Social networks of patients and health care providers in cardiovascular risk management

Naomi Heijmans
For reasons of consistency within this thesis, some terms have been standardised throughout the text. As a consequence the text may differ in this respect from the articles that have been published.

The studies presented in this thesis have been performed at the Scientific Center for Quality of Healthcare (IQ healthcare). This center is part of the Radboud Institute for Health Sciences (RIHS), one of the approved research institutes of the Radboud university medical center.

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Social networks of patients and health care providers in cardiovascular risk management

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Contents

Chapter 1  Introduction  7

Chapter 2  Social networks of health care providers and patients in cardiovascular risk management: a study protocol

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Chapter 3  Improving participation rates by providing choice of participation mode: two randomized controlled trials


Chapter 4  Social network composition of vascular patients and its associates with health behavior and clinical risk factors

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Chapter 5  Social networks of vascular patients and associations with current and changed health behaviors

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Chapter 6  Information exchange networks of health care providers and evidence-based cardiovascular risk management: an observational study


Chapter 7  General Discussion  139

Appendix

A1: basic network questions for patients  155
A2: network questionnaire for health care professionals  157
A3: network questionnaire for alters of health care professionals  163
A4: network questionnaire for patients  169
A5: network roster for alters of patients  181
B1: Bivariate estimates on clinical risk factors  184
B2: Bivariate estimates of negative social network composition and clinical risk factors  186
B3: Deviations from the study protocol  187

Summary  189
Samenvatting  197
Dankwoord  205
Curriculum Vitae  211
1

Introduction
Introduction

This thesis concerns social networks of patients and healthcare providers involved in cardiovascular risk management (CVRM). Although a wide range of interventions has improved CVRM in the Netherlands, further improvements remain possible. The studies presented in this thesis aimed to identify additional determinants for CVRM using a social networks approach. This introduction starts with the provision of a background in CVRM and social networks of patients and health care providers. After this, the main research questions and a short overview of the content of the thesis are presented.

Cardiovascular disease and high risk for cardiovascular disease

Cardiovascular disease (CVD) remains an important cause of mortality and reduced quality of life worldwide. In 2013 in the Netherlands, CVD was the most common cause of death for women and the second cause of death in men. Treatment for CVD is expensive, with total costs up to 2.1 milliard euro reported in 2011 in the Netherlands. CVD include coronary heart disease, angina pectoris, heart failure, cerebrovascular disease (stroke or transient ischemic attack), aneurism of the aorta, and peripheral arterial disease. Risk factors for CVD are common in the Dutch population. Although some risk factors are not modifiable (such as age and male sex), there are several risk factors which can be influenced and treated. These include, amongst others, health behaviors (smoking, physical activity, and diet) and control of clinical risk factors (blood pressure, cholesterol levels, and body-mass index).

Risk factors are used to derive risk profiles. Risk estimates, calculated using risk functions based on the risk profile, provide estimates of the absolute 10 year risk for death or disease due to CVD. When this risk is 20% or higher, patients are termed being at high risk for CVD.

Cardiovascular risk management and social network analysis

CVD can be prevented by an adequate treatment of risk factors. CVRM comprises the diagnostics, treatment, and follow-up of risk factors for CVD, and includes the provision of advice, counseling, and preventive treatment. A wide range of preventive and clinical interventions, targeted at the population and patients at risk, are recommended in prevailing practice guidelines, emphasizing comprehensive CVRM, changes in health behaviors, and preventive drug therapy. Many conditions for providing recommended CVRM have been optimized in recent years in the Netherlands, including the publication of a multidisciplinary clinical guideline, nationwide supply of paper-based and online patients education tools for CVD patients as well as the general public, and the targeted reimbursement for chronic illness in primary care. Although these efforts have contributed to the quality of CVRM in routine practice, still a specific number of patients did not completely receive recommended CVRM or did not reach target values of CVRM. This led to the question what additional determinants of CVRM and outcomes can be identified, which could be targeted in programs to optimize CVRM.
Social network analysis (SNA) offers a new perspective on the implementation of evidence-based practice in health care. With SNA, relationships between people, groups, or organizations, are mapped and measured, providing a visual and mathematical analysis of human relationships. Social networks are important channels for information exchange and social influence, which are influenced by network structures and characteristics. SNA in healthcare has been used to describe and understand a range of processes, such as social support of patients, communication and collaboration of health professionals, and the uptake of new practices in a population. However, insights into network-related mechanisms underlying healthcare delivery and health behavior of patients are still limited.

Setting of the research
In this thesis, we set out to explore the role of social networks of patients and healthcare providers for understanding patient health behavior and clinical risk factors as well as the delivery of evidence-based CVRM and outcomes in primary care. In our studies, we tested several hypotheses on social network characteristics of patients and health care providers. For patients, we constructed networks on individuals considered to be important for handling their condition or diseases. For health care professionals, networks were constructed on information exchange on CVRM in general practices.

The network studies were performed parallel to a randomized controlled trial (RCT), which aimed to improve CVRM in primary care. Both studies were part of the ‘Tailored Implementation for Chronic Diseases (TICD)’ project. The network-related studies focused on patients with established CVD and at high risk for CVD participating in the larger RCT, individuals who patients considered important for handling their condition or disease (so called ‘alters’), and health care professionals in general medical practice.

Patients participated in the network study by telephone interviews or postal questionnaires. In chapter 2 we provide results of two randomized controlled trials that were performed to assess whether response rate of patients could be enhanced by providing choice of participation mode. Alters of patients participated in postal questionnaires. Health care professionals participated in postal questionnaires as well, and medical record auditing was performed for extracting data on patient clinical risk factors and delivery of CVRM care by practice nurses.

Social networks, health behavior and clinical risk factors of patients
CVRM heavily emphasizes control of clinical risk factors (blood pressure, serum cholesterol, body-mass index), preventive medication, and adequate health behaviors (diet, physical activity, and non smoking. As such, patients have a central and responsible role in CVRM. Ample research evidence illustrates that health behavior is not only an individual effort, but also influenced by the social environment. Several examples are provided by studies showing that social integration and social support were related to reduced mortality from diverse causes, and studies showing that several health behaviors or traits (e.g. alcohol
and aspirin use, obesity, depression) were clustered, instead of randomly spread, within networks 14-18.

Although many subsequent studies have confirmed the impact of social networks on health, its underlying mechanisms are only partly understood. These may relate to, amongst other, social support, social capital, and social influence 19. Social support consists of navigation to, and the provision of information, practical help, or emotional comfort by people or organizations in a person’s social network. It includes assistance with health related activities and attainment and maintenance of appropriate health behaviors. Related is the concept of social capital, indicating the availability of support for a specific individual. Most studies on social capital focused on access to resources, as such defining this constructed as membership in social networks that facilitate access to resources, e.g. information on health and health behaviors 20. Several studies showed that greater social capital has been linked to better health or well-being 21.

Social influence represents a different mechanism. Studies showing clustering of behaviors and health related traits (e.g. smoking or obesity) in networks led to the notion of contagion of behaviors and information within networks 14-18. Social contagion represents a multifaceted process and involves infection, information, and behaviors. Spread of information and (resulting) behaviors can result from multiple underlying process of social contagion, e.g. imitation of successful behavior, role modeling, social comparison, and selection of contacts. Homophily, or homogeneity, is a related concept, representing the principle that contacts between people who share similarities will occur at a higher rate than among people who are more dissimilar 22. Such specific contacts shape and influence opportunities for spread of information and behaviors within networks, consequently influencing formation of attitudes and norms 22,23, and other social influence processes, e.g. social reinforcement 22,24. Clustering seems to occur together with homophily, although it should be noted that causality of effects is difficult to establish 25.

These concepts provided input for the construction of three main hypotheses on social network characteristics, which underlie several studies in this thesis. We explored whether social network characteristics were related to patient health behavior (physical activity, diet, and smoking), change in health behavior, achievement of targets for CVRM clinical risk factors (SBP, LDL, and BMI), and delivery of evidence-based care for CVRM by practice nurses.

The first hypothesis considered clustering and its ability to shape opportunities for various social influence mechanisms. As clustering has been found for several behaviors and traits, we expected patients to be more likely to hold favorable health habits and reach targets for clinical risk factors if their alters hold favorable health behaviors as well.

The second hypothesis considered the possible influences of depression. Depression occurs commonly in cardiac patients 26 and is an invalidating risk factor for impaired
efforts for improving health behavior. In specific cardiac patients groups, depression and depressive symptoms have been related to both worsened health behaviors and increased mortality. Furthermore, depression has been shown to have a contagious pattern within networks. As such, depression and depressive symptoms may negatively influence health behaviors and clinical risk factors in two ways: first by influencing patients themselves, and second by contagiously spreading within networks. We therefore hypothesized that patients whose networks contain people with depression or depressive symptoms are less likely to hold or achieve adequate health behaviors and reach targets for clinical risk factors.

The third hypothesis focused on the opportunity for spread of information and behaviors and social capital. Obviously, it is important that health information is accessible and reliable. People able to allow for this are most likely health professionals, such as physicians or nurses. Social capital can be enhanced when such persons are present in networks, and in this way we defined social capital as having a network that facilitates access to resources. We expected patients who hold health professionals within their network to be more likely to hold or attain adequate health behaviors and clinical risk factors.

Social networks and delivery of CVRM care

SNA in healthcare has also been used to enhance understanding of communication and collaboration of health care professionals, and diffusion and sharing of knowledge among health care professionals. Examples illustrating the importance of social networks of health care professionals are provided by studies showing that interaction and communication patterns among health care providers can be crucial to improve patient safety, and coordination and quality of care. The expanding literature on networks of health care provided us with input for the construction of several hypotheses on network characteristics that can be related to the delivery of evidence-based care for CVRM. These are outlined below.

Network density indicates the proportion of all possible connections in a network that are actually present. When a network has a high density, many members know each other and interact with each other frequently, which enables a fast spread of information. This multiplicity of ties create opportunities for various social influence processes, e.g. social comparison, imitation of successful behavior, and the setting of group norms. High density has been related to fast diffusion of information, and has been shown to improve tasks that depend on cooperation, and coordination performance.

Dense networks are expected to be characterized by a high frequency of contact because of its multiplicity of connections. This can be of importance for delivery of evidence-based care for CVRM as it enhances opportunities for social influences which, in turn, can offer protection against egocentric choices. The underlying mechanism is derived from game theory of human collaboration and competition. Amongst others, game theory recognizes the distinction between single and repeated interactions, and
the importance of the history of contact between people. Experiments showed that
dynamics of repeated contacts were important for the provision of a context which
facilitated and enhanced the development of long-term cooperation and trust between
actors 37,38.

Homogeneity, or homophily (‘love of the same’), refers to the tendency of individuals
with similar characteristics to associate and bond with each other. Homophily can be
interpreted as social heuristic, by which persons assume that individuals similar to them
are more likely to accept them, to be trustworthy, and to have similar beliefs. Contacts
with similar people then, may be preferred to avoid risks (e.g. potential conflicts and
misunderstandings) of connecting with others 39,40. Possible social influence mechanisms
by which high homogeneity may enhance uptake of information which spreads in a given
network include mutual reinforcement of attitudes and behaviors 40. Social networks can
be homogenous on several attributes. Examples include studies showing that physicians
were more likely to exchange information and provide advice during patient treatment
if their attitudes towards evidence-based medicine were similar, if they had the same
specialty, worked in the same organization, and had co-authored peer-reviewed papers 41.

Centrality describes the number of connections a given network member has. A high
number of connections can allow for greater access to and control over resources 42,
as such people with high centrality are expected to be influential network members.
Previous studies showed associations of high centrality with enhanced knowledge
transfer 43,44, and lower costs and fewer specialty referrals 45. In social networks of primary
care for CVRM, CVRM coordinators or case managers are expected to represent persons
with high centrality. Both are purposefully created to become highly central individuals in
health care delivery networks.

Informal opinion leaders may be present within social networks. Opinion leaders are
persons who influences opinions, attitudes, beliefs, motivations, and behaviors of others 46.
This role is not necessarily linked to a position in a formalized organization and is as such
informal. Previous studies indicated that opinion leaders may provide evidence-based
practice 47 with results showing that presence of opinion leaders in networks has been
related to speeding adoption of clinical guidelines 48 and to adherence to guidelines for
unstable angina 49.

Outline

Our main aim was to identify additional determinants for CVRM using a social networks
approach. We therefore described social networks of patients and health care professionals
involved in CVRM and explored which network characteristics were related to patient
health behavior, change in health behavior, clinical risk factors, and delivery of evidence-
based care for CVRM.
The following research questions were addressed:

- Does choice of participation mode improve response rate of patients invited to participate in a social networks study?

- Which patients’ social network characteristics are related to patients’ health behavior and clinical risk factors?

- Which patients’ social network characteristic are related to patients’ health behavior and change in health behavior?

- Which general practices’ social network characteristics are related to delivery of evidence-based care for CVRM and achievement of targets of patients’ clinical risk factors?

In this thesis we present three observational studies testing effects of social network characteristics hypothesized to influence health behaviors and clinical risk factors of patients and the provision of evidence-based care for CVRM by health care professionals. Chapter 2 provides the study protocol of this research project. In chapter 3 we test different methods for enhancing response rate of patients invited to the social networks study. In Chapter 4 we test hypothesized influences of network characteristics on patients health behavior and clinical risk factors. Chapter 5 focuses on network characteristics and changes in patient health behavior. Finally, in chapter 6 we explored associations between network characteristics and the provision of CVRM care by health care professionals.
References


2

Social networks of health care providers and patients in cardiovascular risk management: a study protocol

BMC Health Services Research 2014;14:265-76.

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Abstract

Background In recent years, preventive and clinical interventions for cardiovascular risk management have been implemented widely in primary care in the Netherlands. Although this has enhanced quality and outcomes of cardiovascular risk management, further improvement remains possible. In the planned observational study, we aim to examine the role of social networks of healthcare providers and patients in quality and outcomes of cardiovascular risk management.

Methods/design In a longitudinal observational study, data on social networks of approximately 300 primary care providers from 30 general practices and 900 cardiovascular patients will be collected twice, with a six month interval, using a mix of measures. Social networks are documented with specifically designed questionnaires for patients, relatives, and healthcare professionals. For each included patient, we will extract from medical records to gather data on clinical processes and cardiovascular risk predictors. Data on self-management and psychosocial outcomes of patients will be collected using questionnaires for patients. The analysis focuses on identifying network characteristics, which are associated with (changes in) cardiovascular risk management or self-management.

Discussion This research will provide insight into the role of social networks of patients and providers in cardiovascular risk management in primary practice.
Background

Cardiovascular disease (CVD) remains an important cause of mortality and reduced quality of life worldwide. In 2010, CVD was the number one cause of death among women and the second cause of death for men in the Netherlands. A wide range of preventive and clinical interventions targeting the population and patients at risk are recommended in prevailing practice guidelines, emphasizing comprehensive cardiovascular risk management (CVRM), lifestyle changes, and preventive drug therapy. In recent years, many conditions for providing recommended CVRM have been optimized in the Netherlands. These include the publication of a multidisciplinary clinical guideline and organizational standards for general practices, introduction of nurses in general practices, nationwide supply of paper-based and online patient education tools for CVD-patients as well as the general public, and targeted reimbursement for chronic illness care in primary care. While these developments have improved CVRM, a specific number of patients still did not completely receive recommended CVRM or did not reach target values of CVRM. So, the question is what additional determinants of CVRM and outcomes can be identified and addressed to optimize cardiovascular risk management.

Social network analysis (SNA) offers a new perspective on the implementation of evidence-based practice in healthcare. Previous research, which used SNA in health care, showed that social networks of patients and healthcare professionals could be measured in a valid way and showed substantial variation. Pilot studies in primary care in the Netherlands have confirmed the feasibility and viability of specific measures for documenting social networks of information sharing. Despite these and other studies in health care, insights into network-related mechanisms underlying healthcare delivery and self-management (health-related behaviors) are still limited. In this study, we will explore the role of social networks of healthcare providers and patients in the delivery and outcomes of CVRM in primary care. Social networks will be constructed using data on information exchange between individuals involved in CVRM.

Theoretical background

The potential relevance of social networks for health outcomes is illustrated by a number of studies, which suggested that health-related behaviors are not randomly spread in a population but associated with social network structures. This has led to the notion of ‘contagion processes’ in social networks, which seem to apply to a range of items, including infections, information, and behaviors. The underlying mechanisms of contagion patterns are heterogeneous, depending on the item of interest. For spread of information and behaviours, psychological mechanisms such as imitation of successful behaviours, role modelling, social comparison and selection of contacts can be drivers of contagion.

Contagion processes can be either simple or complex. In simple contagion processes, a single encounter has direct consequences. If applied to the transfer of information, the
assumption is that access to information is the main enabler of uptake. Given the wide range of available information sources in health care, including many on the world wide web, and resulting information overload for both health professionals and patients, simple contagion may currently be rare. In many cases, information needs to be selected, prioritized and positively labeled to be put into action. Thus, a single exposure is often not sufficient to lead to change of knowledge or behaviors. Complex contagion represents spread of items under the influences of intensive, repeated and valued contacts. The assumptions of complex contagion are consistent with a number of theories. For instance, the Diffusion of Innovation Theory proposes that uptake of information occurs in most individuals by informal, personal contacts rather than through formal education.15

Drawing on previous research and theories on social networks and translation of information contagion into attitudes and behaviors, several network characteristics which may influence the delivery of primary care for CVRM by health professionals and self management of patients at risk for CVD and with established CVD can be inferred. For a schematic representation of the hypothesized relations see Figure 1. For healthcare professionals we expect a number of social network characteristics to be of importance. Firstly, a high density (the proportion of all possible connections in a given network that are actually present) is expected to be beneficial as it provides multiple opportunities for various social influence mechanisms, such as for example imitation of successful behaviors and social comparison.8,16,17. Secondly, a high frequency of contacts (within existing relationships) is expected to be important, as this enhances social influence and offers protection against egocentric choices.16,18,19. Thirdly, high homogeneity of individuals in a network (e.g. regarding educational background) is expected to enhance social comparison uptake of information items that are disseminated in the network.20. Fourthly, individuals with high centrality in a social network are expected to be influential as they have many connections and high centrality has been associated with enhanced knowledge transfer.21,22. In healthcare, individuals with high centrality are expected to be present in social networks as CVRM-coordinators or case managers. Both are purposefully created to become highly central individuals in healthcare delivery networks. Fifth, an informal opinion leader may be identifiable in a network. He or she represents a person who influences opinions, attitudes, beliefs, motivations, and behaviors of others.23. For these network-related factors, it may be noted that the direction of the social influence (e.g. better or worse CVRM) depends on the content of the information that is shared.

For patients we also expect network characteristics to be important for and related to self-management (that is, health behaviors for diet, physical activity, and smoking). Firstly, the presence of a high number of individuals with favorable self-management as previous research showed that self-management behaviors (e.g. smoking, alcohol use, obesity) are clustered within networks.12-14. Secondly, the effect of having individuals with appropriate self-management within ones network should be more profound when these individuals are also connected to each other, with resulting opportunities for multiple
Figure 1 Hypothesized relations

- Characteristics of social networks:
  - High density
  - High frequency of contact
  - High homogeneity
  - CVRM coordinator with high centrality
  - Consistently identified opinion leader

- Social mechanisms, formation attitudes & behavior:
  - Various social influence mechanisms e.g. imitation of successful behavior, social comparison
  - Protection against egocentric choices
  - Uptake of information
  - Knowledge transfer
  - Influences opinions, beliefs, motivations, behaviors

- CVRM care and patient' health outcomes:
  - Professional performance
  - Self-management
  - Health outcomes

- Health professionals
- CVD and patients at risk
- Various social influence mechanisms e.g. imitation of successful behavior, social comparison
- Protection against egocentric choices
- Uptake of information
- Knowledge transfer
- Influences opinions, beliefs, motivations, behaviors
- Professional performance
- Self-management
- Health outcomes

- Multiple social influence mechanisms
- Contagious patterns
- Social capital
social influence mechanisms. Thirdly, networks which contain few individuals with depressive symptoms may be positively related to self-management, as depression has shown to have both a contagious pattern in networks and to be related to worse health behaviors and impaired efforts for achieving lifestyle change. Fourthly, the presence of persons who can provide information on CVRM in patients’ informal networks (e.g. nurses or physicians) adds to the social capital of an individual and can be expected to enhance self-management.

