs which they felt during their treatment time, in terms of resources, information's, emotional & spiritual supports, instrumental or practical supports, occupational, livelihood support. Level of each reported will be categorized as high, moderate and low. Challenges in terms of stigma and discrimination and barriers faced at health facilities will also be inquired.
3. Social network of patients will be elicited by using name generator methods. This will require the respondent (TB patient) to free list his/her actual social network members (either by name or nick name). The question for name generator will be *"Who are the persons with whom you had lived, cohabitated, had friendship, socialized, worked or had some reciprocal relationships during your treatment period*". The respondents will be asked to mention the relationship he/she has with these network members by themselves. The other attributes of the social network members like

age, sex, occupational status, TB status and risk behaviors will be inquired. The free listed social network relationships will be broadly classified as family, relatives, friendship, neighborhood, community, occupational, and occasional relationships or as based on the responses. The disclosure by TB patients of their disease status to these social network members will be inquired.

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4. The different supports (in terms of resources, information's, psychological supports, spiritual supports, appraisal supports, occupational and practical supports) received by the TB patient's from their social network members to address their needs will be inquired as follows : *Which social network members advised you on the problems you faced during the treatment period? Which social network members gave you the money/nutritious food which you needed during the treatment period? Which social network members offered their practical helps for you during the treatment period (like helping in transportation to treatment centre)? Which social network members advised you on problems you faced during the treatment period? Which social network members provided you emotional support when you were feeling psychologically down? Which social network members you visited for social purposes or with whom you spend times during together during treatment period? Which social network members gave you the moral and spiritual support to overcome your difficulties during treatment?* Support provided by the community-based organization members and faith-based institutions and hospital staff will also be collected. The level of received support will be coded as Supported "Always" or "sometimes" or "rarely". Frequency of socialization, experiences of stigma and information on quality of life will be collected.

5.Information on the relationship nature, frequency of meet will be inquired. Perceived closeness of between the TB patient and his/her social network members will be collected from the perspective of patient only and will be graded as High Moderate and Low The nature and closeness of relation between the network members of TB patients will also be inquired from the patients perspective only and will be graded.

Patient and public involvement:

The research question and objective of the proposed study were informed by the past experiences of investigators in interviewing TB patients about their out of pocket expenditures for TB treatment and coping up mechanism they used to address financial and related burden. We have conducted many informal talks with treatment completed and loss to follow up patients, their families and friends to understand the importance of their social supports during the proposal development phase. We directly heard from the patients on how important was social network supports for them. We will conduct a patient -provider meeting at TU level to explain and disseminate the outcome of this study.

Data validity and relevance

The accuracy of the social network data collected from the patient is crucial and key for this study. We will be using the following methods and steps to ensure its accuracy and reliability.

1)The respondents will be asked to free list their social network members and their type of relationship with them. No preconceived relationship categories will be used to question the participant. This validated method will be followed to avoid the respondent biases, when participants are presented with preconceived relationship categories to fit in their networks[18].

2) To assure the reliability and validity of the ego centric networks obtained in our study testing -retesting method will be used. Re -interview by a second interviewer will be done among 5% of our sample after a time gap of one month for re-collecting only the social network information. Pearson's correlation coefficient will be used to compare the aggregated network characteristics reported in both interviews. Re interviewed respondents will be provided additional incentives for their cooperation and time spent for the study. This method has been validated in earlier studies[19].

3) An in-built mechanism to check for the consistency of the social network reporting by patients will be used. The strength of relation of any two-network member reported by the respondent will be repeat coded for the second time to check for consistency in responses. Any discrepancy will be clarified with the respondent again.

4) Participants will be explained about the importance of their social network information which could make an impact in ensuring social network supports for other patients in future. This will motivate the participant to provide valid responses. Considering gender sensitiveness in reporting personal information's in Indian context, interviewers of same gender as that of participant will assigned for interviewing them. Health staff of treatment center who had delivered medication to the patient will be referred at the time of interview initiation which will improve the respondent's confidence to share personal network information's. Participants will be provided monetary incentive to for their time spent for their interview.