**Research aims:**
The overall aims of the study are:
1. To describe social networks of health care professionals in primary care involved in CVRM as well as those of patients with established CVD or a high risk thereof using a social networks approach.
2. To explore which characteristics of social networks are linked to key aspects of the delivery of high-quality CVRM (that is, providing advice and recommended treatment) and of patients’ self-management.
3. To explore the influence of several network characteristics on changes in delivery of high-quality CVRM and in patient’s self-management.
4. To evaluate different methods for including patients in a study of social networks.

**Key hypotheses:**
In summary, the following key hypotheses will be explored in the planned research project:

**Hypotheses on health professionals:**
Patients are more likely to receive recommended CVRM and reach CVRM targets in general practices which have social networks characterized by: high density, high frequency of contact, high homogeneity, an appointed CVRM-coordinator who has a high degree of centrality, and a consistently identified opinion leader for CVRM.

**Hypotheses on patients:**
Patients are more likely to have favorable self-management and reach CVRM targets if they have social networks which contain: a high number of individuals with adequate self-management, a high number of individuals with adequate self-management who are connected to each other, few individuals with depressive symptoms, and individuals who provide access to individuals who can provide information on CVRM, particularly health professionals (such as nurses or physicians).
Methods

Study design:
This observational research is part of the ‘Tailored Implementation for Chronic Diseases’ (TICD) project. The TICD-project has the overall aim to develop and test methods of tailoring implementation interventions to determinants of practice in chronic illness care in five different chronic conditions in five different countries in Europe 29.

This study will be performed parallel to a two-arm RCT as developed by the Dutch team (trial registration: NTR4069). This approach is chosen as it will allow for both the investigation of network characteristics for quality of current CVRM care by health professionals and self-management of patients and for associations of network characteristics with changes in quality of CVRM care and self-management after completion of the RCT intervention program. The RCT aims at enhancing primary care for CVRM by improving professional performance of practice nurses 30. Practice nurses conduct care for patients with chronic conditions. They provide patients with education and guidance about their disease, medication-use, and changes in lifestyle and independently perform consultation hours and regular checkups.

For this RCT, comparing an intervention vs a control (postponed intervention) group, a tailored intervention package has been developed which offers practice nurses several options for enhancing their knowledge on CVRM and counseling skills. Additionally, the package provides recommendations for referral of patients. This package consists of training and feedback on motivational interviewing technique and an e-learning program on CVRM. Also, practice nurses will be advised to pay particular attention to the presence of depressive symptoms and plan action according to these as patients with CVD have a higher risk for experiencing depressive symptoms 27 with concomitant impairments in altering self-management 20. More specifically, practice nurses are recommended to refer patients without depressive symptoms to e-health learning modules, patients with mild depressive symptoms to a physical exercise group, and patients with severe depressive symptoms to psychological help as appropriate in their practice 30. Data on professional performance of practice nurses, patients’ self-management and treatment outcomes will be measured at baseline and follow-up at six months after the start of this intervention 30.

In the present research we will measure characteristics of social networks of health professionals and patients at the start of the intervention program and after completion of it. Social networks will be constructed on information exchange on CVRM purposes. Data on professional performance of health professionals and self management and CVRM treatment targets of patients will be collected by patients’ medical file extraction, self-report questionnaires and telephone interviews. Additionally, we will measure network characteristics of so called ‘alters’ of health professionals and patients. An alter represents an individual who has contact with the person under investigation, typically family members for patients and other healthcare providers for healthcare professionals.
Ethical approval:
The Medical Ethical Committee of Radboud University Nijmegen Medical Centre has waived approval for both the social network study and the RCT study 30.

Sample:
The sample will consist of health care professionals, patients with high risk for CVD or established CVD and their alters.

Health care professionals:
We will include all health care professionals working in general practices participating in the RCT and who are involved in patient care (typically, general practitioners, practice nurses, and practice assistants). Based on power calculations in the RCT, 30 practices are planned to be included.

Patients:
Eligible patients are adults aged 18 or older, with high risk for CVD or established CVD and who are capable of providing informed consent 30. Patients with high risk for CVD have a risk score of 20% or higher of 10-years-morbidity and mortality due to CVD. International Classification of Primary care (ICPC) codes will be used to extract eligible patients from medical records. Exclusion criteria are: diabetes mellitus, pregnancy and lactation, terminal illness, cognitive impairments, and poor language skills. Per practice we plan to include 15 patients with established CVD and 15 at high risk.

Alters:
Alters of health care professionals will comprise individuals with whom information on CVRM is exchanged but who are not part of the general practices’ network, as well as opinion leaders from outside general practices. We aim to include all alters of health care professionals. Alters of patients include key individuals for information exchange, which most likely will be spouses or children of patients. We aim to include up to four persons considered to be important for dealing with patients’ condition or disease as indicated by the included patients in our measurements.

Recruitment process and data collection
Specific details regarding the inclusion procedure of general practices and patients in the intervention are described in the protocol of the RCT 30. For the RCT, all interventions and data collection procedures were planned to be performed from July 2013 until June 2014. The recruitment process and data collection procedures on behalf of these network studies will be performed parallel to the data collection of the RCT. Data collection procedures for social networks of health professionals and patients were planned in the same period, with some extension for patients needed until July 2014 because of our
RCT:
1601 invitations send to general practices
30 practices, 900 patients randomized into:
1) Intervention group
2) Control group

Start of RCT -> practice visit
Practice consultus distributes network questionnaires to health professionals
During practice visit, patients are selected for participation in the RCT

HPs-ALTERS
Contacted by TICD research team using contact details as provided by health professionals

PATIENTS
Receive questionnaire-booklet of RCT including question if they are willing to participate in the social network research.

Invitations in first six practices:
1) Complete additional questions by phone
2) Complete additional questions by phone OR by paper-based questionnaire

Invitations in following practices:
1) Complete additional questions by paper-based questionnaire
2) Complete additional questions by phone OR by paper-based questionnaire

Group 1:
Network measures According to invitation

Group 2:
Network measures According to patient preferences

PATIENTS-ALTERS
Contacted by patients themselves

After six months:
Follow up measurements for RCT & repeated measurements of networks for health professionals and patients
invitation procedures (see p8 for details). As data collection procedures for alters of health professionals start after receipt of completed questionnaires of health professionals and patients themselves, we expect to complete these procedures in August 2014. For a flow chart of the studies, see Figure 2.

**Health care professionals**
The RCT will start with an outreach visit in which a comprehensive explanation of the RCT study and network measurements on behalf of the present research will be provided to practice nurses. Outreach visits will be performed by a trained practice consultant. A practice consultant is an expert in coaching and advising general practices in processes of change and improvement. Before these practice visits, names of persons who are involved in patient care in general practices will be derived online and checked for accuracy by practice nurses and will be used to generate personalized network rosters. These network questionnaires will be handed over to practice nurses during practice visits so that she or he can spread these to other health professionals within the general practice. Health professionals within general practices typically will be general practitioners, practice nurses, and practice assistants. A letter which contains comprehensive information on the network study will be enclosed to the questionnaire. Prepaid envelopes will be provided for returning filled out questionnaires.

**Alters of healthcare professionals**
For including alters of health professionals, names, profession, and contact details will be extracted from completed network questionnaires of health professionals working within general practices. Invitation letters and network questionnaires will be mailed to alters within two weeks after receiving these completed questionnaires. When none or insufficient contact details are provided, we aim to collect these by using an Internet-search. Criteria entered in the Internet search will vary depending on information provided. We mainly will use Google for finding details needed.

**Patients**
Patients will be selected from the general practices’ electronic data base using ICPC codes during practice visits of the RCT. They will receive a questionnaire booklet at the start and end of the intervention period on behalf of the RCT. For inclusion in the network study, we will include three basic network questions (see Appendix A1) in this questionnaire booklet followed by an invitation for participation in the network study. An informed consent form will be enclosed and will be returned along with the questionnaire booklet of the RCT. During the inclusion of the first six practices, patients will be randomized into one of two groups. The first group will receive an invitation in the questionnaire booklet to participate in the network study by a telephone interview. The second group will be invited by the choice to participate by 1) a telephone interview or 2) a paper-based
questionnaire. After inclusion of these practices we will invert the design for another six practices so that the first group will receive an invitation to participate in the network study by a paper-based questionnaire and the second group will be invited by providing the choice to participate by either 1) a paper-based questionnaire or 2) a telephone interview. These response groups are included so that we will be able to compare which approach is most feasible for including patients in network measurements as current research on this is scarce. For inclusion of patients from additional practices, we will employ the inclusion method as assessed to be most feasible. The basic questions are incorporated in the RCT questionnaire to ensure that basic data for all patients is included. Questionnaires will be send and interviews will be held approximately two weeks after receipt of accepted invitations.

**Alters of patients**
Patients are asked to spread questionnaires to their alters, for which specific instructions will be provided in their own questionnaires or during interviews. For this purpose, patients will receive four additional questionnaires; one for their personal opinion leader (specified on network questionnaires as ‘the person considered to be most important for dealing with condition or disease’), and three for ‘important others’ (specified as ‘other persons considered to be important for handling condition or disease’) with accompanying information letters and informed consent forms. We have chosen to include four alter-questionnaires as limited current research indicates that this is the maximum number of important or significant others within patients’ networks. Patients and alters can contact TICD researchers for additional questionnaires if desired.

**Reminder procedures**
In case of no response from healthcare professionals, we will ask practice nurses to remind non responding persons in their general practice. In case of no response from patients we will send letters as reminders.

**Outcomes & measures**

**Primary outcomes for health professionals**
Baseline and 6-month follow-up measures will be conducted for health care professionals, patients, and their alters.

**Health care professionals and their alters**
Main outcomes for health professionals will consist of 1) the description of social networks and 2) the hypothesized effects of several social network characteristics, controlled for possibly confounding variables, on professional performance of practice nurses and patients’ health outcomes. Additionally, exploration of effects on social network characteristics on changes in professional performance after completion of the RCT are of main interests.
Professional performance: Professional performance reflects application of recommendations for personalized counseling and education of CVRM patients by practice nurses. Professional performance is represented with a dichotomous score, reflecting adequate or inadequate performance. We will consider personalized lifestyle advice as provided by practice nurses to be adequate when at least one of the following conditions is met:

1) There is a record in the patients' medical file or other healthcare provider-based records that the patient has received advice on at least one lifestyle item as specified in prevailing guidelines of CVRM; diet, smoking or physical exercise, and which has been relevant for the individual patient in the previous six months. At least one target, made up maximally 15 months ago, for improving an aspect of lifestyle should be recorded. Also, practice nurses are required to make a register note when a patient has an adequate lifestyle.

2) There is a notation in the patients' medical file that the patient has none, mild or major depressive symptoms and that the patient has been referred to E-health, a physical exercise group, or depression treatment respectively.

Other measurements on health care professionals will include:

Descriptive variables: Descriptive measures will include size of practice (number of staff and patients), profession, and involvement in other organizations or projects and will be measured using the Epa Cardio abstraction tool for medical audit instrument 32.

Information items for constructing social networks: For constructing social networks we will use a specifically developed and personalized roster questionnaire (see appendix A2 for the network questionnaire for health professionals from general practices participating in the RCT and appendix A3 for the network questionnaire of alters of health professionals). On this network roster, health professionals will be asked to indicate their social contacts for CVRM information sharing and receiving on two subjects:

1) medical policy for CVRM in general and on 2) CVRM for specific patients. In this network roster, names are listed of all persons involved in patient care within a general practice so that respondents can tick names of persons with whom they share information. Also, space is provided for names of persons outside the general practice, respondents are asked to fill out these names themselves.

Frequency of contact: For measuring frequency of contact for information sharing, health professionals are asked to indicate whether they have been in contact on a 1) daily/weekly or 2) monthly/yearly basis with each person they share information with.
**CVRM-coordinators:**
For the identification of the presence of CVRM-coordinators within general practices we will ask health professionals to list the name(s) of the person(s) responsible for coordination of CVRM within the particular general practice.

**Opinion leaders:**
For the identification of opinion leaders we will ask health professionals to write down the name and occupation of the person they consider to have ‘a significant influence on their current practice in CVRM’. Health professionals will be instructed that this person can be anyone from inside or outside the general practice, and that the influence this person has had can be either current or from the past.

**Priority for preventive treatment and CVRM targets:**
For determining whether social network characteristics are related to certain attitudes on clinical processes for CVRM, and whether these attitudes are more or less present in certain social networks, we will measure priority for preventive treatment and achievement of CVRM targets by presenting five statements containing general recommendations and targets for CVRM (e.g. ‘for patients with a high risk for CVD, strive for a systolic blood pressure < 140 mmHg’). These items were selected from current guidelines and previous research indicated that primary care for these items can be enhanced. Health professionals are asked to indicate on a 5-point Likert scale (1: totally unimportant – 5: highly important) how important they consider ‘a change in direction of the presented target’ as indicator for priority for preventive treatment and ‘achievement of the presented target’ as indicator for priority for CVRM targets.

**Primary outcomes for patients**

**Patients and their alters**
Main outcomes for patients will consist of 1) description of social networks, 2) response rates after different invitations for participation in the network study, and 3) the hypothesized effects of several social network characteristics, controlled for possibly confounding variables, on self-management and health outcomes. Additionally, exploration of effects of social network characteristics on changes in self-management and health outcomes after completion of the RCT are of main interest.

**Response rates:**
One of the main outcomes for patients are response rates of including patients by inviting them with either 1) an invitation with one option to participate in the social network study or 2) an invitation to participate in the research with two options so that patients can indicate their preference for participating by a telephone interview or a paper-based questionnaire.
**Self-management:**
Self-management will be measured using a composite questionnaire on physical activity; *Rapid Assessment of Physical Activity (RAPA)*, 9 items \(^{33}\), diet; *reduced Rapid Eating and Activity Assessment (REAP-s)*, 12 items \(^{34}\), and smoking; *(MID-SIZED Model)*, 8 items \(^{35}\).

Scores on the RAPA ≥ 5 indicate sufficient physical activity. The REAP-s asks how often persons engage in particular diet patterns in a regular week (e.g. high sugar/calorie sweets and beverages intake), using four response categories (‘often/usually’, ‘sometimes’, ‘rarely’, and (for items where appropriate) ‘not applicable’). Patients who score ≤ 5 items on the REAP-s as ‘often/usually’ will be considered to have a healthy diet. Current smoking status is indicated by a dichotomous score (yes/no).

**Health outcomes:**
Health outcomes will consist of SBP, cholesterol, and risk score. Thresholds for desired treatment values for SBP and cholesterol may differ for patients at risk, with established CVD, patients of certain ages, and according to individual targets set in agreement with treating health professionals and will be analyzed accordingly. Risk scores, only applicable to patients without established CVD, will be calculated using prevailing risk estimation tables \(^{36}\). The following parameters will be used in the calculation: age, gender, smoking status, systolic blood pressure (SBP) and total cholesterol/HDL-cholesterol ratio. The Epa Cardio abstraction tool \(^{31}\) for medical audit will be used for abstracting these health outcomes.

**Other measures on patients will include:**
**Descriptive variables:**
Descriptive measures will include age, sex, ethnicity, marital status, educational level, and social economic status (SES). For data collection we will use a questionnaire containing items from the Epa cardio abstraction tool \(^{32}\).

**Information items for constructing social networks:**
For constructing and measuring social networks, patients are asked to indicate on a network roster from which persons they have received information on 1) medical treatment, 2) handling their condition or disease, and 3) practical help. We will provide a specifically developed and personalized roster questionnaire with names and disciplines of health professionals from their general practices (see appendix A4). Patients are offered the possibility to add names of other persons (healthcare professionals/people in personal circle) they have received information from.

Alters are asked to indicate on a network roster to which persons they have provided information on 1) medical treatment, 2) handling their condition or disease, and 3) practical help using a specifically developed and personalized roster questionnaire (see appendix A5).
**Frequency of contact:**
For measuring frequency of contact, patients will be asked to indicate how often they have received information from persons who have provided information in the last year. Similarly, alters will be asked how often they have provided information.

**Central care providers:**
A central care provider represents the health professional patients will contact first when they have questions regarding a specific condition or disease and who coordinates care when multiple health professionals are involved in treatment. For identification of central care providers we will ask patients to write down the name of the person they consider to be their central care provider for CVRM, specified as ‘the first person they would approach in case of uncertainties or troubles regarding their condition or disease’.

**Opinion leaders:**
For identification of opinion leaders patients will be asked to write down the name of the person they consider ‘to be most important for dealing with disease or lifestyle’. Patients will be instructed that this person doesn't need to be ‘most important’ for a specific reason and that this person doesn’t need to be part of the patient’s personal environment.

**Number of alters with appropriate self-management:**
For assessing what number of alters in patients’ networks have adequate self-management we will ask patients to indicate whether he/she believes that their indicated alters smoke, have a healthy diet, and engage in sufficient physical activity. In addition, we will ask alters of patients to complete questionnaires on their lifestyle habits (smoking; *MID-SIZED Model*, 8 items 35), diet; *reduced Rapid Eating and Activity Assessment (REAP-s)*, 12 items 34), and physical activity; *Rapid Assessment of Physical Activity (RAPA)*, 9 items 33).

**Connectedness of alters:**
For assessing whether alters of patients are also connected to each other, we will use information from the network rosters completed by all alters of a given patient.

**Number of alters with depressive symptoms:**
For assessing whether alters with depressive symptoms are present in patients’ networks we will ask alters of patients to complete the Patient Health Questionnaire (PHQ-9) 37, which is a short questionnaire for depression.

**Number of alters providing access to CVRM information:**
For assessing how many persons who can provide access to CVRM information are available in patients' social networks we will ask patients to indicate how many of the
persons from whom they receive CVRM related information have a medical occupation or have been educated for this.

**Personal characteristics:**
For assessment of personal characteristics of patients we will measure patient activation (Patient Activation Measure, PAM\(^{38}\)), therapy adherence (Medication Adherence Measure\(^{39}\)), quality of life (EQ-SD\(^{40}\)), and depressive symptoms (Patient Health Questionnaire, PHQ-9\(^{37}\)). Alters of patients will complete the PHQ-9. Higher total scores on these measures will indicate higher patient activation, therapy adherence, quality of life, and depressive symptoms respectively.

**Sample size calculation**
The RCT study, in which the present research is embedded, is powered to detect a 15% difference in provided personalized lifestyle advice by including 900 patients clustered within 30 practices\(^ {30}\). For the present research, we calculated the sample size for detecting a 15% difference in response rate of patients who are approached by 1) an invitation for participation in this study with a telephone interview and 2) the choice for participating by a telephone interview or a paper-based test. Assuming alpha is 0.05, power of 0.80, a response rate of 50% in the first group and 65% in the second group, we estimated that we need to include 338 patients.

**Data analysis**
We will use UCINET for constructing and obtaining social network parameters of general practices on broad and specific information exchange and general information receipt networks of patients. The statistical package R will be used for all other analyses. All data analyses will be based on ‘intention to treat’.

**Construction of network characteristics**
Density represents the proportion of all possible connections in a network that are actually present. Homogeneity represents the similarity of persons within clusters. Similarity of persons will be assessed regarding priority given to preventive treatment and CVRM targets, and other individual characteristics. Centrality is a measure for the extent to which a network is organized around a single person and can be divided into in- and outdegree centralization. The first specifies information flow from various network members to a single person, the latter whether information flows from a single person to the other network members.
**Statistical analyses:**

Response rates for health professionals and patients will be determined. For patients we will compare response rates between the patient group invited by either a single option for participation and the group that will be offered the choice to participate by either a telephone interview or a paper-based test in order to assess which method is most feasible for including them in social network research using $X^2$ tests.

Reliability of reported social network connections will be investigated by examining the proportion of all possible connections that will be mutually reported present or absent (reciprocity coefficients in non-directed networks). In accordance with guidelines on handling missing values, we will substitute these by values as provided by responses of other individuals. In case of no information on connections, we will indicate no contact by filling in a zero in the data 41.

For describing social networks of health professionals and patients we will compute network parameters and provide visualization by using graphic displays. Random permutation tests will be used for comparisons of network characteristics.