Calculation of personal social network metrics:

Personal network metrics of patients will be calculated by constructing and analyzing the proximity matrix using the standard methods which have been successfully used and tested for their validity in earlier studies[18]. These metrics will be used to understand the structure of the personal social network metric

from the ego's perspective in addition to the attributes of the network members. Personal network measures will be calculated after the removal of ego from the adjacency matrix, since personal networks of ego is a primary actor who connects all his personal networks. The key network metrics which will be used in this study are as follows

Network size: The total number of unique personal network members(alters) reported by each patient

Networks density: The percent of connection that exist in the personal network of patient out of all possible connections

Components: A component is a portion of personal network in which the network members of a patient are connected to one another directly or indirectly by at least one tie.

Degree centrality: Number of direct ties a personal network member has with other network members

Cliques: Set of personal network members of patient who are connected to one another directly

Betweenness centralization: The number of times a network member of patient who connects pairs of other network members, who otherwise cannot reach one another.

Number of isolates: Personal network member of a patient who doesn't have any contact with other members of personal networks.

Data Analysis Plan

Descriptive analyses will be performed to examine the characteristics of the study population, and the results will be presented as the mean and standard deviation (SD) or percentages and numbers. We will generate the following statistics for patients and their network members

Proportion of patient by key socio demographic characteristics, mean social network size, proportion of social network members segregated by perceived closeness, frequency of meet, disclosure status (with whom disease status disclosed or not by patients), proportion of social network members segregated by risk behaviors (having alcohol and smoking habits), mean network size segregated by relationship types (family members, extended family members, friends, neighbors, occupational contacts, community contacts, faith groups, hospital based contacts), mean number of network members who provided supports (segregated by different type of received support)

To assess the differences between participants with different adherence and treatment outcomes status chi-square, analysis of variance (ANOVA) and Kruskal-Wallis tests will be used as appropriate. Multinomial logistic regression analysis will be used to examine the association of the social network properties of TB patients with different treatment outcome and adherence status as dependent variables. Regression will be adjusted for key socio demographic characteristics of TB patients including age, sex, occupation, marital status, income status, alcohol intake, smoking and comorbidities. Disclosure status of TB by patients with social network members, socialization levels and stigma experiences will be used as instrumental variables to address the endogeneity of regressors using validated methods earlier reported[20][21]. These instrumental variables will be used since they could cause variation in the network size and type of social network support received by the participant but doesn't have any direct impact on treatment outcomes or adherence. Odds ratios (ORs) and 95% confidence intervals (95%CIs) will be reported. Associations with $p \leq 0.05$ will be considered for statistical significance. Missing data Statistical interactions (effect modification) of the social network characteristics with individual characteristics (gender, will be tested and if found significant, stratified analysis will be done. Cluster analysis will used to group networks and cliques of similar kinds.

For handling missing values with regard to the attributes or relationship nature in social network data, statistical correlation between complete dataset and missing dataset will be found to check for significant differences and further appropriate imputation methods will be used[22]. Descriptive and inferential statistics will be conducted using IBM SPSS software version 20.0. Social network data will be analyzed using NodeXL (version 1.0.1.92) for generating the social network metrics and socio grams.

Ethics and Human protection

The proposal was approved by the Institutional Review Board and Ethics Committee of School of Public Health, SRM University Kancheepuram Chennai. The ethics committee assessed and judged about the protection of confidentiality of patient's social network information, analysis methods, ethical issues involved. The data collection process will be conducted in the treatment centers of RNTCP or at the place of residence of TB patients as per his/her willingness. Prior permission will be obtained for conducting interviews at the centers and will be done in a private place for ensuring privacy and confidentiality. Interviews which are conducted at the residence of the patient will be done only with the presence of patient alone and not in presence of others. Appointments will be fixed with the patient based on their convenience in this regard. Study informed consent will be followed a detailed explanation of the objectives and the expected information about their social networks and related supports. Participants will be clarified that interviews will involve only them, and no contacts will be made with any of their social network contacts. Confidentiality of their network information will be assured to them. Participants will be requested to provide information on social networks based on their complete willingness. We will ensure that interviewers belong to the same gender as the participant if participant feel discomfort in sharing network relations with opposite gender. Participants will not be compelled to disclose the actual names of their network members and rather will be provided choice to use nick names. If participants are