For testing our hypotheses and further explorative analyses, controlling for potential confounders, we will use multivariate logistic regression models to investigate the effect of social networks characteristics on professional performance of practice nurses and patients' self-management and health outcomes.

In the analysis of professional performance of practice nurses regression models will include six network characteristics (density, frequency of contact, homogeneity, presence of informal opinion leaders and CVRM-coordinators, and centrality) as predictors of main interest. As control variables we will include trial arm (intervention vs control group), personal characteristics (amongst others education, years of experience in profession), and practice characteristics (practice size, involvement in other projects or organizations).

In the analyses of self-management and health outcomes in patients, several multivariate logistic regression models will be estimated. For self-management, separate models will be estimated on physical activity, diet, and smoking. For health outcomes, separate models will be estimated on SBP, cholesterol, and risk score. Models will include four network characteristics as predictors: number of alters with favorable health behaviors, who are also connected among each other, number of alters with depressive symptoms, and number of alters who can provide CVRM-related information. The regression models will be controlled for trial arm (intervention vs control group), patient group (high risk or established CVD), and several personal characteristics: age, sex, ethnicity, marital status, SES, patient activation, therapy adherence, and depressive symptoms.

Two approaches will be used to investigate effects of social network characteristics on change in professional performance of practice nurses and self-management and health outcomes of patients after the intervention period at six month follow-up. First, follow-up outcomes measures will be treated as dependent variables. We will estimate similar models as described above and include baseline measures of outcomes of interest.
as predictors. Second, we will consider change as the difference between the baseline- and follow-up measures of the diverse outcomes of interest. Ordinal logistic regression models will be estimated, with change represented in three categories; a shift from inadequate to adequate outcomes, no change, and shift from adequate to inadequate outcomes.

**Discussion**

Although many efforts to improve primary care for CVRM have been conducted, recent research shows that improvements remain possible. The wide range of approaches aimed at improvement in primary care signals the need for the identification of new opportunities for enhancing CVRM. Social network analysis may be a promising approach to provide these needed new insights. The results of this study can be of practical importance for clinicians and policymakers involved in maintaining and enhancing quality of health care by enhancing the understanding of certain characteristics of networks and their associations with positive or negative quality of CVRM care. Such insights can provide guidance to efforts aimed at improving functioning of networks. For example, if high homogeneity is found to be present in social networks and can be associated with high quality CVRM-care or change into this direction, future efforts aimed at enhancing health care can consider this network characteristic when composing health-care teams. Also, the results of this research can have a clinical importance by clarifying the role and importance of patients’ social environments for handling disease and maintaining or altering self-management. These insights can provide input for future research and interventions aiming at improving self-management of patients.
References

Improving participation rates by providing choice of participation mode: two randomized controlled trials

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Michel Wensing
Abstract

**Background** Low participation rates reduce effective sample size, statistical power and can increase risk for selection bias. Previous research suggests that offering choice of participation mode can improve participation rates. However, few head-to-head trials compared choice of participation mode using telephone interviews and postal questionnaires as modes of interest. Aiming to explore effects of choice of participation, two randomized controlled trials were performed comparing participation rates of patients provided with and without choice of participation mode, using interviews and questionnaires as participation modes.

**Methods** Two trials were embedded in a larger study on cardiovascular risk management in primary care. Patients with a chronic cardiovascular condition recruited for the larger study were invited to participate in an additional survey on social networks, using invitations with and without choice of participation mode. Primary outcome was participation rate. Other outcomes of interest were participation rate conditional on willingness to participate, and initial willingness to participate. In trial 1 we compared outcomes after choice of participation mode (interview or questionnaire) with invitations for participation in a telephone interview. In Trial 2 results for choice of participation mode were compared with postal questionnaires.

**Results** In Trial 1 no differences were found in participation rates (65% vs 66%, p = 0.853) although conditional participation rate was highest for interviews (90% vs 72%, p < .01). Initial willingness to participate was higher when choice of participation mode was provided (90% versus 73%, p < .01). In Trial 2 participation rate and conditional participation rate was higher when choice of participation mode was provided (59% vs 46%, p < .01 and 66% vs 53%, p < .01, respectively). No differences were found for initial willingness to participate (90% vs 86%, p = 0.146).

**Conclusion** Offering choice of participation mode had benefit on participation rates compared to invitations to participate in questionnaires, but not when compared to invitations to participate in telephone interviews.
Background

Low participation rates reduce effective sample size, statistical power and can increase risk for selection bias. Appealing evidence suggests that offering potential participants choice of participation mode may improve response rates. However, few head-to-head trials compared telephone interviews and postal questionnaires as participation modes of interest.

In recent years, mixed mode designs for data collection became increasingly popular. The idea is that participants who are lost when offering a particular participation mode, can still be included by providing an alternative mode. Previous research reported that respondents do have mode preferences, but evidence on whether mode preference actually predicts participation remains inconclusive. Only a few studies investigated participation rates, comparing participants provided with and without choice of mode, and using telephone interviews and postal questionnaires as participation modes of interest. A study on census questionnaires compared response rates among several panels of households, provided with and without choice to respond by telephone or by mail. This study did not identify enhanced response rates when comparing the households panels provided with choice compared to households who were only allowed to respond by mail. Another study in cancer survivors reported completion rates calculated for patients who provided consent to participate in the study and found improved completion rates for patients allowed to choose a participation mode compared to those not provided with choice and participating in telephonic interviews or postal questionnaires as designated by the researchers. However, differences did not reach statistical significance. So, evidence for choice of participation mode using telephone interviews and postal questionnaires as choice options is scarce and mixed.

The vast part of previous research on choice of participation mode compared a traditional mode (e.g. face-to-face interview, postal questionnaires) with web-based modes (e.g. email, online questionnaires) as choice options and found that response rates of those allowed to choose a participation mode declined. Such results may be explained by a cognitive burden of choosing, technical problems, and deciding to participate but failing to do so. The latter may occur as responding on web-based options involves a break in response processes, e.g. a switch in behavior is required when moving from sorting and responding emails to filling out questionnaires.

Although web-based participation modes may have their attractiveness (e.g. reduced costs, less missing data) it may not be suitable for all groups. For instance, elderly individuals with chronic diseases may be less likely to participate. In the current research, we aim to investigate the effect of providing choice of participation mode in a survey of social information exchange networks in patients with chronic cardiovascular conditions. This group is typically an older one with a lower use of the Internet. Data from 2013 showed that only 55% of persons between 65-75 years in the Netherlands used Internet on a daily
basis, which is substantially lower compared to 87% of persons between 12-65 years. For persons 75 years and older, this percentages drops to 20% \(^{13}\). Therefore, participation modes of interest were telephone interviews and postal questionnaires.

In this study, in the following to be referred to as SNS (Social Network Study), two randomized controlled trials (RCT) were performed. Patients with a chronic cardiovascular condition were randomly allocated to a choice and no-choice arm for participation mode. Considering the scarce and mixed literature, we aim to explore effects of providing choice of participation mode. Assuming that providing choice of mode will retain patients who are lost when a single provided mode is provided, we will test the following hypothesis:

H1: Participation rates will be higher when potential participants are provided with choice of participation mode, compared to those of patients provided with only one participation mode.

Two trials were performed, varying participation mode in the no-choice arm. This approach was chosen to exclude the possibility that results would be biased by the possibility that the no-choice arm would simply represent a less popular mode. In trial 1 we compared participation rates of choice of participation mode with invitations for a telephone interview. In trial 2 the choice arm was compared with an invitation for a postal questionnaire. Additionally, using data from patients from choice arms and expecting that patients would voice preferences for a particular participation mode, mode preference will be determined.

**Methods**

**Design and Study population**

The SNS (ISRCTN89237105) is part of the ‘Tailored Implementation for Chronic Diseases’ (TICD)-project \(^{14}\) and was an observational study on social networks of information sharing from patients involved in cardiovascular risk management (CVRM) \(^{15}\). Within the SNS, two RCTs on choice of participation mode were embedded. The SNS and its RCTs were, in turn, performed parallel to a larger two-arm RCT (NTR4069), also part of the TICD project (see Figure 1). In this paper we will refer to the larger RCT as the ‘TICD-RCT’. The TICD-RCT aimed at improving CVRM in primary care by enhancing professional performance of practice nurses and included a random sample of general practices from several geographical areas in the Netherlands. For specific details on the TICD-RCT we refer to its study protocol which has been published elsewhere \(^{16}\).

Potential participants for the SNS were identified from the TICD-RCT. Both patients with high risk for cardiovascular disease (CVD) and established CVD were included. International Classification of Primary Care (ICPC) codes were used to extract eligible patients from medical records from general practices. Extraction was performed by
TRIAL 1: interview (no choice) vs interview or questionnaire (choice)

N=391 patients from 7 general practices enrolled in TICD-RCT and completed questionnaires which included invitations for the SN study

SN STUDY

N=391 patients randomized to receive:

No choice invitation (n=198):
invited to participate in SNS by a telephone interview

Choice invitation (n=193):
Invited to participate in SNS by a telephone interview or postal questionnaire

Non participants (n=68):
• Declined to participate (n=60)
• Unable to reach patients (n=8)

Analysed (n=198)

* Completed interview (n=130)
* Originally willing to participate (n=145)
Analysed (n=198)

TRIAL 2: questionnaire (no choice) vs interview or questionnaire (choice)

N=592 patients from 8 additional general practices enrolled in TICD-RCT and completed questionnaires which included invitations for the SN study

SN STUDY

N=592 patients randomized to receive:

No choice invitation (n=294):
invited to participate in SNS by a questionnaire

Choice invitation (n=298):
Invited to participate in SNS by a telephone interview or postal questionnaire

Non participants (n=160):
• Declined to participate (n=160)

Analysed (n=294)

* Completed questionnaire (n=134)
* Originally willing to participate (n=253)
Analysed (n=294)

Non participants (n=121):
• Declined to participate (n=118)
• Unable to reach patients (interview only) (n=3)

Analysed (n=298)

* Completed interview or questionnaire (n=177)
* Originally willing to participate (n=268)
Analysed (n=298)
research assistants in cooperation with practice nurses. Eligible patients were 18 years or older and capable of providing informed consent, exclusion criteria consisted of: diabetes mellitus, pregnancy and lactation, terminal illness, cognitive impairments, and poor language skills. To exclude patients with diabetes ICPC codes were used, other exclusion criteria were assessed by practice nurses.

**Data collection procedures**

Participants for the SNS were approached using differently formatted invitations enclosed at the end of postal questionnaire booklets sent on behalf of the TICD-RCT at baseline of the TICD-RCT intervention program (see also Figure 1). TICD-RCT questionnaires mainly contained questions on health-related lifestyle. Invitations for the SNS contained a concise explanation on the study purpose. An informed consent form was enclosed, explaining that patients consented to be approached for a baseline and follow up measure after six months. No incentives for participation were offered. On invitations with choice, patients could indicate their preferred participation mode by ticking one of two boxes for ‘Yes, I agree to participate in a telephone interview’ and ‘Yes, I agree to participate by a postal questionnaire’.

**Randomization**

Randomization to the choice or no-choice arm of the SNS was performed per general practice, using a computer assisted procedure and was performed by an independent research assistant. Patients were not informed about study arms of both the SNS and the TICD-RCT.

Two trials were performed subsequently, following inclusion procedures of the TICD-RCT. Subsequent rather than simultaneous conduct of the two trials matched best with the logistics of running the TICD-RCT.

**Trial 1: telephone interview versus choice of participation mode**

Invitations for trial 1 were sent from June 2013 till November 2013. During this period, patients were randomly invited to participate in a telephone interview on their social networks (the no-choice arm) or invited to participate in either a telephone interview or postal questionnaire (the choice-arm). In trial 1 patients from seven general practices were invited for the TICD-RCT. Of these, three general practices were randomized to the control arm of the TICD-RCT and four to its intervention arm. A total of 391 patients (mean patients per practice: 56, SD 12.9) completed questionnaire booklets for the program evaluation and thus received invitations for the SNS in trial 1.
Trial 2: postal questionnaire versus choice of participation mode

Invitations for trial 2 were sent from December 2013 till February 2014. Patients were randomized to participate in the SNS in a postal questionnaire (the no-choice arm) or provided with choice for a telephone interview or a postal questionnaire (the choice-arm). During this trial, inclusion procedures to the TICD-RCT needed to be adjusted because too few patients were included to achieve the TICD-RCTs’ aimed sample. Therefore, the number of patients receiving questionnaires was increased by 25%. A total of 592 patients (mean patients per practice: 74, SD 5.9) from eight additional general practices (three in the control and five in the intervention arm of the TICD-RCT) received invitations for trial 2.

In both trials, telephone interviews were held and postal questionnaires were sent up to a maximum of two months after receipt of completed informed consent forms. This interval of two months was needed to include patients who were difficult to reach for interviews and due to logistical constraints in the TICD-RCT. For telephone interviews, a maximum of ten attempts were made before considering patients as unable to reach. Patients were contacted for telephone interviews during office hours and in early evening (up to 20.00 pm). For postal questionnaires, patients were provided with a postage-paid envelope to return their completed questionnaires.

For patients in choice arms of the two trials, all who indicated a preferred participation mode received an interview or questionnaire according to the stated preference. For patients who indicated to be willing to participate by both modes (i.e. ticked both the boxes for telephonic interview and postal questionnaire), all were sent a postal questionnaire. This approach was chosen for reasons of feasibility.

The telephone interview & postal questionnaire

Telephone interviews and postal questionnaires contained identical questions, regardless of study arm for the SNS and TICD-RCT. Total number of main questions was five, including sub questions the total number of questions was 45. The SNS included questions on 1) information sharing with health care providers and persons from patients’ personal networks, and 2) on persons that patients considered to be important for handling their condition or disease. Questions were tailored to general practice. In this way, for items on information sharing with health care providers, names and disciplines of persons from patients’ general practices were prelisted with space for additional names and disciplines if needed.

Note that the number of questions to be completed was dependent on the composition of patients’ networks, so that patients with smaller networks needed to complete fewer questions. Patients with missing data on questions that they could have completed given their answers on other questions, were considered as partial completions. Patients were considered as withdrawn when they refused to participate when being contacted for the interview or when they contacted the research team (either by telephone, email, or letters) about their non participation or when they failed to return their questionnaire within two months.
Mean duration of interviews was 15.7 minutes (SD 6.91). Number of pages for the questionnaire was twelve.

**Ethical approval**
The Medical Ethical Committee of Radboud University Nijmegen Medical Centre has waived approval for the social network study and its associated response trials 15, as well as the TICD-RCT 16.

**Measures & Outcomes**
The primary outcome was participation rate. Secondary outcomes consisted of conditional participation rate, willingness to participate, and mode preference. Definitions for all outcomes are summarized in Table 1.

*Participation rate:* was defined as the percentage of patients who actually participated in the SNS. That is the total number of patients who had completed and partially completed an interview or questionnaire for the SNS divided by the total number of participants in the TICD-RCT (conform to AAPOR RR2 17).

*Conditional participation rate:* the invitation procedures of this study allowed for determining what percentage of patients participated in the SNS, given that they were willing to participate. This secondary outcome is defined as the total number of patients who had completed and partially completed an interview or questionnaire for the SNS divided by the total number of patients willing to participate in the SNS (conform to AAPOR COOP2 17).

*Willingness to participate:* was defined as the percentage of patients initially willing to participate in the SNS. That is the total number of patients willing to participate in the SNS divided by the number of participants in the TICD-RCT. This definition is conform to AAPOR RR2 17 with the number of patients accepting invitations to participate in the SNS in the numerator.

*Mode preference:* additionally, we determined preference for participation mode for patients in the choice arms of the SNS. Mode preference was determined as the total number of patients willing to participate by a specific mode (telephone interview, postal questionnaire, or both) divided by the number of participants who were provided choice of participation mode and who accepted to participate in the SNS.

**Sample size & statistical analysis**
Assuming a two-tailed alpha of 0.05, 80% power, a response rate of 50% in the no-choice arm and 65% in the choice arm, we estimated we needed to include a total of 338 patients in each trial 15.

Data were analyzed using SPSS version 20. All analyses were based on intention to treat. Chi square tests were used to examine differences in participation rates, conditional participation rates, and willingness to participate for the different invitation formats.
Relative risks (RR) and 95% confidence intervals are reported for the effectiveness on participation rates, conditional participation rates, and willingness to participate. Reference categories consisted of ‘decided not to participate’ for participation rates and conditional rates and of ‘unwilling to participate’ for willingness to participate.

Two types of sensitivity analyses were performed. First, effect of choice of participation mode was controlled for general practice clustering, TICD-RCT trial arm, and patient characteristics (sex, age, and patient group: high risk or CVD). For this means, we estimated logistic models with participation rate, conditional participation rate, and willingness to participate in trial 1 and 2 as outcomes, using generalized estimating equations (GEE) with general practice as subject variable. The working correlation structure was specified as exchangeable, and robust sandwich estimators were used. Second, patients from choice arms who indicated to be willing to participate in the SNS by both modes, all were sent questionnaires. To examine whether this approach influenced outcomes, we again used chi square tests to examine differences in participation rate, conditional participation rates, and willingness to participates, excluding patients without preference of participation mode.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Participation rate</td>
<td>completed and partially completed SNS interview or questionnaire</td>
</tr>
<tr>
<td>Conditional participation rate</td>
<td>completed and partially completed SNS interview or questionnaire</td>
</tr>
<tr>
<td>Willing to participate</td>
<td>willing to participate in SNS</td>
</tr>
<tr>
<td>Mode preference</td>
<td>received a choice-format invitation and willing to participate in SNS</td>
</tr>
</tbody>
</table>

Table 1 Definitions of outcomes
Results

Description of sample
Table 2 provides descriptive characteristics of the samples in each trial. Participants in trial 1 had a mean age of 72 years, 38% female, and 60% were at high risk for CVD. In trial 2 mean age was 73 years, 32% female, and 58% were at high risk for CVD.

Table 2  Sample characteristics

<table>
<thead>
<tr>
<th>Trial arm</th>
<th>Trial 1</th>
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<th></th>
<th>Trial 2</th>
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<tbody>
<tr>
<td></td>
<td>No choice</td>
<td>Choice</td>
<td>Total</td>
<td>No choice</td>
<td>Choice</td>
<td>Total</td>
</tr>
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<td>Participants</td>
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<td>193</td>
<td>391</td>
<td>294</td>
<td>298</td>
<td>592</td>
</tr>
<tr>
<td>Female</td>
<td>72 (36%)</td>
<td>77 (40%)</td>
<td>149 (38%)</td>
<td>95 (32%)</td>
<td>97 (33%)</td>
<td>192 (32%)</td>
</tr>
<tr>
<td>Age</td>
<td>71.8 (SD 9.2)</td>
<td>73.1 (SD 9.9)</td>
<td>72 (SD 9.6)</td>
<td>72.9 (SD 8.8)</td>
<td>72.3 (SD 10.3)</td>
<td>73 (SD 9.6)</td>
</tr>
<tr>
<td>HR</td>
<td>118 (59.6%)</td>
<td>115 (60%)</td>
<td>233 (60%)</td>
<td>168 (57%)</td>
<td>173 (58%)</td>
<td>341 (58%)</td>
</tr>
<tr>
<td>CVD</td>
<td>80 (40.4%)</td>
<td>78 (40%)</td>
<td>158 (40%)</td>
<td>126 (43%)</td>
<td>125 (42%)</td>
<td>251 (42%)</td>
</tr>
</tbody>
</table>

Abbreviations: HR = high risk for CVD, CVD = cardiovascular disease

TRIAL 1: No choice (telephone interview) versus choice of participation mode
Results from Trial 1, comparing outcomes of patients invited to participate in the SNS in a telephone interview and provided with choice of participation mode (n = 391) are summarized in Table 3.

Participation rates Participation rates of patients with and without choice of participation mode did not differ (RR 0.98, 95%CI: 0.74 – 1.28); 65% of patients who choose their preferred participation mode actually participated, compared to 66% of patients who were not allowed to choose participation mode (X² 0.03 (1), p = .853).

Conditional participation rates conditional participation rates (that is the percentage of patients actually participating, provided that they were willing to participate) differed, with fewer (72%) patients willing to participate by means of a participation mode according to their preference actually doing so and more (90%) patients willing to participate in an interview actually doing so (RR 0.37, 95%CI: 0.22 – 0.63). This 18% difference in participation rates was statistically significant (X² 15.654 (1), p < .01).

Willingness to participate In trial 1, more patients were initially willing to participate in the network study when allowed to choose a participation mode compared to patients invited for an interview (RR 2.72, 95%CI: 1.67 – 4.42); 90% of patients allowed to choose their preferred participation mode were willing to participate, compared to 73% patients invited to participate in an interview. This 17% difference was significant: X² 18.63 (1) p < .01.)
TRIAL 2: No choice (postal questionnaire) versus choice of participation mode

Results from Trial 2, comparing outcomes of patients invited to participate in the SNS by a postal questionnaire and provided with choice of participation mode (n = 592) are summarized in Table 3.

Participation rates: participation rate of patients who were allowed to choose participation mode was higher than that of patients who were not allowed to choose their participation mode (RR 1.34, 95%CI: 1.13 – 1.59); 59% versus 46% respectively. This 13% difference was significant (X² 11.33 (1), p < .01).

Conditional participation rates: conditional participation rate was higher for patients who were allowed to choose participation mode; 66% versus 53% (RR 1.39, 95%CI: 1.12 – 1.71). This 13% difference was significant (X² 9.25 (1), p < .01).

Willingness to participate: in trial 2, initial willingness to participate did not differ (RR 1.39, 95% CI: 0.89 – 2.16); 90% of patients who received a choice format invitation were willing to participate, whereas 86% of patients who were invited to participate via a questionnaire were willing to participate. This 4% difference was not statistically significant (X² 2.11 (1), p = .146).

Table 3 Willingness to participate, participation rates, and conditional participation rates in trial 1 and 2

<table>
<thead>
<tr>
<th>Invitation formats</th>
<th>No choice</th>
<th>Choice</th>
<th>( X^2 )</th>
<th>df</th>
<th>p</th>
<th>RR (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TRIAL 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interview (n=198)</td>
<td>130 (66%)</td>
<td>125 (65%)</td>
<td>0.03</td>
<td>1</td>
<td>0.853</td>
<td>0.98 (0.74 - 1.28)</td>
</tr>
<tr>
<td>Conditional participation rate</td>
<td>130 (90%)</td>
<td>125 (72%)</td>
<td>15.65</td>
<td>1</td>
<td>&lt;.01</td>
<td>0.37 (0.22 - 0.63)</td>
</tr>
<tr>
<td>Willing to participate</td>
<td>145 (73%)</td>
<td>174 (90%)</td>
<td>18.63</td>
<td>1</td>
<td>&lt;.01</td>
<td>2.72 (1.67 - 4.42)</td>
</tr>
<tr>
<td><strong>TRIAL 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questionnaire (n=294)</td>
<td>134 (46%)</td>
<td>177 (59%)</td>
<td>11.33</td>
<td>1</td>
<td>&lt;.01</td>
<td>1.34 (1.13 - 1.59)</td>
</tr>
<tr>
<td>Conditional participation rate</td>
<td>134 (53%)</td>
<td>177 (66%)</td>
<td>9.25</td>
<td>1</td>
<td>&lt;.01</td>
<td>1.39 (1.12 - 1.71)</td>
</tr>
<tr>
<td>Willing to participate</td>
<td>253 (86%)</td>
<td>268 (90%)</td>
<td>2.11</td>
<td>1</td>
<td>0.146</td>
<td>1.39 (0.89 - 2.16)</td>
</tr>
</tbody>
</table>

Abbreviations: \( X^2 = \) chi square, RR = relative risk
**Mode preference**

For patients from the choice arms of the two trials and who accepted the invitation to participate in the SNS, mode preference was inferred (see Table 4).

In trial 1, a total of 174 patients from the choice arm was willing to participate in the SNS. Of these patients, 46% were willing to participate in both modes. 54% of patients preferred one participation mode of which 21% preferred the telephone interview and 33% preferred the postal questionnaire.

In trial 2, a total of 268 patients from the choice arm was willing to participate in the SNS. Of these patients, 41% were willing to participate in both modes. 59% of patients preferred one participation mode of which 12% preferred the telephone interview and 47% preferred the postal questionnaire.

Conditional participation rates of patients from the choice arm, stratified for chosen participation mode, were highest for interviews with a 100% participation rate in trial 1 and 84% in trial 2.

**Table 4** Mode preference

<table>
<thead>
<tr>
<th>Participation mode:</th>
<th>Interview</th>
<th>Questionnaire</th>
<th>No preference*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trial 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willing to participate</td>
<td>37 (21%)</td>
<td>57 (33%)</td>
<td>80 (46%)</td>
<td>174</td>
</tr>
<tr>
<td>Participated</td>
<td>37 (100%)</td>
<td>35 (61%)</td>
<td>53 (66%)</td>
<td>125 (72%)</td>
</tr>
<tr>
<td><strong>Trial 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willing to participate</td>
<td>32 (12%)</td>
<td>127 (47%)</td>
<td>109 (41%)</td>
<td>268</td>
</tr>
<tr>
<td>Participated</td>
<td>27 (84%)</td>
<td>83 (65%)</td>
<td>67 (61%)</td>
<td>177 (66%)</td>
</tr>
</tbody>
</table>

* Patients willing to participate by both participation modes were considered to have no preference for mode

**Sensitivity analyses**

**GEE analyses**

Table 5 provides results of three logistic models using GEE with participation rate, conditional participation rate, and willingness to participate as outcomes while controlling the effect of choice of participation mode in trial 1 (interview vs. choice of participation mode) for general practice clustering, TICD-RCT trial arm, and several patient characteristics (sex, age, and patient group). Effects of choice of participation mode remained stable for all outcomes. In Table 6 results are presented for trial 2 (questionnaire vs. choice of participation mode). Effects of choice of participation mode remained stable for participation rate and conditional participation rate. Different from the chi square test, the effect of choice of participation mode did reach statistical significance (OR = 1.42, p < .001) in the analysis for willingness to participate.
**Examining choice of participation mode excluding patients without mode preference**

In these analyses (see also Table 7) comparisons for participation rates, conditional participation rates, and willingness to participate were repeated excluding patients from choice arms of both trials who did not express preference for a participation mode. Results were similar to those of the main analyses as reported in table 3.

**Table 5** Logistic regression models using GEE for outcomes in trial 1: no choice (interview) versus choice of participation mode

<table>
<thead>
<tr>
<th></th>
<th>Participation rate OR (95% CI)</th>
<th>Conditional participation rate OR (95% CI)</th>
<th>Willingness to participate OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNS choice arm</td>
<td>0.99 (0.68 - 1.44)</td>
<td><strong>0.27</strong>* (0.17 - 0.44)</td>
<td><strong>3.52</strong>* (2.75 - 4.51)</td>
</tr>
<tr>
<td>SNS no-choice arm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TICD-RCT intervention arm</td>
<td>0.84 (0.62 - 1.14)</td>
<td>*<em>0.60</em> (0.40 - 0.90)</td>
<td>1.14 (0.64 - 2.02)</td>
</tr>
<tr>
<td>TICD-RCT control arm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient group: CVD</td>
<td>1.16 (0.75 - 1.79)</td>
<td>1.37 (0.62 - 3.04)</td>
<td><strong>1.25</strong> (1.07 - 1.46)</td>
</tr>
<tr>
<td>Patient group: high risk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.96 (0.73 - 1.26)</td>
<td>1.12 (0.59 - 2.12)</td>
<td>0.85 (0.64 - 1.13)</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.99 (0.98 - 1.02)</td>
<td>*<em>1.03</em> (1.01 - 1.06)</td>
<td>0.97 (0.94 - 1.002)</td>
</tr>
</tbody>
</table>

*** p < .001 ** p < .01 * p < .05, OR = odds ratio, estimated intercepts omitted from table

**Table 6** Logistic regression models using GEE for outcomes in trial 2: no choice (postal questionnaire) versus choice of participation mode

<table>
<thead>
<tr>
<th></th>
<th>Participation rate OR (95% CI)</th>
<th>Conditional participation rate OR (95% CI)</th>
<th>Willingness to participate OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNS choice arm</td>
<td><strong>1.81</strong>* (1.37 - 2.39)</td>
<td><strong>1.81</strong> (1.29 - 2.55)</td>
<td><strong>1.42</strong>* (1.22 - 1.65)</td>
</tr>
<tr>
<td>SNS no-choice arm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TICD-RCT intervention arm</td>
<td>0.95 (0.53 - 1.73)</td>
<td>0.98 (0.50 - 1.90)</td>
<td>0.8 (0.54 - 1.19)</td>
</tr>
<tr>
<td>TICD-RCT control arm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient group: CVD</td>
<td>0.95 (0.70 - 1.30)</td>
<td>0.93 (0.60 - 1.43)</td>
<td>1.12 (0.65 - 1.94)</td>
</tr>
<tr>
<td>Patient group: high risk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.87 (0.68 - 1.10)</td>
<td>0.92 (0.67 - 1.25)</td>
<td>0.86 (0.51 - 1.44)</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1.01 (0.99 - 1.02)</td>
<td>*<em>1.02</em> (1.001 - 1.03)</td>
<td>*<em>0.97</em> (0.94 - 0.99)</td>
</tr>
</tbody>
</table>

*** p < .001 ** p < .01 * p < .05, OR = odds ratio, estimated intercepts omitted from table
Discussion

In this study we examined whether participation in a survey study can be improved by providing choice of participation mode. Results were mixed. In trial 1 patients offered the telephone interview (no-choice arm) were as likely to participate as those offered choice of participation mode, whereas in trial 2 those offered a postal questionnaire (no-choice arm) were substantially less likely to participate compared with patients offered choice of participation mode. Considering only patients who indicated to be willing to participate in the SNS, conditional participation rates differed over the two trials as well for the no-choice and choice arms. In trial 1, conditional participation rate was higher in the no-choice arm (for interviews) while it was lower in the no-choice arm for questionnaires in trial 2. Willingness to participate was higher for patients provided with choice of participation mode, although differences with no-choice arms were only significant in trial 1 (no-choice for telephone interviews).

Few previous research seemed to have compared choice of participation mode for telephone interviews and postal questionnaires. Different from Dillman et al.⁵ we found that choice of participation mode did enhance participation rate when compared to no choice participation in questionnaires. Some of our results are in accordance with those of Denniston et al.⁶ who considered conditional participation rate and found, although not significant, higher conditional participation rates for choice of participation mode compared to no-choice participation in interviews and questionnaires. However, in this

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Table 7  Sensitivity analyses excluding patients without mode preference

<table>
<thead>
<tr>
<th>Invitation formats</th>
<th>No choice</th>
<th>Choice</th>
<th>(X^2)</th>
<th>df</th>
<th>p</th>
<th>RR (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TRIAL 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>interview (n=198)</td>
<td>interview or questionnaire (n = 113)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation rate</td>
<td>130 (66%)</td>
<td>72 (64%)</td>
<td>0.12</td>
<td>1</td>
<td>0.73</td>
<td>0.95 (0.69 - 1.29)</td>
</tr>
<tr>
<td>Conditional participation rate</td>
<td>130 (90%)</td>
<td>72 (77%)</td>
<td>7.43</td>
<td>1</td>
<td>&lt;.01</td>
<td>0.44 (0.24 - 0.81)</td>
</tr>
<tr>
<td>Willing to participate</td>
<td>145 (73%)</td>
<td>94 (83%)</td>
<td>4.006</td>
<td>1</td>
<td>&lt;.05</td>
<td>1.59 (1.00 - 2.55)</td>
</tr>
<tr>
<td><strong>TRIAL 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>questionnaire (n=294)</td>
<td>interview or questionnaire (n=189)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation rate</td>
<td>134 (46%)</td>
<td>110 (58%)</td>
<td>7.33</td>
<td>1</td>
<td>&lt;.01</td>
<td>1.30 (1.07 - 1.59)</td>
</tr>
<tr>
<td>Conditional participation rate</td>
<td>134 (53%)</td>
<td>110 (69%)</td>
<td>10.63</td>
<td>1</td>
<td>&lt;.01</td>
<td>1.53 (1.17 - 1.99)</td>
</tr>
<tr>
<td>Willing to participate</td>
<td>253 (86%)</td>
<td>159 (84%)</td>
<td>0.34</td>
<td>1</td>
<td>0.56</td>
<td>0.88 (0.57 - 1.36)</td>
</tr>
</tbody>
</table>

Abbreviations: \(X^2\) = chi square, RR = relative risk
study we observed an opposite pattern when comparing choice of mode with the no-choice arm for interviews. In line with Denniston et al., we found that initial willingness to participate was higher for patients provided with choice on participation mode and lowest for patients invited solely for telephone interviews. Reported differences in our study are larger than in previous research comparing choice of participation mode for interviews versus questionnaires and questionnaires versus web options. This may have resulted because we recruited patients who were already participating in the TICD-RCT, possibly representing a sample motivated to participate in research.

Results of this study suggest that offering choice of participation mode can enhance participation rates, at least when compared to invitations for participation by a questionnaire. However, this conclusion may seem conflicting with trial 1 in which conditional participation rate was higher in the no-choice arm for interviews. Yet it may be that the participation mode itself created a higher conditional participation rate. Advantages of interviews that may lead to higher participation rates consist, amongst others, of personal contact and opportunity for providing additional explanation and information. Higher participation rates for interviews compared to questionnaires have been described in the literature. However, advantages of interviews may have been especially relevant given the topic of the SNS. Although not quantitatively assessed, patients often commented they experienced little burden of their condition or disease and therefore had difficulties relating to questions on persons providing or sharing information on CVRM. An often stated remark was that patients were not in need of information related to CVRM. It may be that advantages of interviews kept these patients in the study while such patients were lost when participating by questionnaires, in which no additional explanation could be provided to patients doubting whether the topic of the research was applicable to their situation. So, it remains possible that conditional participation rates of interviews without choice on participation mode will be different when compared to choice of participation mode for a different research topic.

On the other hand, it may be that practical decisions in the performance of this study reduced participation rates in the choice arms. Patients provided with choice of participation mode but willing to participate by both participation modes, were all sent a questionnaire. Although this approach was chosen for reasons of feasibility, results comparing the no-choice arms of both trials suggest that participation rates could have been higher when patients willing to participate by either mode were interviewed. Interviews may be a less popular mode than questionnaires (willingness to participate in the no choice arm was 73% for interviews in trial 1 vs 86% for questionnaires in trial 2), but they do seem to come with a higher participation rate for those willing to participate in it (participation rates in no choice arm for interviews 66% vs 46% in the no choice arm for questionnaires, and conditional participation rates in no choice arm for interviews 90% vs 53 in no choice arm for questionnaires). So, participation rates in the choice arms of both trials could have been reduced by only using questionnaires as participation mode and
could have been higher when interviews were held with patients who were willing to participate by either mode.

Therefore, it may be a valuable strategy to provide choice of participation mode anyhow, using such an approach, optimal participation rates may be attained by 1) providing patients with choice, and 2) usage of participation modes with likely high participation rates, such as interviews, in a maximum number of patients willing to do so.

Limitations of this study consist of the following. First, specific procedures from the research may have influenced outcomes. Due to practical matters, we needed an interval up to a maximum of two months between receipt of accepted invitations and completing interviews and sending questionnaires. It remains unsure which way this may have influenced our results. On one side, participants may have lost their interest or motivation if there is a wider time gap upon deciding to participate and actually doing so. However, participants in the SNS were also participating in the TICD-RCT for which they needed to complete a 20 page (including 87 questions) questionnaire booklet. Therefore, too few time between surveys of both studies may have discouraged patients from participating as well. Another limitation was the provision of only questionnaires in patients willing to participate in the SNS by both participation modes. Third, caution is warranted to generalize findings of this study. As we recruited patients already participating in research, it is possible participants in the SNS represented a more motivated sample to participate in research. The topic of the SNS may limit generalizability as well. As patients indicated they had difficulties relating to the topic, results may be different for other topics. Finally, concomitant with the applied exclusion criteria of the TICD-RCT, our findings cannot necessarily be generalized to other patient groups, such as those with other chronic diseases or patients with cognitive impairments or poor language skills. Nevertheless, the patient population represents a heterogeneous sample of middle aged and elderly people with one or more chronic diseases.

Conclusion

Providing choice of participation mode can enhance participation rates, at least when compared to invitations to participate by questionnaires.
References

Social network composition of vascular patients and its associations with health behavior and clinical risk factors

_Plos One 2017; a slightly adapted version of this article has been accepted for publication_

Naomi Heijmans
Jan van Lieshout
Michel Wensing
Abstract

Background This study aimed to explore linkages of patients’ social network composition with health behaviors and clinical risk factors.

Methods/design This observational study was embedded in a project aimed at improving CRVM in primary care. 657 vascular patients (227 with cardiovascular disease, 380 at high vascular risk), mean age 72.4 (SD 9.4) years, were recruited as were individuals patients considered important for dealing with their disease, so called alters (n=487). Network composition was measured with structured patient questionnaires. Patient and alter questionnaire data were used to measure health behavior (physical activity, diet, and smoking). Clinical risk factors (systolic blood pressure, LDL cholesterol level, and body mass index) were extracted from patients’ medical records. Six logistic regression analyses, using generalized estimating equations, were used to test three hypothesized effects of network composition (having alters with healthful behaviors, without depression, and with specialized knowledge) on six outcomes, adjusted for demographic, personal and psychological characteristics.

Results Having alters with overall healthful behavior was related to healthful patient diet (OR 2.14, 95%CI: 1.52-3.02). Having non-smoking alters in networks was related to reduced odds for patient smoking (OR 0.17, 95%CI: 0.05-0.60). No effects of presence of non-depressed alters were found. Presence of alters with specialized knowledge on CVRM was inversely related to healthful diet habits of patients (OR 0.47, 95%CI 0.24-0.89).

Discussion Diet and smoking, but not physical exercise and clinical risk factors, were associated with social network composition of patients with vascular conditions. In this study of vascular patients, controlling for both personal and psychological factors, fewer network influences were found compared to previous research. Further research is needed to examine network structure characteristics as well as the role of psychological factors to enhance understanding health behavior of patients involved in CVRM.
Background

Cardiovascular disease (CVD) was the most common cause of death for women, and the second cause of death for men, in the Netherlands in 2013. Cardiovascular risk management (CVRM) aims to prevent or delay CVD and, amongst others, heavily emphasizes control of clinical risk factors (blood pressure, serum cholesterol, body-mass index) and healthful behaviors (healthful habits for diet, physical activity, and non-smoking). Accordingly, patients have a central role in CVRM. Changing unhealthful behavior, or maintaining healthful behaviors, does not come easily. Research showed that health behavior is not only influenced by individual characteristics, but also by the individuals’ social environment. For instance, research indicated that particular aspects of social networks, e.g. high social support and social integration, were related to reduced mortality from diverse causes. Subsequent studies found that persons with particular health related behaviors and characteristics tended to be connected within social networks. Such clustering patterns have been described for smoking, alcohol use, aspirin use, health screening, obesity, and depression.

So, social network studies provided compelling results which may help to understand and enhance health behaviors. The current body of evidence largely comprises of studies on social support in specific populations (including vascular patients) on the one hand and studies on social networks in general populations on the other hand. Although most studies controlled social network influences for a variety of individual characteristics (e.g. age, sex, education), few studies on health behavior used psychological traits as control variables. However, psychological traits, e.g. depression or patient activation, are known to influence health behaviors as well. As such we were interested in the influence of social networks over and above these traits. Also, most social network studies relied exclusively on patient-reported health behaviors, which may be subject to bias, rather than recorded clinical indicators. Finally, a substantial number of studies used data of contacts of patients, so called alters, as reported on by patients, instead of including alters in the research themselves. Our research aimed to overcome these limitations of previous studies.

Network-related factors

Several mechanisms through which social networks influence health behaviors and health outcomes have been described and include, amongst others, social support, social capital, and social influence. Social support is the provision of information, practical help, or emotional comfort by individuals or organizations in the individual’s social network. It is related to improved health behavior by means of assistance with health related activities and with maintaining healthful behaviors. Provision of support can come from anyone within a given network, although evidence suggests that family seems to be most relevant for self-care.
Social capital is a related concept as it indicates the availability of support for a specific individual. Access to resources has mostly been studied by studies on social capital, defining this construct as membership in social networks that facilitate access to resources, e.g. information on health and behaviors. Greater social capital has been linked to better health or well-being.