not willing to disclose all their network relations but only some, they will not be compelled further. Participants will be provided chance to withdraw from the interview if they feel uncomfortable. As interviews will involve personal questions related to the social networks and related supports we will involve trained and experienced study staff to make the interview comfortable for participants. Participants will be provided compensation for their travel, food and time spent for the study. Patients who are loss to follow up will be motivated and counselled to continue the treatment again. We will work in coordination with the program staff to support the loss to follow up patients for continuing back the treatment. For willing patients, we will link them with local community organizations and community volunteers -who are already working as part of the TB free city project- to meet their needs. All data forms will be kept confidential and all analysis will be performed by delinking the names of the patients. Names/nick names of the social network members will not be entered during the data entry process and only relationship types will be entered. All data forms will be kept in a strictly confidential and data access will be password protected. We will also be disseminating our findings to the Programme and research stakeholders involved in Tuberculosis Programme in India and possible interventions will be discussed and communicated with policy makers. A manuscript with the key findings of this exploratory study will be published in a peer-reviewed journals. After completion of the study, and after the key findings are published data requests could be submitted to the researchers at the School of Public Health SRM University.

Discussion

This exploratory social network analysis will highlight on the size and composition of social network of TB patients and the different kind of supports they received during their TB treatment period. . The study will throw light on the complexity of the multiple needs of the TB patients and the network relations which have enabled them to address these multiple needs Study findings will highlight whether the social

network supports received by TB patients influenced their favorable treatment outcomes and adherence. Identifying the gaps in the social network support between TB patients with different treatment outcomes and adherence will further lead to design and test the effectiveness of tailored social network driven interventions to address the gaps in the patient support systems through randomized network intervention trials at community levels. The findings from our study could single out the specific supports which are deemed essential TB patients, and which are lacking for them in the context of their treatment adherence and completion. Our exploratory study finding which is limited by its cross sectional design could be further rigorously assessed for their causality on treatment outcomes and adherence through larger randomized network intervention trials. Our finding on the social network of on TB patients would thus enable to address the gaps in the individual patient level support mechanisms in an scientific and evidence based way which has not be tried anywhere before. The evidence generated by this study would be of first of its kind and would certainly encourage novel patient centric tailored interventions for addressing treatment barriers and challenges experienced by patients in resource poor settings.

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BMJ Open

A study protocol for an exploratory cross-sectional social network study to assess the influence of social networks on the care seeking behavior, treatment adherence and outcomes of Tuberculosis patients in Chennai, India

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Title: A study protocol for an exploratory cross-sectional social network study to assess the influence of social networks on the care seeking behavior, treatment adherence and outcomes of Tuberculosis patients in Chennai, India

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Abstract

Introduction

Poor treatment adherence and outcomes of tuberculosis (TB)patients leads to drug resistance, increased chances for morbidity, mortality, and transmission of the disease in the community. Individual level psychological, behavioral factors risk factors of patients and structural level social and health system determinants of treatment adherence and outcomes had been studied widely in India and other countries. There is an evidence gaps on how the TB patient's care seeking behavior, treatment adherence and outcomes are influenced by the social network structure of TB patients and the different supports they received from social network members.

Methods and Analysis

We propose an exploratory cross-sectional social network study to assess the social network structure of TB patients in Chennai, who recently completed their treatment under the Revised National Tuberculosis Program (RNTCP) in India. We will employ ego centric personal social network survey to 380 TB patients to generate their social network relationships and will retrospectively assess the type of supports they received from different network members re. Supports received will be categorized as emotional support, resources support, appraisal support, informational support, spiritual support, occupational support and practical support. Social network size, composition, density, centrality and cohesion for the individual TB patient will be calculated and sociograms will be developed. Multinomial logistic regressions will be used to assess the relationship between the "structure of social network members" and "social network supports" on the differential treatment seeking behavior , treatment adherence and outcomes among TB patients.