Social influence is a different type of mechanism in networks. The finding of clustering of behaviors (e.g. smoking, alcohol use) within networks led to the notion of social contagion of behaviors and ideas in social networks. Social contagion is a multifaceted process, which may apply to information, ideas, behaviors and infections. Multiple underlying mechanisms of contagion can result in spread of information and (resulting) behavior, e.g. imitation of successful behavior, role modeling, social comparison, and selection of contacts. In this context, homophily (also termed homogeneity) refers to the principle that contacts between persons who share similarities will occur at a higher rate than among persons who are more dissimilar, thus shaping opportunities for spread of information and behaviors within networks, with consequences for the formation of attitudes and norms, and social influence processes (e.g. social reinforcement). Noting that it is difficult to distinguish selection and causal effects, clustering seems to occur together with homophily.

Using these concepts, a number of network-related determinants of health-related behaviors and clinical indicators were formulated for this study (see Figure 1 for a summary). First, as clustering is found for several behaviors and traits and can shape several opportunities for various social influence mechanisms, we expected patients to be more likely to hold healthful behaviors, that is healthful habits for physical activity, diet, and smoking, if their alters have such behaviors as well.

Second, we considered the influence of depression, which is a known predictor of many health-related behaviors. Depression can impede efforts for improving health behaviors and has a common occurrence in cardiac patients. Depression and depressive symptoms have been related to impaired health behaviors and increased mortality in specific cardiac patients groups. In addition to these negative effects, depression has been shown to have a contagious pattern in networks. In this way, depression or depressive symptoms may assert a negative influence on health behaviors in two ways: first by influencing patients themselves and second by contagiously spreading within social networks. Therefore, we expect that social networks without individuals with depression are positively related to healthful behaviors.

Third, in addition to opportunities for spread of information and behaviors, it is obviously important that reliable information and knowledge on CVRM and health behaviors spreads within networks. Individuals who can allow for this include health professionals, such as nurses, physicians and allied health professionals. Having such persons within ones network can add to so called social capital, which is in this way
Figure 1 Hypothesized relations

- **Social network composition**
  - Presence of alters with adequate health behaviors
  - Presence of alters without depressive symptoms or depression
  - Presence of alters who can provide access to CRVM - information

- **Social mechanisms, formation attitudes & behavior**
  - Multiple social influence mechanisms
  - Contagious patterns
  - Social capital

- **CVRM related outcomes**
  - Health behaviors
  - Clinical risk factors
defined as having social networks that facilitate access to resources. We expect that patients with health professionals within their networks will be more likely to have healthful behaviors and have positive clinical indicators.

In the study presented here, we focused on composition of support networks of patients with high vascular risk and vascular diseases. Lifestyle support networks were constructed on individuals that patients considered to be important for managing their health-related behaviors. This definition of a social network is broader than often applied. We examined a broad, instead of specifically and narrowly, defined network for several reasons. First, we considered the result that support can be provided by anyone, which indicates that support for health behavior may stem from multiple specific networks (e.g. from family or friends). Second, network characteristics as identified in our hypotheses may occur in multiple networks a person engages in, e.g. alters with healthful behaviors may be a friend from a sport club or a spouse. Third, multiple types of specific networks may contribute to health.

In summary, the main aim of this research was to explore social network composition and its associations with health behaviors and clinical risk factors in patients with vascular conditions. We set out to test the following key hypotheses: Patients will be more likely to have healthful behaviors and reach target values for clinical risk factors if they have social networks which contain:
1. Individuals with healthful behaviors
2. No individuals with depressive symptoms or depression
3. Individuals with specialized knowledge on health, particularly health professionals

**Methods**

**Design & Study population**

This study is part of the ‘Tailored Implementation for Chronic Disease’ (TICD) project and was an observational study on social networks of vascular patients and their alters: individuals who patients considered important for managing their health behaviors. This study was performed parallel to a larger two-arm cluster randomized controlled trial (RCT) (NTR4069). The trial aimed at testing a tailored intervention for improving CVRM in primary care by enhancing professional performance of practice nurses and included a random sample of general practices from several geographical areas in the Netherlands. Specific details of the trial are described elsewhere.

Patients at high risk for CVD and patients with established CVD were included. They were identified from the baseline measurement of the trial which used International Classification of Primary Care (ICPC) codes to extract eligible patients from medical records.
from general practices. Extraction was performed by practice nurses in cooperation with research assistants. Eligible patients were 18 years or older and capable of providing informed consent; exclusion criteria consisted of: diabetes mellitus, pregnancy and lactation, terminal illness, cognitive impairments, and poor language skills. Patients with diabetes were excluded using ICPC codes, practice nurses assessed other exclusion criteria. Alters of patients consisted of individuals that patients indicated to be important for managing their health behaviors. A maximum of four alters was included as literature indicated this is the maximum number of important or significant others to be expected within social networks of patients.

Ethical approval
The Medical Ethical Committee of Radboud University Nijmegen Medical Centre has waived approval for the social network study and the RCT. The study protocols and all its materials (e.g. informed consent forms, questionnaires and letters), as well as the consent process, for both studies were submitted to the Medical Ethical Committee of Radboud University Medical Centre Nijmegen. This committee assessed that the Dutch law for medical scientific research does not apply to these studies. As the studies did not involve testing of body materials, no approval was required from a local medical ethical committee. Participants of this study provided consent by signing written informed consent forms. All data were collected prospectively, and consisted of questionnaire data on social networks and health behavior of patients, questionnaire data on health behavior of alters, and data extracted from medical records of patients on clinical risk factors (systolic blood pressure and LDL cholesterol) and professional performance of practice nurses. None of the authors were treating physicians of participants in the social network study and the RCT study.

Data collection procedures
Patients were invited for participation in the social network study using invitations included at the end of postal questionnaire booklets send for purposes of the trial at baseline of its intervention program (see also Figure 2 ‘study flow’). Postal questionnaires for the RCT mainly focused on health related lifestyle. Invitations for the social network study contained a concise explanation on the study purpose and were accepted by completing an enclosed informed consent form. Postal questionnaires for the social network study were send up to a maximum of three months after receipt of completed informed consent forms. This interval was needed due to logistical constraints in the RCT. Data collection was performed from December 2013 until March 2014. For including alters of patients, four additional questionnaires titled ‘questionnaire for close ones’ were send along with patients questionnaires. These four alter questionnaires had identical contents. An information letter was used to inform patients that these questionnaires were meant for individuals whom they had identified in their own questionnaire as ‘important for
managing their condition or disease’. The term ‘condition’ was used in questionnaires for high risk patients, and ‘disease’ in those for CVD patients. Patients were asked to give these questionnaires to their alters and provided with explanation on how to do this. Invitation letters for alters, providing concise information about the research, were enclosed to alter questionnaires along with informed consent forms. Patients and alters were provided with postal aid envelopes for returning their questionnaires. Data on clinical risk factors of patients at baseline of the RCT were gathered from patients’ medical records using the Epa Cardio abstraction tool 29, and were collected at the end of the RCT intervention program (performed from March 2014 until December 2014). This medical audit was performed by trained research assistants.

Outcomes
Outcomes of this research were the description of network composition, patient health behavior, consisting of patient-reported physical activity, diet, and smoking, and the clinical indicators systolic blood pressure (SBP), low density lipoprotein cholesterol (LDL), and body mass index (BMI). Patient health behavior and the clinical indicators were dichotomous variables.

Health behaviors were measured using a composite questionnaire on: physical activity (Rapid Assessment of Physical Activity (RAPA), 9 items30); diet (reduced Rapid Eating and Activity Assessment (REAP-s), 12 items 31); and smoking (MID-SIZED Model, 8 items 32).

Physical activity was considered to be healthful if item 6 of the RAPA (‘I do 30 minutes or more a day of moderate physical activities, 5 or more days a week’) or 7 (‘I do 20 minutes or more a day of vigorous physical activities, 3 or more days a week’) was answered affirmatively. Diet was assessed with the REAP-s which asks to indicate how often (usually/often, sometimes, rarely/never, or not applicable) one engages in several unhealthful dietary habits in an average week. The REAP-s assesses habits on intake of grains, fruits and vegetables, calcium/dairy, saturated fat, and sugar. Patients who scored a maximum of two items ‘usually/often’ were considered to have healthful diet habits. Current smoking status was measured using one item from the Mid-sized Model. This item had four categories (‘yes, I smoke’, ‘no I quit smoking in the past 6 months’, ‘no, I quit smoking more than 6 months ago’, and ‘no, I never smoked’) which was recoded to a dichotomous variable (smoking vs non smoking).

Three clinical indicators of patients were abstracted from medical records using the Epa Cardio abstraction tool 29: SBP, LDL, and BMI. Elevated SBP was defined as SBP > 140 mmHg. Elevated LDL was defined as LDL > 2.5 mmol/l. BMI was calculated by dividing patients’ weight by the square of height in meters. Overweight was scored with BMI > 25 kg/m².
Figure 2  Study flow

**Studies**

RCT

1104 patients from 25 general practices enrolled in RCT and completed baseline questionnaires which included invitations for the social network study

SOCIAL NETWORK STUDY

N=657 patients participating in social network study

Patients: **health related behaviors**

Patients received network questionnaires along with 4 questionnaires for their alters and were asked to spread these to their alters

Patients: **clinical risk factors**

Non participants (n=447)

MEASURES

Patients: **health related behaviors**

Postal questionnaire on i.a.: Physical activity (RAPA), diet (REAP-s), smoking (y/n), Patient activation (PAM), Medication adherence (MMAS), depressive symptoms (PHQ-9)

Alters: **health related behaviors**

487 alters completed postal questionnaire on Physical activity (RAPA), diet (REAP-s), smoking (y/n), depressive symptoms (PHQ-9)

Patients: **social networks**

Postal questionnaire on social network constructed on persons considered important for handling condition or disease

Patients: **clinical risk factors**

Medical audit of medical records using Epa Cardio abstraction tool: SBP, LDL, BMI
Measures

Descriptive variables
Descriptive data of patients and their alters on age, sex, ethnicity, marital status, educational level, and working status were gathered using items from the Epa Cardio abstraction tool in questionnaire booklets of the RCT for patients and in questionnaires for alters respectively.

Individual characteristics
Individual characteristics of patients were: patient activation (Patient Activation Measure, PAM), therapy adherence (Medication Adherence Measure), and depressive symptoms (Patient Health Questionnaire, PHQ-9) and were measured using questionnaire booklets of the RCT. Higher total scores on these measures indicated higher patient activation, therapy adherence, and more depressive symptoms respectively. Alters completed the PHQ-9 as well, a cutoff score of 5 or higher indicated presence of depressive symptoms.

Alter health behavior
Health behavior of alters was measured using a composite questionnaire which was identical to that completed by patients (physical activity; RAPA, diet; REAP-s, smoking status; MIDSIZED MODEL). Scoring rules for defining healthful physical activity, diet, and smoking status were also identical to those applied to patient data.

Social networks
Alters of patients were identified using two questions. First patients were asked to mention one person whom they considered to be most important for managing their condition or disease and health-related behaviors. It was explained that these included diet-, physical exercise-, and (if applicable) smoking habits. It was also stated that this person does not need to be ‘most important’ for a specific reason and does not need to be part of the patient’s personal environment. Second, patients were asked to name a maximum of three persons (other than their ‘most important other’) they considered important for managing their condition or disease. It was again explained that these persons did not need to be important for any specific reason. We emphasized that persons mentioned in this question did need to be part of patients’ personal environment. Patients were asked to appoint type of relation with each of their alters, response categories consisted of family, friends, acquaintances, or others.

Data analysis
SPSS (version 22) was used for all analyses. All analyses were performed two tailed, using $p < .05$ indicating significance.
Construction of social network composition
We followed an identical procedure for the construction of all network compositions variables. First, we counted the number of alters with a certain behavior or trait who were present within patients’ networks. As few patients had more than one alter with a particular characteristic, we decided to dichotomize the social network composition variables. The resulting variables then, represented presence of one or more alters with a specific behavior or trait. Absence of alters with the behavior or trait of interest was used as reference categories. Note that data of patients without alters were not used in the construction of the following network components; presence of individuals with healthful behaviors, without depressive symptoms, and with specialized knowledge. This approach was chosen as presence of alters without a specific behavior or trait represented a different category than not having alters at all.

Presence of important others:
Data from patients’ network questionnaires were used to create a dichotomous variable (important others present versus absent) using the items inferring on ‘your most important other’ and ‘name 3 others who you consider important for managing condition or disease’.

Presence of individuals with healthful behaviors
Four variables were created to test this network component using data from the RAPA (physical activity), REAP-s (diet), and a dichotomous item for smoking from alters’ questionnaires.

First, for assessing the influence of separate health behaviors of alters, three variables were created indicating whether an alter(s) with 1) healthful physical activity, 2) healthful diet habits, and 3) non-smoking habits, was present in patients’ networks.

Second, a dichotomous item for presence of alters with overall healthful behavior was created. Alters were considered to have overall healthful behavior when they engaged in healthful physical activity, and kept a healthful diet, and didn’t smoke.

Presence of individuals without depressive symptoms or depression
The PHQ-9 from alters questionnaires was used for assessment of depressive symptoms. Alters with a total score lower than 5 were scored as without depressive symptoms.

Presence of individuals with specialized knowledge on health, particularly health professionals
For assessing presence of persons with specialized knowledge on health in networks, data on occupation of alters were used using data from alter questionnaires. Alters with any job in health care were considered as having specialized knowledge on health.
**Hypotheses testing**

Logistic regression models were used for hypothesis testing, using General Equation Estimation (GEE) modeling to account for possible clustering due to sampling of patients from general practices. The working correlation matrix was specified as exchangeable and robust sandwich estimators were used.

A two-step procedure was used to obtain parsimonious multivariate models for testing of social network composition predictors. First, bivariate tests of the six social network composition factors and eleven patient predictors were performed. Second, predictors with p-values up to 0.10 were entered in multivariate models. Six multivariate models were specified, three models using patient health behavior (physical activity, diet, and smoking) as outcomes and three models using patient clinical risk factors (SBP, LDL, and BMI) as outcomes. Social network composition predictors consisted of the six variables specified in the hypotheses (presence of alters, presence of alters with healthful physical activity, healthful diet, non-smoking habits, and overall healthful behavior, alters without depressive symptoms, and alters with specialized knowledge on health). Patient predictors consisted of age, sex, education (high (completed higher vocational training or university) vs low education (vocational training or lower), marital status (relation (being married or having a partner) vs single), working status (employed vs unemployed), patient group (CVD vs high risk), RCT trial arm (intervention vs control), individual characteristics (patient activation and depressive symptoms), and health behaviors (physical activity, diet, and smoking, provisory on the dependent variable of the analysis). Originally, we planned to include nationality and primary language as patient control predictors. Almost all respondents had the Dutch nationality and language, so we decided to omit these variables from the analyses.

**Alter participation**

Additional analyses were performed to assess whether participation of alters was related to the six patient outcomes. Therefore, a dichotomous item was constructed, representing ‘all or some alters participating’ vs ‘no alters participating’, which was tested with logistic regression analyses using GEE modeling.

**Sensitivity analyses**

**Negative network composition:**

Three sensitivity analyses were performed. First, our hypotheses are phrased positively, so that patients with networks containing individuals with healthful behaviors will be more likely to engage in healthful behaviors themselves. However, if these hypotheses hold, an opposite pattern for negative network composition is just as likely to occur. Therefore, we tested the additional propositions that patients will be less likely to have healthful behaviors and favorable clinical risk factors, if their network contain: one or more alter(s) who hold unhealthful behaviors, alter(s) with depressive symptoms, and alter(s) without...
specialized knowledge on health. We followed a similar approach for construction of negative network composition predictors and for the specification of multivariate models for testing these predictors as for the positively phrased predictors. The six multivariate models were repeated with negative social network composition predictors using patient health behavior (physical activity, diet, and smoking) and risk factors (SBP, LDL, and BMI) as outcomes.

**Mixed network composition:**
Second, network composition characteristics were tested using dichotomous items representing presence of one or more alters with certain behaviors versus absence of alters with these behaviors. As such, we assessed effects of presence of alters with either healthful or unhealthful behaviors. For assessing the effect of networks in which both alters with healthful and unhealthful behaviors or traits were present ("mixed network composition"), we created six ordinal variables for each of the characteristics of interest (alters’ physical activity, diet, smoking, overall health behavior, depression, and knowledge of health). Categories of these variables consisted of; 1) both alters with healthful and unhealthful behavior or trait present in networks, 2) alters with unhealthful behavior/trait present, 3) alters with healthful behavior or traits present. The last category was used as the reference category. These were tested bivariately using health behaviors and clinical risk factors as outcomes with logistic regression analyses using GEE modeling.

**Psychological controls:**
Third, we explored the relative importance of psychological characteristics on outcomes in this study of network composition. Therefore, we examined the multivariate regression models which included psychological variables and in which network components became non-significant. Effects of these network components were reconsidered by repeating these analyses while excluding the psychological variables.

### Results

**Response rates**
A total of 1104 patients from 25 general practices, were invited to participate in this study. A total of 657 patients completed network questionnaires, an overall response rate of 60%. Alter response rate was considered in terms of network completeness. 477 patients reported to have one or more alters. Of 159 patients, all their alters participated in this study (33.3%), of 101 patients at least one but not all alters participated (21.2%), and of 217 patients none of their alters participated (45.5%).
Sample & social networks characteristics
Table 1 provides descriptive data of patient characteristics and patients’ social networks. Patients had a mean age of 72.4 years, 32% was female, and 44% had established CVD. 73% of patients reported to have at least one alter. Data on type of relation were available for 382 alters, most (85%) were family of patients, 4% were friends, 2% were acquaintances, and 9% of relations were described as ‘other’.

Results for the impact of network composition on physical activity, diet, and smoking are presented in Table 2.

Physical activity
Bivariate logistic GEE regressions
Two network components were related to healthful physical activity: presence of alters with a healthful diet (OR 1.81, 95%CI 0.93-3.52), and presence of non smoking alters (OR 2.84, 95%CI 1.30-6.18).

Multivariate logistic GEE model
None of the network composition variables remained significant in the multivariate model controlled for patient characteristics. These included sex (OR 1.49, 95%CI 0.90-2.47), patient activation (OR 1.05, 95%CI 1.00-1.10), depressive symptoms (OR 0.85, 95%CI 0.77-0.93), diet (OR 1.74, 95%CI 1.03-2.92), and smoking status (OR 0.54, 95%CI 0.23-1.28).

Diet
Bivariate logistic GEE regressions
Results of bivariate analyses showed that four network components were related to healthful patient diet: presence of alters with healthful physical activity (OR 1.51, 95%CI 1.04-2.19), presence of non smoking alters (OR 2.75, 95%CI 1.05-7.16), presence of alters with overall healthful behavior (OR 2.01, 95%CI 1.45-2.80), and alters with specialized knowledge (OR 0.59, 95%CI 0.34-1.03).

Multivariate logistic GEE models
Two multivariate models were estimated; one including the network components ‘presence of alters with overall healthful behavior’ and one including the variables ‘presence of physically active alters’ and ‘presence of non smoking alters’ along with ‘presence of alters capable of providing information’.

Odds for healthful diet, relative to an unhealthful diet, were 114% higher for patients with networks that contained alters with overall healthful behavior (OR 2.14, 95%CI 1.52-3.02) compared to patients whose networks did not contain such alters. Effects of presence of physically active alters and of non smoking alters reduced to non significance in the multivariate model whereas the effect of presence of alters with specialized knowledge remained significant.
Table 1 Descriptive data

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>n (%) or mean (SD)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>72.44 (9.4)</td>
<td>657</td>
</tr>
<tr>
<td>Sex</td>
<td>Female 212 (32.3%)</td>
<td>657</td>
</tr>
<tr>
<td>Nationality</td>
<td>Dutch 622 (95.5%)</td>
<td>651</td>
</tr>
<tr>
<td>Primary language</td>
<td>Dutch 637 (98.9%)</td>
<td>644</td>
</tr>
<tr>
<td>Educational level</td>
<td>High 190 (29.4%)</td>
<td>646</td>
</tr>
<tr>
<td>Marital status</td>
<td>Relation 517 (79.4%)</td>
<td>651</td>
</tr>
<tr>
<td>Work</td>
<td>Employed 111 (17%)</td>
<td>653</td>
</tr>
<tr>
<td>Patient group</td>
<td>CVD 286 (43.5%)</td>
<td>657</td>
</tr>
<tr>
<td>TICD trial arm</td>
<td>intervention 384 (58%)</td>
<td>657</td>
</tr>
<tr>
<td>Patient activation</td>
<td>PAM total score 42.29 (6.67)</td>
<td>608</td>
</tr>
<tr>
<td>Therapy adherence</td>
<td>MMAS total score 1.28 (0.63)</td>
<td>127</td>
</tr>
<tr>
<td>Depressive symptoms</td>
<td>PHQ total score 2.41 (3.41)</td>
<td>646</td>
</tr>
<tr>
<td>Physical activity</td>
<td>Healthful 331 (52.4%)</td>
<td>632</td>
</tr>
<tr>
<td>Diet</td>
<td>Healthful 388 (60.3%)</td>
<td>643</td>
</tr>
<tr>
<td>Smoking</td>
<td>Yes 70 (10.8%)</td>
<td>646</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>LDL&gt;2.5 mmol/l 173 (71.2%)</td>
<td>243</td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>SBP&gt;140 mmHg 194 (53.6%)</td>
<td>362</td>
</tr>
<tr>
<td>Weight</td>
<td>BMI&gt;25 119 (73%)</td>
<td>163</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social network characteristics</th>
<th>n (%)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant others</td>
<td>Present 477 (72.6%)</td>
<td>657</td>
</tr>
</tbody>
</table>

**Positive network composition**

- Presence of alters with/who:
  - Healthful physical activity 170 (64.45%) | 264
  - Healthful diet habits 219 (80.2%) | 273
  - Non smoking 250 (91.2%) | 274
  - Overall healthful behavior 119 (44.2%) | 269
  - Without depressive symptoms 246 (91.4%) | 269
  - With specialized knowledge on health 42 (30.9%) | 136

**Negative network composition**

- Presence of alters with/who:
  - Unhealthful physical activity 155 (58.7%) | 264
  - Unhealthful diet habits 105 (38.5) | 273
  - Smoking 48 (17.5) | 274
  - Overall unhealthful behavior 198 (73.6) | 269
  - With depressive symptoms 63 (23.4%) | 269
  - Without specialized knowledge on health 108 (79.4%) | 136
knowledge became significant (OR 0.47, 95%CI 0.24-0.89). In other words, the odds for healthful diet were 53% lower for patients whose networks contained alters capable of providing information on CVRM.

In the multivariate models we controlled for the following patient characteristics: sex (Model 1 OR 0.32, 95%CI 0.17-0.60, Model 2 OR 0.33, 95%CI 0.15-0.75), patient activation (Model 1 OR 1.01, 95%CI 0.96-1.06 and Model 2 OR 1.01, 95%CI 0.96-1.07), and smoking status (Model 1 OR 0.50, 95%CI 0.23-1.08, Model 2 OR 0.54, 95%CI 0.19-1.51).

**Smoking**

*Bivariate logistic GEE regressions*

Three network components were related to patient smoking: presence of alters with a healthful diet (OR 0.29, 95%CI 0.12-0.69), presence of non-smoking alters (OR 0.08, 95%CI 0.02-0.27), and presence of alters without depressive symptoms (OR 0.30, 95%CI 0.12-0.75).

**Multivariate logistic GEE model**

One network component remained significant in the multivariate model of patient smoking: odds for smoking were 83% lower for patients whose social networks contained non-smoking alters (OR 0.17, 95%CI 0.05-0.60). The model was controlled for the following patient characteristics: age (OR 0.97, 95%CI 0.94-1.01), education (high vs low, OR 0.70, 95%CI 0.28-1.77), working status (employed vs unemployed, OR 2.10, 95%CI 0.70-6.32), patient group (CVD vs high risk, OR 0.80, 95%CI 0.30-2.17), depressive symptoms (OR 1.06, 95%CI 0.95-1.18), diet (OR 0.54, 95%CI 0.22-1.31), and physical activity (OR 0.47, 95%CI 0.23-0.99).

---

**Table 1** Continued

<table>
<thead>
<tr>
<th>Social network characteristics</th>
<th>Presence of alters with/who:</th>
<th>n (%)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td><em><em>Mixed</em> network composition</em>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical activity</td>
<td>61 (23.1%)</td>
<td>264</td>
<td></td>
</tr>
<tr>
<td>Diet</td>
<td>51 (18.7%)</td>
<td>273</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>24 (8.8%)</td>
<td>274</td>
<td></td>
</tr>
<tr>
<td>Overall health behavior</td>
<td>48 (17.8%)</td>
<td>269</td>
<td></td>
</tr>
<tr>
<td>Depressive symptoms</td>
<td>48 (17.8%)</td>
<td>269</td>
<td></td>
</tr>
<tr>
<td>Specialized knowledge on health</td>
<td>14 (10.3%)</td>
<td>136</td>
<td></td>
</tr>
</tbody>
</table>

*Mixed networks contain both alters with healthful and unhealthful characteristics*
Clinical risk factors
None of the social network components were related to any of the clinical indicators (SBP, LDL, and BMI) in the bivariate analyses and therefore were not tested in multivariate models. Bivariate estimates for effects of social network components and of patient characteristics are included in Appendix B1.

Alter participation
Alter participation (all or some alters participating vs none of the alters participating) was not related to any of the outcomes.

Sensitivity analyses
Negative social network composition & patient health behavior
Results for physical activity, diet, and smoking are presented in Table 3. Overall, results mirrored those of positive network composition; relations had opposite directions for negative network components. Results from multivariate models showed that having alter(s) without specialized knowledge was related to increased odds for healthful physical activity (OR 3.48, 95%CI 1.21-10.10), having alters with overall unhealthful behavior was related to reduced odds for healthful patient diet (OR 0.48, 95%CI 0.30-0.75), and having smoking alter(s) was related to increased odds for patient smoking (OR 5.53, 95%CI 2.11-14.52).

Negative social network composition & clinical risk factors
Results for SBP, LDL, and BMI are included in Appendix B2. One network component was related to one patient health outcome; odds for elevated SBP were increased for patients whose networks contained alters with unhealthful diets (OR 2.21, 95%CI 1.16-4.21). This effect remained significant (OR 2.17, 95%CI 1.11 – 4.28) controlled for age (OR 1.06, 95%CI 1.02 – 1.11), work status (OR 1.54, 95%CI 0.66 – 3.62), and patient group (OR 0.72, 95%CI 0.40 – 1.28).

Mixed social network compositions
Mixed network composition for alters’ health knowledge was related to increased odds for healthful patient physical activity (OR 3.92, 95%CI 1.24-12.43), and mixed network composition for alter diet was related to elevated SBP of patients (OR 2.73, 95%CI 1.15-6.51). None of the other mixed social network components were related to any of the outcomes.

Psychological variables
Multivariate models were repeated for positive and negative network composition while excluding the psychological control variables patient activation and depressive symptoms. Effects of network composition on patient’ physical activity, diet, and smoking did not change when these psychological variables were excluded from the models.
Table 2: Positive network composition & patient health behaviors

<table>
<thead>
<tr>
<th>POSITIVE NETWORK CHARACTERISTICS</th>
<th>PHYSICAL ACTIVITY</th>
<th>DIET</th>
<th>SMOKING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bivariate</td>
<td>Multivariate</td>
<td>Bivariate</td>
</tr>
<tr>
<td></td>
<td>OR (95%CI)</td>
<td>n</td>
<td>OR (95%CI)</td>
</tr>
<tr>
<td>Presence of:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any alter</td>
<td>0.90 (0.65-1.24)</td>
<td>632</td>
<td>0.99 (0.65-1.48)</td>
</tr>
<tr>
<td>Physically active alter(s)</td>
<td>1.02 (0.62-1.67)</td>
<td>255</td>
<td>1.51* (1.04-2.19)</td>
</tr>
<tr>
<td>Alter(s) with healthful diet</td>
<td>1.81 (0.93-3.52)</td>
<td>264</td>
<td>1.41 (0.70-2.51)</td>
</tr>
<tr>
<td>Non smoking alter(s)</td>
<td>2.84** (1.30-6.18)</td>
<td>265</td>
<td>2.05 (0.73-5.75)</td>
</tr>
<tr>
<td>Alter(s) with overall healthful behavior</td>
<td>1.28 (0.79-2.06)</td>
<td>260</td>
<td>2.01*** (1.45-2.80)</td>
</tr>
<tr>
<td>Alter(s) without depressive symptoms</td>
<td>0.95 (0.38-2.35)</td>
<td>261</td>
<td>0.92 (0.45-1.89)</td>
</tr>
<tr>
<td>Alter(s) with specialized knowledge</td>
<td>0.70 (0.36-1.35)</td>
<td>132</td>
<td>0.59 (0.34-1.03)</td>
</tr>
<tr>
<td>N in multivariate model</td>
<td>243</td>
<td></td>
<td>248</td>
</tr>
</tbody>
</table>

Multivariate tests: network predictors were controlled for patient characteristics which were significantly related to the outcome of interest in bivariate testing. These were: for physical activity; sex, patient activation, depressive symptoms, diet, and smoking status. For diet; sex, patient activation, and smoking status. For smoking; age, education, working status, patient group, depressive symptoms, diet, and physical activity. Estimated intercepts were omitted from the table. *** = p < .001, ** = p < .01, * = p < .05, bold and cursive = p > .05 and < .10.
### Table 3: Negative social network composition & patient health behaviors

<table>
<thead>
<tr>
<th>PHYSICAL ACTIVITY</th>
<th>DIET</th>
<th>SMOKING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OR (95%CI)</strong></td>
<td><strong>n</strong></td>
<td><strong>OR (95%CI)</strong></td>
</tr>
<tr>
<td><strong>Bivariate</strong></td>
<td><strong>Multivariate</strong></td>
<td><strong>Bivariate</strong></td>
</tr>
<tr>
<td>Physically inactive alter(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.76</td>
<td>255</td>
</tr>
<tr>
<td></td>
<td>(0.45-1.27)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alter(s) with unhealthy diet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.93</td>
<td>264</td>
</tr>
<tr>
<td></td>
<td>(0.54-1.61)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking alter(s)</td>
<td>0.59*</td>
<td>265</td>
</tr>
<tr>
<td></td>
<td>(0.37-0.96)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alter(s) with overall unhealthy behavior</td>
<td>0.63</td>
<td>260</td>
</tr>
<tr>
<td></td>
<td>(0.32-1.22)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alter(s) with depressive symptoms</td>
<td>1.05</td>
<td>261</td>
</tr>
<tr>
<td></td>
<td>(0.59-1.85)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alter(s) without specialized knowledge</td>
<td>2.44</td>
<td>132</td>
</tr>
<tr>
<td></td>
<td>(0.93-6.43)</td>
<td></td>
</tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Multivariate tests: network predictors were controlled for patient characteristics which were significantly related to the outcome of interest in bivariate testing. These were: for physical activity; sex, patient activation, depressive symptoms, diet, and smoking status. For diet; sex, patient activation, and smoking status. For smoking; age, education, working status, patient group, depressive symptoms, diet, and physical activity.
Discussion

In this observational study we explored linkages between vascular patients’ network composition on the one hand and health behaviors and clinical health indicators on the other hand. Controlling for demographic, personal, and psychological characteristics, we found a few linkages: alters’ smoking behavior was related to patients’ smoking and alters’ overall health behavior was related to patients’ diet. None of the hypothesized network components were related to clinical indicators, except that the presence of alters with unhealthful diet habits in patients’ networks was related to increased odds for elevated SBP of patients. Overall, these findings only partly support the notion that health-related behaviors are associated with patients’ social network composition.

Our result that odds for smoking were increased in networks which contain other smokers is in line with several prior studies 5,9,36, which showed that smoking as well as other behaviors appeared to be social contagious or social transmissible 4-8, as often indicated by clustering of particular behaviors in networks. Several processes have been proposed to explain clustering. First, clustering may occur because of homophily: the selection of contacts who have similar traits or behaviors. Second, behaviors of one person trigger similar behaviors in another, a process termed induction. Third, similar experienced external causes may cause individuals to share traits or behaviors 37. The observational design of our study does not allow to infer which mechanism is responsible for the identified relation between smoking of patients and their alters. However, in the study population of middle aged and older people, with relatively stable social networks, it may reflect mutual reinforcement of smoking behaviors rather than selection of smoking network members.

Furthermore, we found that patients’ odds for healthful diet were increased if their networks contained alters with overall healthful behavior. We are unaware of previous research on overall health behavior of alters and specific components of patient health behavior. Possibly, this result may indicate the presence of another underlying network mechanism than clustering. Prior research suggested that social contacts can be beneficial for spread of information and role modeling 38, of which alters with overall healthful behavior can be likely candidates. Other studies noted that social contacts may provide encouragement 39. Being able to master healthful behaviors themselves, such alters may likely be persons to encourage patients to achieve particular health behaviors.

No associations between alters’ and patients’ physical activity and diet respectively, were found, which is dissimilar to results of studies on contagion of several health related behaviors 40. There are several potential explanations. First, due to the low response rate of alters, sample size and power in the multivariate analyses was limited. Also, network effects were controlled for several patients characteristics. Among these were characteristics which were hypothesized to be influenced by networks themselves as well (e.g.
analyses for physical activity were controlled for depressive symptoms, diet, and smoking behaviors). Longitudinal research is needed to unravel such relations. Also, control variables may have had possible mediating roles (e.g. depressive symptoms). As such, it is possible that by using our modeling approach we overadjusted effects of network composition. Second, we may have applied a too broad definition of a support network. Although support networks have been shown to positively influence health, other studies showed that specific persons may be important for influencing health behavior. Previous research on older adults found homophily for health behaviors in close contacts, or in the ‘inner circle’ of networks. Other research showed that, when it comes to influencing behavior, not all persons are of equal importance and that particular connections may be more likely to exert influences. Furthermore, research indicated the importance of the spouse for several health behaviors, cognitions, and health outcomes. If influences on diet and physical activity are dependent on specific persons from networks, our network definition may have led us to include persons in our analyses which are not close enough to substantially affect patient behavior, thereby distorting effects of persons who may have had considerable influences. This may be especially true for diet in the context of the study population which tend to mention family as members of their support network and the fact that eating tends to take place with family members. Considering the older age of patients, they are likely to eat most often with their spouse who may have therefore have had more influence on patient diet than other family members and other persons. Third, it is possible that patient characteristics are more important for understanding diet and physical activity than network composition. Some support for this thought can be found considering the several bivariate effects of network components which did not remain significant when controlled for patient factors and the results on clinical risk factors, with several patient factors significant in the multivariate models and only one network component contributing to clinical indicators.

Effects of having alters with specialized knowledge on health (social capital) were contrary to our hypotheses for some outcomes and lacking for other outcomes. This is dissimilar to other research. We may have found different results because of our specific definition of social capital as having persons (that is health professionals) in networks which specialized knowledge on health. Two main interpretations then may explain why we have found different results. First, participants in this study may have been not in need of information on CVRM as currently available information sources on health care (in the Netherlands) are wide ranging, with many on the Internet. Also, although having health professionals within one network implies having access to reliable information, it remains uncertain whether patients also received this information. Previous research on informational support indicated information works best when it is needed, the so called Matching hypothesis. ‘Mismatching’ then, may occur when health professionals are present but when information is provided at wrongly timed occasions, and perhaps too
often. Mismatching may then result in negative interactions, which may be particularly relevant in this study given our low response rate of alters. It may be that especially alters who felt committed to patients and their health participated. Such engaged alters may become over involved, which may put strain on relations. This notion may be supported by the one effect found for social capital which was related to reduced odds for appropriate diet. Second, although we hypothesized patients to benefit when alters with specialized knowledge were present in networks, it may be also be possible that the effect runs the opposite way. Our negative effect may then reflect patients in need of information (i.e. those with unhealthful behaviors), seeking out or contacting alters who can provide these.

We found virtually no effects of network composition on clinical risk factors. A plausible route for influences of network components is by first influencing health behavior of patients, which then result in particular outcomes of clinical risk factors. Given that only a few of our hypothesized network components were related to patient health behavior, it is then not surprising that clinical risk factors were unaffected by network composition.

Behavioral and clinical outcomes were overall not different for patients with and without a support network (i.e. presence of alters). This is in contrast to research on social isolation in patients with chronic conditions. However, in this research we constructed networks on persons which were considered important for managing disease. Patients without such alters do not necessarily have to be socially isolated, and may have well had other (type of) contacts with possible influences on health behavior and outcomes. Our result also seems in contrast to research on social support, which has mainly reported positive influences of support on health. However, in line with our finding, several other studies reported no effects of support as well or identified negative effects of networks. Other studies noted that, in addition to social support, other mechanisms such as social influence and social engagement are important for understanding the role of the social environment in influencing health as well. Support networks identified in this study mainly consisted of family of patients. A previous study on older adults attempting to identify dimensions of support networks, showed that family was not associated with health outcomes while social engagement was significantly related to both psychological and physical health outcomes. Another study differentiating types of people within older adults networks found that only contacts with people with whom socializing was enjoyed were related to self rated-health. Such results may emphasize the relevance of other, or more specifically defined, social mechanisms than social support. Additionally, other studies showed that particular connections within networks are of more importance than others. In our study, we may have not been able to sufficiently tap into such mechanisms using our definition of support networks, or we may have not identified, or differentiated between, specific contacts with particular importance. It is also possible that social support by family members did not have pronounced effects in this population of vascular patients, or that positive and negative network influences cancelled each other out.
Other research found stronger evidence of the protective effects of social networks on health than this study. However, these previous studies considered whole networks instead of personal support networks, other network characteristics, including social integration (48), social connectedness (49), other type of networks (e.g. friendship (50)), and other structural characteristics of networks (e.g. network size (51) or diversity (43,52)). Our study may suggest that other network characteristics or wider social structures can be of more importance for behavior and clinical risk factors than the presence of alters with certain features in an individual support network. Future research should focus on the identification of these characteristics or structures.

Previous network research gave less attention to psychological characteristics as determinants of health behaviors. In this study, network influences were controlled for patient activation and depressive symptoms as psychological constructs. Our multivariate analyses showed that these variables indeed were associated with physical activity and LDL. It should also be noted that the prevalence of depressive symptoms in our sample was rather low for both patients and their alters. Our results indicate that to enhance understanding of health behavior and clinical risk factors, and the relative importance of individual and social influences in health, future research should take both into account.

Strengths of the study included the use of validated measures of health behavior, the use of clinical indicators abstracted from medical records, the adjustment for psychological factors in the regression models, and the inclusion of patients’ alters in the study. Limitations of this research include the following. First, the observational design does not allow for causal inferences between network composition and health behaviors and clinical risk factors. As such, the results of this study should be interpreted carefully and future research is needed to establish causal relations between network influences and health outcomes. Second, the response rate of alters was low and we cannot exclude the possibility of a selection bias within this group. Therefore, care is warranted for the interpretation and generalization of our results. Also, and although the response of patients was reasonable, the low response of alters left us with a limited sample size and reduced power in the regression models. Third, our patient sample may have been prone to selection bias as well. It may be that patients having merely positive contacts were more likely to participate than patients whose network comprised more negative contacts, or then patients without a network.

Furthermore, we excluded patients with diabetes, which represent a group with high risk for CVD. This study was tied to the sampling strategy of a RCT aiming to improve primary care for CVRM. As primary care for diabetes has received much attention (supportive materials, continuing education programs, additional reimbursement) in the Netherlands, inclusion of patients with diabetes would have compromised outcomes of the RCT. Therefore, care is warranted for generalizing our results to other patient groups. Fourth, we tested our hypotheses in six regression models. Such repeated testing increases risk for type 1 error rate, for which solutions such as adjustment of p-values are available.
However, we decided not to adjust the threshold for statistical significance given the explorative aim of the study, and because such adjustments come with the risk of enhanced type II error rate, which can be especially relevant given our smaller sample size. Fifth, several aspects of our specific approach may have led to limited variability in our data to explore associations. These include the small number of alters we were able to include in the study. Related, we cannot be sure that more alters would have been identified if we had employed another (less broad) definition of networks. Also, in multivariate tests of network composition, we included each patient characteristic that was bivariately related to the outcome of interest. Among these were characteristics which may be mediating variables (e.g., depression). Also, in analyses on health behavior outcomes, we adjusted for other health behaviors (e.g., in analyses on smoking, we adjusted for diet and physical activity). This approach, and the limited sample size, may have led to over-adjustment of potential effects of network composition.