Ethics and Human protection : The proposal was approved by the Institutional Review Board and Ethics Committee of School of Public Health, SRM University Kancheepuram. Confidentiality and privacy of participants will be protected. Duty of care for patients who have not completed treatment will be ensured by taking all possible measures to bring them back for treatment.

Keywords: Social Network, Tuberculosis, India, Social Support, Ego centric, Treatment adherence, Treatment completion.

Article Summary

Strengths and limitations of this study:

- The study will generate evidence on the social network characteristics of TB patients and the different social supports enabled by the network members.
- The study evidences will complement the existing evidences on individual behavioral determinants and structural determinants of tuberculosis treatment adherence and completion.
- The findings of this study will lead to further develop and test individual patient centric intervention's for addressing barriers and challenges faced by TB patients to complete treatment with adherence.
- The retrospective collection of information may lead to recall bias and respondent bias among participants in accurately reporting their social network support they received during treatment period.

Introduction

Antituberculotic treatment (ATT) through Directly Observed Treatment Short course (DOTS) as an effective strategy for Tuberculosis(TB) treatment , had saved millions of lives in India [1,2]. Inspite of

effective treatment available, challenges in adherence to medication remains a key barrier in program settings [3]. Improper TB medication leads to poor treatment outcomes among patients leading to drug resistance, morbidity, mortality, and disease transmission in the community. Studies have identified individual patient level factors leading to poor treatment adherence which are, "relief from symptoms" at the initiation of treatment , "adverse reactions or side effects" to drugs, "alcoholism", psycho social problems like "depression" and "stigma", familial and occupational problems, lack of money and loss of wages, nonsupportive health staff lack of awareness and knowledge about the treatment etc. [4–7]

Psycho- social and behavioral factors of TB patients and structurally determining economical and health system related factors had been widely studied for their impact on the TB treatment adherence and outcomes in India and other countries. But still there is a paucity of research on how the social networks of TB patients influence their health care seeking behavior, treatment access, adherence and completion. There is a need to assess how the social networks of TB patients enable them to receive the different types of social, psychological, economical and practical supports during their treatment period.

Social network analysis (SNA) is the study of social structure which connects individuals. Social network has three sub components, which are i) the network relationships i.e. the characteristics or attributes of the individuals , ii) network structures which is the positions of individuals within the network, and iii) the network functions which is the influence of network members between each other[8]. Social network is a novel research discipline which is increasingly applied for diverse purposes in the health research settings. Social network studies have generated data which are different from the conventional data in providing insights into the relationship dynamics between members of a social group and its impact on health behaviors. A study which examined the association between network diversity and health behaviors among cancer patients showed that low network diversity was significantly associated with sedentary and risky health behaviors (lack of physical exercise, increased weight & obesity, smoking, and

alcohol intake) [9].A study in Ethiopia utilized social network data to understand the duration and adoption of modern contraception among rural residents and found that friendship or spatial networks is minimal in influencing contraception use [10]. A study conducted among aboriginal communities assessed their social interaction patterns showed that specific community members were having higher betweenness, degree and closeness centrality and thus were facilitating the flow of health information to members of the social network[11]. A study in Bangladesh highlighted the importance of social networks as a medium and mean to support the needy and vulnerable mother in changing their health care seeking behavior to effectively access maternal health service [12]. Social network analysis had been successfully employed to identify the social structure and key individuals who influence the safe condom use and client management of key populations (like sex workers, Men who have sex with men(MSM) and Injecting Drug Users(IDUs) [13]. Social network research had been used to describe how critical social partnerships helped these key populations to increase their social support and social capital [14].

Social network as a novel research discipline had been used in many countries for understanding the tuberculosis transmission dynamics in the community. Still the potential of social networks in influencing the health care seeking behavior and treatment status of individual tuberculosis patients within their familial and social context has not been given sufficient research focus..