Sixth, questionnaires to measure networks were not validated. Seventh, questionnaires to measure networks were not validated. Sixth, an interval up to a maximum of three months between completing RCT questionnaires and sending network questionnaires was needed. It remains unsure whether and how this affected results. A too short interval between receiving both questionnaires may be discouraging to participate, whereas a too large interval may have caused a loss of interest or motivation to participate.

**Conclusion**

In this explorative study, we found some evidence for influences of network composition on patients’ health behavior. Odds for patient smoking were reduced if their networks contained non-smoking alters and increased odds for healthful patient diet habits if their networks contained alters with overall healthful behavior. We included alters of patients and controlled effects of network composition for several psychological variables, which are known to influence several patient health behaviors by themselves. Several identified effects of network components reduced to non-significance when controlled for such psychological characteristics of patients.

As such, this study indicated it is important to take network composition into account but also that other influences matter as well. Future research is warranted to further examine relations between network composition and health outcomes. It may be noted that several aspects of our study may have influenced our results and should be taken into account in future studies as well. These include that the modeling of predictors of outcomes could have taken an alternative approach, in which mediating or moderation roles of individual and psychological characteristics of patients are explicitly modeled. In addition, the inclusion of alters of patients needs further attention. Factors to be considered include the identification of alters as well as the enrollment of these individuals in the study.
References

Social networks of vascular patients and associations with current and changed health behaviors

Submitted

Naomi Heijmans
Jan van Lieshout
Michel Wensing
Abstract

Background Patients’ health behaviors have an important role in cardiovascular risk management (CRVM). We explored associations of social network characteristics of cardiac patients with current and changed diet and physical activity, using data of both patients and individuals who patients considered important for managing their disease (alters).

Methods This prospective observational study in primary care settings involved 189 vascular patients (81 with cardiovascular disease, 108 at high vascular risk) and 175 alters. Networks were measured in structured telephone interviews. Questionnaires were used to measure patients’ and alters’ health behaviors. Patients’ health behavior was measured at time of interviews and at 6 months follow-up. Multivariate linear regression analyses, using generalized equation estimations, were used to test three hypothesized effects of networks (having a high number of alters with: healthful behaviors, depression, and specialized knowledge) on current diet and physical activity. Ordinal and logistic regression analyses were used to assess changes in diet and physical activity.

Results For diet positive effects were found for alter-reported number of alters with healthful diet ($b$ 2.45, $p$<.05), healthful physical activity ($b$ 2.35, $p$<.05), and specialized knowledge ($b$ 3.40, $p$<.05). Negative effects were found of patient-reported number of alters with healthful physical activity ($b$ -2.46, $p$<.05) and overall healthful behavior ($b$ -2.42, $p$<.05). For change in diet, similar patterns were found for alter-reported network characteristics while patient-reported characteristics had no effects. For physical activity we found no effects of alter-reported network characteristics. Negative effects were found of patient-reported network size ($b$ -1.24, $p$<05), number of alters with overall healthful behavior ($b$ -1.19, $p$<05), and alters with CVRM knowledge ($b$ -0.89, $p$<05) on current physical activity. However, number of alters with healthful diet (OR 7.92, $p$<05) and healthful physical activity (OR 9.85, $p$<.05) were related to improvement in physical activity.

Discussion Overall, network effects differed between diet and physical exercise, current and changed behaviors, and between patient- and alter-reported networks. Our results may suggest that health behaviors are influenced more by actual, rather than by perception of, behaviors of individuals in networks.
Background

Cardiovascular disease (CVD) is worldwide an important cause of mortality and reduced quality of life. To prevent or delay CVD, cardiovascular risk management (CVRM) has been implemented. CVRM, amongst others, heavily emphasizes the importance of behavioral risk factors of which important examples include diet and physical activity. Patients’ health behavior has a central role in CVRM. Current research has provided ample evidence showing that health behavior is not only an individual effort, but also influenced by the social environment. For instance, social integration and social support have been related to reduced mortality from diverse causes, although underlying mechanisms are only partly understood. Other studies showed how behavior may be socially contagious by demonstrating the clustering of multiple behaviors within social networks. These patterns have been described for smoking, alcohol use, aspirin use, health screening, obesity, and depression. So, social network studies provide compelling results which may help to understand and enhance health behaviors. However, one drawback of a substantial number of network studies is the reliance on patients’ reports on connections and attributes of others, so called alters. Also, few studies on elderly patients with chronic conditions focused on change in health behaviors. In the present research, we set out to explore relations between current and change in patient health behaviors for diet and physical activity and selected social network characteristics, which were inferred from the current scientific literature. Both patients and their alters were included in the study, providing the opportunity for comparing network effects in patient-reported and alter-reported networks.

Network-related factors

While the correlation of social networks and health has been confirmed in many studies, the underlying mechanisms are only partly understood. These may relate to, amongst others, social support, social capital, and social influence. Social support is the provision of information, practical help, or emotional comfort by individuals or organizations in the individual’s social network and includes assistance with health related activities and maintaining healthful behaviors. A related concept is that of social capital, which indicates the availability of support for a specific person. Studies on social capital mostly focused on access to resources, defining this construct as membership in social networks that facilitate access to resources, e.g. information on health and health behaviors. Greater social capital has been linked to better health or well-being.

A different mechanism is that of social influence. Studies which showed clustering of behaviors and health related traits (e.g. smoking, obesity) in networks led to the notion of contagion of behaviors and ideas within networks. Social contagion represents a multi-faceted process, involving infection, information, and behaviors. Spread of information and (resulting) behavior can result from multiple underlying processes of social contagion,
e.g. imitation of successful behavior, role modeling, social comparison, and selection of contacts. A related concept is that of homophily (or homogeneity). Homophily, or ‘love of the same’, is the principle that contacts between people who share similarities are more likely to emerge than among people who are more dissimilar. These specific contacts shape and influence opportunities for spread of information and behaviors within networks, and consequently influence formation of attitudes and norms, and other social influence processes such as social reinforcement. Selection and causal effects are difficult to distinguish; however, clustering seems to occur together with homophily.

These concepts provided input for the hypotheses for the present study, which are summarized in Figure 1. First, we considered clustering and its ability to shape opportunities for various social influence mechanisms. Clustering has been found for several behaviors and attributes of individuals. Likewise, we expected patients to be more likely to hold favorable health behaviors for diet and physical activity, if more of their alters do so as well.

Our second hypothesis focused on the possible influence of depression. Depression is relatively often present in cardiac patients and is an invalidating risk factor for impaired efforts for improving health behaviors. Studies in cardiac patient populations showed that depressive symptoms were related to worse health behaviors and increased mortality. In addition to these negative effects, depression has been shown to have a contagious pattern in networks. Depression or depressive symptoms may thus influence health behavior in two ways, first by influencing patients themselves and second by contagiously spreading within social networks. Therefore, we hypothesized that patients whose social networks contain people with depression or depressive symptoms are less likely to have healthful behaviors.

The third hypothesis concerned the opportunity for spread of information and behaviors. Valid information on CVRM and health behaviors can enhance the uptake of healthful behaviors. Health professionals can be expected to hold this information and are therefore resources in a network (‘social capital’). We hypothesized that patients with health professionals (physicians, nurses, other health professionals) in their networks will be more likely to have healthful behaviors.

**Perceived versus alter-reported networks**

Current literature on social networks seems to have given little attention to possible differences between perceived and actual alter-reported connections, behaviors and attributes of persons in the network. While individuals may obviously have incorrect perceptions regarding alter characteristics, Studies on interventions for substance use of alcohol, tobacco, and cannabis, mostly conducted on younger populations, found misperceptions of others behaviors, with overestimation of other one’s substance use reported commonly. A meta-analysis of research on social support showed that the average correlation between perceived and actually received support was only moderate.
Figure 1  Summary of hypothesized relations

Social network composition
- Presence of alters with adequate health behaviors
- Presence of alters without depressive symptoms or depression
- Presence of alters who can provide access to CRVM - information

Social mechanisms, formation attitudes & behavior
- Multiple social influence mechanisms
- Contagious patterns
- Social capital

CVRM related outcomes
- Health behaviors
Different influences of perceived and actually received support have been identified, with perceived support often associated with positive health outcomes e.g. 20-22, and inconsistent results reported for received support and health 21,23. One previous network study showed associations between contraceptive use of friends regardless whether perceptions about friends’ use were correct 24. Such findings suggest that it is likely that differences can be found between perceived behaviors of alters and actual alter-reported behaviors. If so, and although limited network research seems to have focused on it, it may well be that perceived behaviors of alters and actual alter-reported behaviors have different influences on patient health behavior. Stated differently, it is currently unclear what matters more for understanding health behavior; characteristics of the social environment itself or the perception of characteristics of the social environment.

In this study we examined characteristics of network of patients with vascular disease, their associations with diet and physical activity and changes in these health behaviors. We explored influences of hypothesized network characteristics, constructed either as patient-reported (‘perceived’ alter behaviors and traits) or as alter-reported characteristics. We set out to test three hypotheses. Patients were hypothesized to be more likely to have healthful diet and physical activity, and show improvement in these, if they have social networks which contain: 1. a high number of individuals with healthful behaviors, 2. few individuals with depressive symptoms, 3. individuals who can provide information on CVRM, particularly health professionals.

**Methods**

**Design & Study population**

This observational study on social networks of vascular patients and their alters is part of the ‘Tailored Implementation for Chronic Diseases’ (TICD) project 25, and was performed parallel to a larger two-arm cluster randomized controlled trial (RCT) (NTR4069). The trial aimed to test a tailored intervention for improving CVRM in primary care by enhancing professional performance of practice nurses and included a random sample of general practices from several geographical areas in the Netherlands 26.

The sample consisted of patients at high risk for CVD and with established CVD and their alters. Patients were identified from the baseline measurement of the trial which used International Classification of Primary Care (ICPC) codes to extract eligible patients from medical records from general practices. Extraction was performed by practice nurses in cooperation with research assistants. Eligible patients were 18 years or older and capable of providing informed consent; exclusion criteria consisted of: diabetes mellitus, pregnancy and lactation, terminal illness, cognitive impairments, and poor language skills. Patients with diabetes were excluded using ICPC codes, practice nurses assessed other
exclusion criteria. Alters of patients consisted of individuals that patients indicated to be important for handling their health behaviors. A maximum of four alters was included as literature indicated this is the maximum number of important or significant others to be expected within social networks of patients 27.

**Ethical approval**
The Medical Ethical Committee of Radboud University Nijmegen Medical Centre has waived approval for the social network study 28 and the RCT 26. The study protocols and its materials (e.g. questionnaires and letters) for both studies were submitted to the Medical Ethical Committee of Radboud University Medical Centre Nijmegen. This committee assessed that the Dutch law for medical scientific research does not apply to these studies. As the studies did not involve testing of body materials, no approval was required from a local medical ethical committee.

**Data collection procedures**
Patients were invited for participation in the social network study through invitations included at the end of postal questionnaire booklets sent for purposes of the trial at baseline of its intervention program. Different formatted invitations were used, which were part of a study on response rates. Results of the response study are published elsewhere 29. Postal questionnaires for the RCT mainly focused on health related lifestyle, and were sent at baseline and at 6-month follow up of the RCT program. Invitations for the social network study contained a concise explanation on the study purpose and were accepted by completing an enclosed informed consent form.

Telephone interviews for the social network study were held within a maximum of three months after receipt of completed informed consent forms. This interval was needed due to logistical constraints within the RCT. Interviews were performed by three interviewers and were held at working days, in morning, midday, and during early evening. In case of no response, patients were called a maximum of eight times, in a period of four weeks, before they were considered as impossible to reach. For inclusion of alters, patients were asked, and provided with a short explanation and rationale, at the end of interviews for their permission to receive questionnaires for the persons they had identified to be important for handling their condition or disease. The term ‘condition’ was used in interviews for high risk patients, and ‘disease’ in those for CVD patients. Questionnaires for alters were sent to patients’ home addresses, were addressed using names as provided by patients (e.g. ‘neighbor’, ‘friend’, or personal names), and patients handed the questionnaires over to their alters. Questionnaires for all alters were identical, were accompanied by an explanatory letter and informed consent form for acceptance of participation, and a postal-paid envelope for returning completed questionnaires and informed consent forms. Alters were not reminded in case of non response. Interviews were held and alters questionnaires were sent from October 2013 till March 2014. Baseline
questionnaires for the RCT were send from September 2013 till February 2014, follow up questionnaires for the RCT were send from June 2014 till September 2014.

**Outcomes**

Outcomes of this study were the description of patient’s support networks and patients’ current and changed diet and physical activity. Diet and physical activity were assessed with previously validated questionnaires, using data collected at baseline and at follow up of the TICD trial. For diet we used the reduced Rapid Eating and Activity Assessment (REAP-s, 12 items) and for physical activity the Rapid Assessment of Physical activity (RAPA, 9 items). Continuous scores were used for follow up measurement of current diet and physical activity, with higher total scores of both scales indicative of higher quality diet and physical activity. For change in diet and physical activity between baseline and follow up, continuous scores at follow up of the TICD trial were subtracted with baseline scores. Negative differences were indicative of decline, no difference indicated unchanged behavior, and positive differences were indicative of improvement.

**Additional measures**

All additional measures were applied at baseline of the trial.

**Descriptive variables**

Descriptive data of patients and their alters on age, sex, ethnicity, marital status, educational level, and working status were gathered using items from the Epa Cardio abstraction tool in questionnaire booklets of the RCT for patients and in questionnaires for alters respectively.

**Individual characteristics**

Individual characteristics of patients were: patient activation (Patient Activation Measure, PAM) and depressive symptoms (Patient Health Questionnaire, PHQ-9) and were measured using questionnaire booklets of the RCT. Higher total scores on these measures indicated higher patient activation, and more depressive symptoms respectively. Alters completed the PHQ-9 as well, a cutoff score of 5 or higher indicated presence of depressive symptoms.

**Patient health behavior**

Health behavior of patient was assessed using a composite questionnaire send on behalf of the RCT, and included the REAP-s for diet, the RAPA for physical activity, and the Midsized Model for smoking status.

Diet was assessed with the REAP-s which asks to indicate how often (usually/often, sometimes, rarely/never, or not applicable) one engages in several unhealthful dietary habits in an average week. Patients who scored a maximum of two items ‘usually/often’ were considered to have a healthful diet. Physical activity was considered to be healthful if item 6 (‘I do 30 minutes or more a day of moderate physical activities, 5 or more days a week’
or 7 (‘I do 20 minutes or more a day of vigorous physical activities, 3 or more days a week’) of the RAPA was answered affirmatively. Current smoking status was measured using one item from the Mid-sized Model. This item had four categories (‘yes, I smoke’, ‘no I have quitted smoking in the past 6 months’, ‘no, I have quitted smoking more than 6 months ago’, and ‘no, I have never smoked’) and was used to create a dichotomous score.

Alter health behavior
Health behavior of alters was measured using a composite questionnaire which was identical to that completed by patients (physical activity; RAPA 31, diet; REAP-s 30, smoking status; MIDSIZED MODEL 35). Scoring rules for defining healthful baseline physical activity, diet, and smoking status were identical to those applied to patient health behavior.

Network members
Alters of patients were identified in telephone interviews using two questions. First patients were asked to mention one person whom they considered to be most important for handling disease/condition or lifestyle. It was explained that ‘lifestyle’ consisted of diet-, physical exercise-, and smoking habits. It was also explained that this individual does not need to be ‘most important’ for a specific reason and does not need to be part of the patient’s personal environment (for instance, health professionals could be mentioned as well). Second, patients were asked to name a maximum of three persons (other than their ‘most important other’) they considered important for handling their condition or disease. It was again explained that these persons did not need to be important for any specific reason. We emphasized that persons mentioned in this question did need to be part of patients’ personal environment.

Some patients mentioned a healthcare professional from the general practice participating in the RCT as their alter. Due to workload for healthcare professionals participating in the RCT program, we were unable to send alter-questionnaires to them. To enhance comparability of patient-reported and alter-reported network characteristics, it was therefore decided to remove patient perception of healthcare professionals from the RCT. This led to a corrected network for a total of 28 patients.

For each alter patients were asked whether, in their opinion, this person holds a healthful diet (yes or no), engages in sufficient physical activity (yes/no), and smokes (yes/no), and hold a job, or were educated for a job, in health care (yes/no). Patients were asked to appoint type of relation with each alters, response categories consisted of family, friends, acquaintances, or others.

Data analysis
SPSS (version 22) was used for all analyses. All analyses were performed two tailed, using p < .05 indicating significance. Linear regression models were used for hypothesis testing of diet and physical activity at follow up, and ordinal regression models were used for
hypothesis testing of changes in diet and physical activity, using General Equation Estimation (GEE) modeling to account for possible clustering due to sampling of patients from general practices. The working correlation matrix was specified as exchangeable and robust sandwich estimators were used.

For ordinal regression models, the parallel lines assumption was tested. In case of significant violation, analyses were repeated using two logistic regression models (‘no change versus worsening’ and ‘improvement versus no change’).

Wilcoxon tests were performed for comparison of patient-reported and alter-reported social network characteristics.

**Construction of social network characteristics**

**Network size**

Using data of telephone interviews, number of alters in the network of each patient was counted.

**High number of individuals with healthful behaviors**

This network characteristic was assessed by testing the effect of alters’ overall health behavior, and by testing influences of its separate components: number of alters with healthful diet, number of alters with healthful physical activity, and number of smoking alters. These four effects were constructed twice; using data of networks as perceived by patients and using data as reported by their alters.

For patient perception of their alters, data from interviews were used to count how many alters believed to hold healthful diet, physical activity, and smoking habits were present. Alters whom patients perceived to hold a healthful diet, to have sufficient physical activity, and non smoking habits were scored as having overall healthful behaviors.

For alter reported health behaviors, data from alters’ questionnaires were used. For number of alters with healthful diet, the number of alters who had a total score ≤2 on the REAP-s was counted. For number of alters with healthful physical activity, it was counted how many alters answered items 6 or 7 affirmatively on the RAPA. Number of smoking alters was counted using a dichotomous item of the Midsized model. Alters were scored as having overall healthful behavior if they complied to all of the following: total ≤2 on the REAP-s, affirmative answer on items 6 or 7 of the RAPA, and who did not smoke.

Resulting variables were re-coded as the four categorical variables were highly skewed. For patient perception data, the following re-codes were made. For number of physically active alters, alters with healthful diet, and alters with overall healthful behavior, cells for counts of 4 became very small, therefore data were re-coded so that the highest category represented having ‘3 or 4 alters’ with the behavior of interest. Few networks contained more than one smoking alter. Therefore, ‘number of smoking alters’ was re-coded into dichotomous variables which then represented presence of smokers (versus absence of smokers) in networks.
For alter reported data, number of physically active alters and alters with healthful diets, data were re-coded so that the highest category represented having ‘2 or more’ alters with the behaviors of interest. The network characteristics number of smoking alters and alters with overall healthful behaviors were dichotomized, representing presence of alters with the behavior, and using absence of alters with the behavior as reference categories.

**Presence of individuals with depressive symptoms or depression**
Number of depressed alters was counted using data on the PHQ-9 from alters’ questionnaires. For each patient, it was counted how many alters had a total score of > 5. Few networks contained more than one alter with depressive symptoms. Therefore, this variable was dichotomized, representing presence of alters with depressive symptoms, and using absence of alters with depressive symptoms as the reference category.

**High number of individuals with specialized knowledge on health**
Presence of alters with specialized knowledge was assessed twice; using data of networks as perceived by patients and using data as reported by their alters.

For patient perception of their alters, data from interviews were used inferring on whether patients perceived their alters to hold a job, or being educated for, in health care. It was counted how many alters patients believed to do so.

For alter reported data, data from an item of the Epa cardio instrument inferring on job type in alters’ questionnaire were used. Alters who had any job in health care were scored as having specialized knowledge.