Rational for the study

We define the social network of TB patients as “those individuals with whom the TB patients had lived, socialized, worked, shared resources and had reciprocal relationships during their treatment period". The social network members are inclusive of family members, relatives, friends, occupational relations, neighborhood relations, community relations etc. Social support for TB patients enabled through their social networks are of different types with respect to their needs during treatment and care for their

disease. The broad domains of support are : Emotional supports (motivation, care, sympathy and understanding received); resources supports (money, food , transportation help, job support, economic and related needs); appraisal supports (decision-making in terms of treatment continuation and completion); informational supports (advice, knowledge ,referrals), spiritual supports (building trust and value in life) and instrumental supports (helping in daily activities like accompanying to hospital, sharing house works, child care)

Social networks impact the health behavior and health status of the individuals by acting as a medium for generating social capital and supports. Social network of individuals enables social learning, and to experience social influences through which the values, norms and behavioral patterns of individuals are reinforced or new one's are diffused. Individuals who have densely network connections have highly cohesive networks and individuals who are centrally located within social networks are more likely to learn about new information's, access resource's, and have newer experiences.

Social network research evidences highlight that some network property like "reciprocity" (relationship being reciprocated by network members is correlated with better psychological status of the individuals and also influence the health behavior and health status of the individuals. Increased "density" and "cohesiveness" (meaning more ties between network members) may help individuals receive emotional supports. Alternatively social network may also have risky impacts for individuals, when network members with risky behaviors (like alcohol and smoking)may have deleterious peer effect on their health status and health behaviors.. With this background this study proposed to assess the social networks of TB patients to help understand how social networks could impact treatment adherence and outcomes among the TB patients.

Study Objectives

a) To assess the social network structure of TB patients with varying treatment seeking behavior, treatment adherence and outcomes

b) To assess the different supports needed and perceived by TB patients from their social network members (resources, information's, psychological supports, spiritual supports, appraisal supports , occupational and practical supports) in the context of their care seeking behavior, treatment adherence and outcomes

c) To assess the influence of TB patients personal social network structure and social network enabled supports on their care seeking behavior, treatment adherence and outcomes

Hypothesis

- There is a significant difference between the social network size and composition of TB patients with favorable and unfavorable treatment outcomes
- There is a significant difference between the social network supports received by TB patients, with favorable and unfavorable treatment outcomes
- There is a significant difference between the social network size and composition of TB patients with regular and irregular adherence
- There is a significant difference between the social network supports received by TB patients with regular and irregular adherence

Methodology

Study setting: Treatment Units of Revised National Tuberculosis Control Program (RNTCP) of Chennai City, Tamil Nadu, India.

Study design

This study would be of exploratory in nature which will first time explore the social networks of the TB patients and its influence on treatment outcome. A cross sectional social network survey will be conducted among TB patients in Chennai city who have recently completed their treatment under the Revised National Tuberculosis Control Program (RNTCP)of Tamil Nadu, India. The type of Social Network would be ego centric personal social network [15,16] and the study settings would be Treatment Units in Chennai, Tamilnadu. By ego centric, we refer our study participant of interest (TB patients) as "Ego". The individuals whom the TB patient is nominating as his/her social network member– relatives, friends, workplace relations, neighbors, advisors, etc., are referred to as alter.

Sample size and sampling method

As there were no studies on personal social network of TB patients in India, we assume a 50% prevalent network difference[17].Considering this at 95% Confidence Interval , with precision of 5%, and 10% drop outs or missing treatment details of patients**,** the expected sample size to identify any differences in the social network structure of TB patients was calculated as 380 **.**Formula used for calculating the sample was Z^2 P (1-P)/d^2 in which "Z" denotes Z Statistic for a level of confidence, "P" denotes expected prevalence or proportion and "d" denotes precision

These 380 TB patients will be recruited from the RNTCP Treatment Units of Chennai Corporation. Out of the 36 TUs of Chennai corporation with varying caseloads, the study TUs will be selected using probability proportional to size (PPS) sampling method. Further individual patient who completed treatment with adherence, completed without adherence and patients who were Lost to follow-up will be recruited consecutively from the treatment registers of all the selected TU's till the required sample size is reached.

Our study will include patients who have initiated treatment in the past six months before the study commences.

Study Duration: The study is planned to be conducted for a period of one year between January 2019 to December 2019. Piloting of study tools has been completed.

Study participants

Inclusion criteria:

1) TB patients who have completed treatment with adherence (n=127)

2) TB patients who have completed their treatment without adherence(n=127)

3) TB patients who were Loss to Follow Up (LFU) during treatment (n=127)

Exclusion criteria: 1) TB patients with HIV confection. 2) Drug resistant TB patients 3) TB patients aged less than 18 years 4) Men Who Have Sex with Men (MSM), Transgender (TG) and other key population with TB. 5) Participants registered for treatment under private sector.

Method of survey: Eligible patient's name, contact details and treatment related information will be listed for every selected TU. Further with the help of program staff at treatment center we will be communicating the eligible patients to inform about the study purposes and request them for their willingness and appointment. Telephonic contact will be made wherever phone numbers are available or home visits will be made with the help of health visitor (HV) of the treatment center. We will be making home visits only to those patients who were earlier visited by the Health visitor for household contact tracing or for treatment follow up purposes. Based on patient's convenience and willingness, an appointment will be made for meeting at the respective treatment center or in their own house. Further informed consent will be obtained from them after explaining the purpose and details of the study. Patients who are in the near completion of treatment will also be contacted during their visits to

treatment centers and appointments will be fixed. For patients who are loss to follow up, the contact details of the support person of the LFU patient will be obtained and they will be contacted to reach the patients. We will plan our home visits to LFU patients along with the health visitor to make an attempt to initiate treatment.

Study variables, methods of collection and sources

1. Socio -demographic information including age, sex, marital status, education, personal and family income occupation status will be collected. treatment related information including: Treatment type, patient type, co infections, dates of treatment initiation and completion, missed dosses of medication and treatment outcomes will be collected from treatment register and cards of patients. Information on risky behaviors like alcohol and smoking habits and comorbidities will be collected.
2. Information on the needs and challenges of the TB patients throughout the period of treatment will be inquired initially. The patients will be asked to free list their needs which they felt during their treatment time, in terms of resources, information's, emotional & spiritual supports, instrumental or practical supports, occupational, livelihood support. Level of each reported will be categorized as high, moderate and low. Challenges in terms of stigma and discrimination and barriers faced at health facilities will also be inquired.
3. Social network of patients will be elicited by using name generator methods. This will require the respondent (TB patient) to free list his/her actual social network members (either by name or nick name). The question for name generator will be *"Who are the persons with whom you had lived, cohabitated, had friendship, socialized, worked or had some reciprocal relationships during your treatment period*". The respondents will be asked to mention the relationship he/she has with these network members by themselves. The other attributes of the social network members like

age, sex, occupational status, TB status and risk behaviors will be inquired. The free listed social network relationships will be broadly classified as family, relatives, friendship, neighborhood, community, occupational, and occasional relationships or as based on the responses. The disclosure by TB patients of their disease status to these social network members will be inquired.

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4. The different supports (in terms of resources, information's, psychological supports, spiritual supports, appraisal supports, occupational and practical supports) received by the TB patient's from their social network members to address their needs will be inquired as follows : *Which social network members advised you on the problems you faced during the treatment period? Which social network members gave you the money/nutritious food which you needed during the treatment period? Which social network members offered their practical helps for you during the treatment period (like helping in transportation to treatment centre)? Which social network members advised you on problems you faced during the treatment period? Which social network members provided you emotional support when you were feeling psychologically down? Which social network members you visited for social purposes or with whom you spend times during together during treatment period? Which social network members gave you the moral and spiritual support to overcome your difficulties during treatment?* Support provided by the community-based organization members and faith-based institutions and hospital staff will also be collected. The level of received support will be coded as Supported "Always" or "sometimes" or "rarely". Frequency of socialization, experiences of stigma and information on quality of life will be collected.

5.Information on the relationship nature, frequency of meet will be inquired. Perceived closeness of between the TB patient and his/her social network members will be collected from the perspective of patient only and will be graded as High Moderate and Low The nature and closeness of relation between the network members of TB patients will also be inquired from the patients perspective only and will be graded.

Patient and public involvement:

The research question and objective of the proposed study were informed by the past experiences of investigators in interviewing TB patients about their out of pocket expenditures for TB treatment and coping up mechanism they used to address financial and related burden. We have conducted many informal talks with treatment completed and loss to follow up patients, their families and friends to understand the importance of their social supports during the proposal development phase. We directly heard from the patients on how important was social network supports for them. We will conduct a patient -provider meeting at TU level to explain and disseminate the outcome of this study.

Data validity and relevance

The accuracy of the social network data collected from the patient is crucial and key for this study. We will be using the following methods and steps to ensure its accuracy and reliability.

1)The respondents will be asked to free list their social network members and their type of relationship with them. No preconceived relationship categories will be used to question the participant. This validated method will be followed to avoid the respondent biases, when participants are presented with preconceived relationship categories to fit in their networks[18].

2) To assure the reliability and validity of the ego centric networks obtained in our study testing -retesting method will be used. Re -interview by a second interviewer will be done among 5% of our sample after a time gap of one month for re-collecting only the social network information. Pearson's correlation coefficient will be used to compare the aggregated network characteristics reported in both interviews. Re interviewed respondents will be provided additional incentives for their cooperation and time spent for the study. This method has been validated in earlier studies[19].

3) An in-built mechanism to check for the consistency of the social network reporting by patients will be used. The strength of relation of any two-network member reported by the respondent will be repeat coded for the second time to check for consistency in responses. Any discrepancy will be clarified with the respondent again.

4) Participants will be explained about the importance of their social network information which could make an impact in ensuring social network supports for other patients in future. This will motivate the participant to provide valid responses. Considering gender sensitiveness in reporting personal information's in Indian context, interviewers of same gender as that of participant will assigned for interviewing them. Health staff of treatment center who had delivered medication to the patient will be referred at the time of interview initiation which will improve the respondent's confidence to share personal network information's. Participants will be provided monetary incentive to for their time spent for their interview.

Calculation of personal social network metrics:

Personal network metrics of patients will be calculated by constructing and analyzing the proximity matrix using the standard methods which have been successfully used and tested for their validity in earlier studies[18]. These metrics will be used to understand the structure of the personal social network metric

from the ego's perspective in addition to the attributes of the network members. Personal network measures will be calculated after the removal of ego from the adjacency matrix, since personal networks of ego is a primary actor who connects all his personal networks. The key network metrics which will be used in this study are as follows

Network size: The total number of unique personal network members(alters) reported by each patient

Networks density: The percent of connection that exist in the personal network of patient out of all possible connections

Components: A component is a portion of personal network in which the network members of a patient are connected to one another directly or indirectly by at least one tie.

Degree centrality: Number of direct ties a personal network member has with other network members

Cliques: Set of personal network members of patient who are connected to one another directly

Betweenness centralization: The number of times a network member of patient who connects pairs of other network members, who otherwise cannot reach one another.

Number of isolates: Personal network member of a patient who doesn't have any contact with other members of personal networks.

Data Analysis Plan

Descriptive analyses will be performed to examine the characteristics of the study population, and the results will be presented as the mean and standard deviation (SD) or percentages and numbers. We will generate the following statistics for patients and their network members

Proportion of patient by key socio demographic characteristics, mean social network size, proportion of social network members segregated by perceived closeness, frequency of meet, disclosure status (with whom disease status disclosed or not by patients), proportion of social network members segregated by risk behaviors (having alcohol and smoking habits), mean network size segregated by relationship types (family members, extended family members, friends, neighbors, occupational contacts, community contacts, faith groups, hospital based contacts), mean number of network members who provided supports (segregated by different type of received support)

To assess the differences between participants with different adherence and treatment outcomes status chi-square, analysis of variance (ANOVA) and Kruskal-Wallis tests will be used as appropriate. Multinomial logistic regression analysis will be used to examine the association of the social network properties of TB patients with different treatment outcome and adherence status as dependent variables. Regression will be adjusted for key socio demographic characteristics of TB patients including age, sex, occupation, marital status, income status, alcohol intake, smoking and comorbidities. Disclosure status of TB by patients with social network members, socialization levels and stigma experiences will be used as instrumental variables to address the endogeneity of regressors using validated methods earlier reported[20][21]. These instrumental variables will be used since they could cause variation in the network size and type of social network support received by the participant but doesn't have any direct impact on treatment outcomes or adherence. Odds ratios (ORs) and 95% confidence intervals (95%CIs) will be reported. Associations with $p \leq 0.05$ will be considered for statistical significance. Missing data Statistical interactions (effect modification) of the social network characteristics with individual characteristics (gender, will be tested and if found significant, stratified analysis will be done. Cluster analysis will used to group networks and cliques of similar kinds.

For handling missing values with regard to the attributes or relationship nature in social network data, statistical correlation between complete dataset and missing dataset will be found to check for significant differences and further appropriate imputation methods will be used[22]. Descriptive and inferential statistics will be conducted using IBM SPSS software version 20.0. Social network data will be analyzed using NodeXL (version 1.0.1.92) for generating the social network metrics and socio grams.

Ethics and Human protection

The proposal was approved by the Institutional Review Board and Ethics Committee of School of Public Health, SRM University Kancheepuram Chennai. The ethics committee assessed and judged about the protection of confidentiality of patient's social network information, analysis methods, ethical issues involved. The data collection process will be conducted in the treatment centers of RNTCP or at the place of residence of TB patients as per his/her willingness. Prior permission will be obtained for conducting interviews at the centers and will be done in a private place for ensuring privacy and confidentiality. Interviews which are conducted at the residence of the patient will be done only with the presence of patient alone and not in presence of others. Appointments will be fixed with the patient based on their convenience in this regard. Study informed consent will be followed a detailed explanation of the objectives and the expected information about their social networks and related supports. Participants will be clarified that interviews will involve only them, and no contacts will be made with any of their social network contacts. Confidentiality of their network information will be assured to them. Participants will be requested to provide information on social networks based on their complete willingness. We will ensure that interviewers belong to the same gender as the participant if participant feel discomfort in sharing network relations with opposite gender. Participants will not be compelled to disclose the actual names of their network members and rather will be provided choice to use nick names. If participants are

not willing to disclose all their network relations but only some, they will not be compelled further. Participants will be provided chance to withdraw from the interview if they feel uncomfortable. As interviews will involve personal questions related to the social networks and related supports we will involve trained and experienced study staff to make the interview comfortable for participants. Participants will be provided compensation for their travel, food and time spent for the study. Patients who are loss to follow up will be motivated and counselled to continue the treatment again. We will work in coordination with the program staff to support the loss to follow up patients for continuing back the treatment. For willing patients, we will link them with local community organizations and community volunteers -who are already working as part of the TB free city project- to meet their needs. All data forms will be kept confidential and all analysis will be performed by delinking the names of the patients. Names/nick names of the social network members will not be entered during the data entry process and only relationship types will be entered. All data forms will be kept in a strictly confidential and data access will be password protected. We will also be disseminating our findings to the Programme and research stakeholders involved in Tuberculosis Programme in India and possible interventions will be discussed and communicated with policy makers. A manuscript with the key findings of this exploratory study will be published in a peer-reviewed journals. After completion of the study, and after the key findings are published data requests could be submitted to the researchers at the School of Public Health SRM University.

Discussion

This exploratory social network analysis will highlight on the size and composition of social network of TB patients and the different kind of supports they received during their TB treatment period. . The study will throw light on the complexity of the multiple needs of the TB patients and the network relations which have enabled them to address these multiple needs Study findings will highlight whether the social

network supports received by TB patients influenced their favorable treatment outcomes and adherence. Identifying the gaps in the social network support between TB patients with different treatment outcomes and adherence will further lead to design and test the effectiveness of tailored social network driven interventions to address the gaps in the patient support systems through randomized network intervention trials at community levels. The findings from our study could single out the specific supports which are deemed essential TB patients, and which are lacking for them in the context of their treatment adherence and completion. Our exploratory study finding which is limited by its cross sectional design could be further rigorously assessed for their causality on treatment outcomes and adherence through larger randomized network intervention trials. Our finding on the social network of on TB patients would thus enable to address the gaps in the individual patient level support mechanisms in an scientific and evidence based way which has not be tried anywhere before. The evidence generated by this study would be of first of its kind and would certainly encourage novel patient centric tailored interventions for addressing treatment barriers and challenges experienced by patients in resource poor settings.

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