Data of both patient perception and alter reports indicated that few networks contained more than one alter with specialized knowledge, this network characteristic was therefore tested as dichotomous variable, representing presence of alters with specialized knowledge and using absence of alters with specialized knowledge as reference categories.

**Hypotheses testing**
In order to obtain parsimonious multivariate models for each outcome, a two step procedure was used for testing of social network predictors, controlled for several patient predictors. First, bivariate tests of twelve patient predictors were performed. Second, patient predictors with p-values up to 0.10 were entered in multivariate models controlling the effect of each social network characteristic.

Network predictors consisted of the six network characteristics as reported on by patients and by alters. Patient-reported network characteristics were: network size, number of: physically active alters, alters with healthful diet, smoking alters, alters with overall healthful behavior, and alters with specialized knowledge. Alter-reported network characteristics were number of: physically active alters, alters with healthful diet, smoking alters, alters with overall healthful behavior, alters with depressive symptoms or depression,
Chapter 5

and alters with specialized knowledge. Patient predictors consisted of age, sex (female vs male), education (high vs low education), marital status (relation vs single), working status (employed vs unemployed), patient group (CVD vs high risk), RCT trial arm (intervention vs control), individual characteristics (patient activation and depressive symptoms), and health behaviors (physical activity, diet, and or smoking, provisory on the dependent variable of the analysis).

Each network characteristic was tested separately and controlled for patient characteristics which were marginally significant or significantly related to the outcome of interest. For both diet and physical activity, six models tested the effects of networks as perceived by patients and six models tested the effects of network characteristics constructed on alter reported data.

For change in diet and physical activity, we started out with six models testing the effects of networks as perceived by patients and another six models tested the effects of network characteristics constructed on alter reported data. For each model the parallel lines assumption was tested, and in case of significant violation, logistic regression models were used.

For diet, the assumption was violated in three models (patient perception of number of alters with healthful diet, number of smoking alters, and alter reported: number of depressed alters). For the effect of number of alters with healthful diet however, logistic models including this predictor as a categorical one failed to converge, likely due to the small sample size, therefore this predictor was included as a continuous variable in the logistic analyses.

For physical activity, the parallel lines assumption was violated in every model except for patient perception of ‘number of smoking alters’ and alter reported ‘number of alters with specialized knowledge’.

Results

Response rates
A total of 694 patients participating in the larger RCT were invited and 197 patients from 18 general practices participated in this study. Response rate was 28%. Eight patients did not meet inclusion criteria and were excluded, leaving a total of 189 participants in the analyses. Alter response rate was considered in terms of network completeness. 167 patients reported to have one or more alters. Of 60 patients, all of their alters participated in this study (36%), of 39 patients at least one but not all alters participated (23%), and of 68 patients none of their alters participated (41%).
Sample & social networks characteristics
Patient descriptive data are summarized in Table 1. Table 2 summarizes network characteristics of patients. Most patients (88%) had at least one alter, mean number of alters was 2.04 (SD 1.30). Most alters were family; of the first alters mentioned 80% were family, and for the second, third and fourth alters mentioned percentages were 85%, 92%, and 88% respectively. Mean duration of relationships with alters in years was 41.42 (SD 18.29) for the first mentioned alters, and 40.83 (SD 14.78), 40.32 (SD 16.60), and 38.69 (SD 16.67) for the second, third, and fourth mentioned alters respectively. Likewise, mean age of the first through the fourth alters was 62.30 (SD 13.57), 50.22 (SD 14.77), 48.80 (SD 15.60), and 46.53 (SD 15.33).

Table 1 Patient descriptive data

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>n (%) or mean (SD)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>73.14 (9.37)</td>
<td>189</td>
</tr>
<tr>
<td>Sex</td>
<td>Female 71 (37.6%)</td>
<td>189</td>
</tr>
<tr>
<td>Nationality</td>
<td>Dutch 175 (97.2%)</td>
<td>180</td>
</tr>
<tr>
<td>Primary language</td>
<td>Dutch 177 (98.9%)</td>
<td>179</td>
</tr>
<tr>
<td>Educational level</td>
<td>High 53 (29.4%)</td>
<td>180</td>
</tr>
<tr>
<td>Marital status</td>
<td>Relation 141 (78.3%)</td>
<td>180</td>
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<tr>
<td>Work</td>
<td>Employed 20 (11.2%)</td>
<td>178</td>
</tr>
<tr>
<td>Patient group</td>
<td>CVD 81 (42.9%)</td>
<td>189</td>
</tr>
<tr>
<td>TICD trial arm</td>
<td>intervention 113 (59.8%)</td>
<td>189</td>
</tr>
<tr>
<td>Patient activation</td>
<td>PAM total score 41.53 (6.41)</td>
<td>168</td>
</tr>
<tr>
<td>Depressive symptoms</td>
<td>PHQ total score 2.71 (3.83)</td>
<td>168</td>
</tr>
<tr>
<td>Smoking</td>
<td>yes 21 (11.1%)</td>
<td>181</td>
</tr>
<tr>
<td>Diet</td>
<td>Baseline Healthful</td>
<td>98 (54.4%)</td>
</tr>
<tr>
<td>Follow up Total score</td>
<td>26.98 (4.34)</td>
<td>133</td>
</tr>
<tr>
<td>Change</td>
<td>Worsened 52 (40.9%)</td>
<td>127</td>
</tr>
<tr>
<td>No change</td>
<td>16 (12.6%)</td>
<td>127</td>
</tr>
<tr>
<td>Improved</td>
<td>59 (46.5%)</td>
<td>127</td>
</tr>
<tr>
<td>Physical activity</td>
<td>Baseline Healthful</td>
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</tr>
<tr>
<td>Follow up Total score</td>
<td>5.37 (1.69)</td>
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</tr>
<tr>
<td>Change</td>
<td>Worsened 41 (33.3%)</td>
<td>123</td>
</tr>
<tr>
<td>No change</td>
<td>49 (39.8%)</td>
<td>123</td>
</tr>
<tr>
<td>Improved</td>
<td>33 (26.8%)</td>
<td>123</td>
</tr>
</tbody>
</table>

Abbreviations: CVD = cardiovascular disease, PAM = patient activation, PHQ = patient health questionnaire
### Table 2  Description of social networks

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<th>Number of alters with/who:</th>
<th>According to patients</th>
<th>According to alters</th>
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<tbody>
<tr>
<td>Healthful diet</td>
<td>0</td>
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<td></td>
<td>1</td>
<td>64 (38%)</td>
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<td></td>
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<td>36 (22%)</td>
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<tr>
<td></td>
<td>3</td>
<td>41 (25%)</td>
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<tr>
<td></td>
<td>4</td>
<td>23 (14%)</td>
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<tr>
<td></td>
<td>n</td>
<td>167</td>
</tr>
<tr>
<td>Healthful physical activity</td>
<td>0</td>
<td>17 (10%)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>56 (33%)</td>
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<td>2</td>
<td>41 (25%)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>36 (22%)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>17 (10%)</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>167</td>
</tr>
<tr>
<td>Smoke</td>
<td>0</td>
<td>120 (72%)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>38 (23%)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>8 (5%)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1 (1%)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0</td>
</tr>
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<td></td>
<td>n</td>
<td>167</td>
</tr>
<tr>
<td>Overall healthful habits</td>
<td>0</td>
<td>22 (13%)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>59 (35%)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>48 (28%)</td>
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<td></td>
<td>3</td>
<td>28 (16%)</td>
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<td></td>
<td>4</td>
<td>14 (8%)</td>
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<tr>
<td></td>
<td>n</td>
<td>171</td>
</tr>
<tr>
<td>Have specialized knowledge</td>
<td>0</td>
<td>95 (51%)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>71 (38%)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>16 (9%)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3 (2%)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>185</td>
</tr>
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<td>With depression or depressive symptoms</td>
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<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>21 (23%)</td>
</tr>
<tr>
<td></td>
<td>2</td>
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<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>90</td>
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</table>
Comparison of patient-reported and alter-reported network characteristics

Wilcoxon tests indicated that network characteristics as reported on by patients and their alters were all significantly different from each other. Statistics were as follows, for number of alters with/who: healthful diet $Z = -6.86$, $p < .001$, healthful physical activity $Z = -6.70$, $p < .001$, smoke $Z = -2.52$, $p < .05$, overall healthful behaviors $Z = -7.38$, $p < .001$, and with specialized knowledge $Z = -3.75$, $p < .01$.

Hypotheses testing

Diet

Results for diet are presented in Table 3. Negative effects of the following patient-reported network characteristics were found; number of physically active alters ($b = -2.46$, $p < .05$), and number of alters with overall healthful behavior ($b = -2.42$, $p < .05$). Alter-reported characteristics were positively related to patient diet with effects of having a physically active alter ($b = 2.35$, $p < .05$), having two or more alters with a healthful diet, presence of alters with depressive symptoms ($b = 2.24$, $p < .05$) and presence of alters with specialized knowledge ($b = 3.40$, $p < .05$). All network characteristics were controlled for the following patient characteristics: age, education, patient group, intervention trial arm, PAM total score, PHQ total score, and smoking status.

Physical activity

Results for physical activity are presented in Table 4. Patient-reported number of alters ($b = -1.24$, $p < .05$), number of alters with overall healthful behavior ($b = -1.19$, $p < .05$) and presence of alters with specialized knowledge ($b = -0.89$, $p < .05$) were negatively related to healthful physical activity. No effects of alter-reported network characteristics were found. All network characteristics were controlled for the following patient characteristics: age, marital status, intervention arm, and diet.
Table 3  Social networks & diet

<table>
<thead>
<tr>
<th>Network characteristics</th>
<th>DIET</th>
<th>b</th>
<th>95% CI</th>
<th>N</th>
</tr>
</thead>
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<tr>
<td><strong>Patient-reported</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>Number of alter(s)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1.33</td>
<td>-1.10</td>
<td>3.76</td>
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</tr>
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<td>3</td>
<td>-0.60</td>
<td>-3.43</td>
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<td></td>
</tr>
<tr>
<td>2</td>
<td>1.16</td>
<td>-1.37</td>
<td>3.68</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.94</td>
<td>-0.04</td>
<td>3.91</td>
<td></td>
</tr>
<tr>
<td>0</td>
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</tr>
<tr>
<td>Alter(s) with healthful physical activity</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 of 4</td>
<td>-2.36</td>
<td>-5.14</td>
<td>0.42</td>
<td>98</td>
</tr>
<tr>
<td>2</td>
<td>-2.46*</td>
<td>-4.58</td>
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<tr>
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<td>-1.24</td>
<td>-2.61</td>
<td>0.13</td>
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<tr>
<td>Alter(s) with healthful diet</td>
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<tr>
<td>3 of 4</td>
<td>-1.15</td>
<td>-4.40</td>
<td>2.10</td>
<td>96</td>
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<td>Present</td>
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<td>Alter(s) with overall healthful behavior</td>
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<tr>
<td>3 of 4</td>
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<td>-3.98</td>
<td>1.78</td>
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<tr>
<td>Alter(s) with specialized knowledge</td>
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</tr>
<tr>
<td>Present</td>
<td>0.30</td>
<td>-1.65</td>
<td>2.25</td>
<td>110</td>
</tr>
<tr>
<td>Absent</td>
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<td></td>
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</tr>
</tbody>
</table>

| **Alter-reported**      |      |    |        |    |
| Alter(s) with healthful physical activity |      |    |        |    |
| 2 or more               | 0.99 | -1.42 | 3.40 | 59  |
| 1                       | 2.35*| 0.67  | 4.02 |  |
| 0                       |      |      |       |    |
| Alter(s) with healthful diet |      |    |        |    |
| 2 or more               | 2.45*| 0.52  | 4.38 | 59  |
| 1                       | 0.89 | -0.87 | 2.64 |  |
| 0                       |      |      |       |    |
| Smoking alter(s)        |      |    |        |    |
| Present                 | 0.54 | -1.73 | 2.79 | 59  |
| Absent                  |      |      |       |    |
| Alter(s) with overall healthful behavior |      |    |        |    |
| Present                 | 1.04 | -0.74 | 2.81 | 59  |
| Absent                  |      |      |       |    |
| Alter(s) with depressive symptoms |      |    |        |    |
| Present                 | 2.24*| 1.36  | 3.12 | 56  |
| Absent                  |      |      |       |    |
| Alter(s) with specialized knowledge |      |    |        |    |
| Present                 | 3.40*| 0.21  | 6.59 | 30  |
| Absent                  |      |      |       |    |

* p < .05, ** p < .01, *** p < .001, bold&cursive: p > .05 < .10.
Table 4: Networks & physical activity

<table>
<thead>
<tr>
<th>Network characteristics</th>
<th>Patient-reported</th>
<th>Physical activity</th>
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<tbody>
<tr>
<td></td>
<td>b</td>
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<td>n</td>
<td></td>
</tr>
<tr>
<td>Number of alters</td>
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<tr>
<td>Alter(s) with healthful physical activity</td>
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<td>-1.16</td>
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<tr>
<td>Alter(s) with healthful diet</td>
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<td>3 of 4</td>
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<td>-1.58</td>
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<tr>
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<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>Absent</td>
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<tr>
<td>Alter(s) with overall healthful behavior</td>
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<tr>
<td>Alter(s) with specialized knowledge</td>
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<td></td>
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<table>
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<td>-1.80</td>
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<td></td>
</tr>
<tr>
<td>Alter(s) with healthful diet</td>
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<td>-0.47</td>
<td>-1.35</td>
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<td>-0.95</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Smoking alter(s)</td>
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<td>-0.30</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Alter(s) with overall healthful behavior</td>
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<td>-0.27</td>
<td>-0.76</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>absent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alter(s) with depressive symptoms</td>
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<td>-0.22</td>
<td>-0.76</td>
<td>0.32</td>
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<tr>
<td></td>
<td>absent</td>
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</tr>
<tr>
<td>Alter(s) with specialized knowledge</td>
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<td>0.81</td>
<td>-0.61</td>
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<tr>
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</tbody>
</table>

* p < .05, ** p < .01, *** p < .001, bold&cursive: p > .05 - < .1.

103
Changes in diet
Results for change in diet are presented in Table 5. No effects of patient-reported network characteristics were found using ordinal regression analyses. However, the assumption of parallel lines was violated in models testing the effects of patient-reported number of alters with a healthful diet and presence of smoking alters. These effects were then testing using two logistic regression models, one contrasting no change with worsening in diet, and one contrasting improvement with no change in diet. In none of these logistic models, effects were found for perceived number of alters with a healthful diet (OR 0.56, p = .313 and OR 1.44, p = .301 respectively). Patient perception of presence of smoking alters was related to reduced odds for no change (OR 0.21, p < .05) and enhanced odds for improvement in diet (OR 8.45, p < .01).

In ordinal regression analyses, positive effects were found for alter-reported network characteristics of number of physically active alters (OR 3.82, p < .05), number of alters with overall healthful behavior (OR 2.86, p < .05), and presence of alters with depressive symptoms (OR 12.43, p < .05). The assumption of parallel lines was violated in the model including the effects of presence of alters with depressive symptoms. Using logistic regression models, we found that this effect was related to enhanced odds for no change in diet (OR 87.66, p < .05) and reduced odds for improvement in diet (OR 0.06, p < .001).

All effects were controlled for the following patient characteristics: intervention arm, PHQ total score, and smoking status.

Change in physical activity
In ordinal regression analyses for change in physical activity, the assumption of parallel lines was violated in almost every model. In only two models ordinal regression was feasible, in which the estimate for patient perceived presence of smoking alters was OR 1.11 (95CI 0.56 – 2.20, p = .759), and for alter reported presence of alters with specialized knowledge: OR 2.53 (OR 0.74 – 8.63, p = .138).

In table 6 we provide the results for logistic regression models for no change and improvement in physical activity. The patient reported network characteristics number of physically active alters (OR 0.03, p < .05), number of alters with a healthful diet (OR 0.12, p < .01), and number of alters with overall healthful behavior (OR 0.10, p < .05) were all related to reduced odds for no change in physical activity. For improvement in physical activity, we found positive effects of the patient reported network characteristic number of physically active alters (OR 9.85, p < .05) and number of alters with a healthful diet (OR 7.92, p < .05).

No effects of alter-reported network characteristics were found. All network characteristics were controlled for the following patient characteristics: working status and PAM total score.
Table 5  Social networks & change in diet

<table>
<thead>
<tr>
<th>Network characteristics</th>
<th>change in diet</th>
<th>Test of parallel lines</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Patient-reported</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of alter(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.55</td>
<td>0.19</td>
</tr>
<tr>
<td>3</td>
<td>0.93</td>
<td>0.38</td>
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<tr>
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<td>0.52</td>
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<tr>
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<tr>
<td>3 of 4</td>
<td>1.07</td>
<td>0.40</td>
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<tr>
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<tr>
<td>Alter(s) with healthful diet</td>
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<td></td>
</tr>
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<td>3 of 4</td>
<td>0.63</td>
<td>0.28</td>
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<tr>
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<td>1.08</td>
<td>0.46</td>
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<tr>
<td>Smoking alter(s)</td>
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<tr>
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<td>0.58</td>
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<tr>
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<tr>
<td>Alter(s) with overall healthful behavior</td>
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<tr>
<td>3 of 4</td>
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<td>Alter(s) with specialized knowledge</td>
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<td><strong>Alter-reported</strong></td>
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<tr>
<td>Alter(s) with healthful physical activity</td>
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<td></td>
</tr>
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<td>Alter(s) with healthful diet</td>
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<tr>
<td>Alter(s) with depressive symptoms</td>
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</tr>
<tr>
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<td>Alter(s) with specialized knowledge</td>
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<tr>
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<td>3.19</td>
<td>0.94</td>
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<tr>
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</table>

*p < .05, **p < .01, ***p < .001, bold&cursive: p > .05 <- .10, ns = no significant violation of parallel lines assumption, sig = significant violation of parallel lines assumption.
### Table 6  Social networks & change in physical activity

<table>
<thead>
<tr>
<th>Network characteristics</th>
<th>No change (vs worsening)</th>
<th>Improvement (vs no change)</th>
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<tr>
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<td><strong>Patient-reported</strong></td>
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<td></td>
</tr>
<tr>
<td>Number of alters</td>
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<td>3 of 4</td>
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<td>0.11</td>
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<tr>
<td>2</td>
<td>0.12**</td>
<td>0.03</td>
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<tr>
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<td>0.05</td>
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<td>0.09</td>
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<td>Alter(s) with depressive symptoms</td>
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<td></td>
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<td>0.09</td>
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<td>0.33</td>
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<tr>
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</tr>
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</table>

| **Alter-reported**      |     |          |    |     |          |    |
| Alter(s) with healthful physical activity |     |          |    |     |          |    |
| 2 or more               | 2.38| 0.31     | 18.06| 45  | 0.85     | 0.09| 3.82|38  |
| 1                       | 0.58| 0.15     | 2.26| 45  | 0.55     | 0.08| 3.90|    |
| Alter(s) with healthful diet |     |          |    |     |          |    |
| 2 or more               | 1.10| 0.15     | 7.88| 45  | 1.23     | 0.46| 3.30|38  |
| 1                       | 1.49| 0.33     | 6.79| 45  | 1.89     | 0.53| 6.76|    |
| Smoke alter(s)          |     |          |    |     |          |    |
| Present                 | 0.80| 0.26     | 2.43| 45  | 3.83     | 0.78| 18.71|38  |
| Absent                  | 0    |          |    |     |          |    |
| Alter(s) with overall healthful behavior |     |          |    |     |          |    |
| Present                 | 1.16| 0.49     | 2.77| 45  | 0.60     | 0.10| 3.63|38  |
| Absent                  | 0    |          |    |     |          |    |

*p < .05, ** p < .01, *** p < .001, bold & cursive: p > .05 -< .10, ns = no significant violation of parallel lines assumption, sig = significant violation of parallel lines assumption.*
Discussion

In this explorative observational study, we set out to test hypothesized associations of social networks of patients with vascular conditions with current and changed diet and physical activity, using patient-reported and alter-reported measures of networks. Support for our hypotheses (see Table 7 for a summary) was mixed and different for diet and physical activity, and for network measures constructed on either patient-reported or alter-reported data. Taken overall, alter-reported measures provided most support for hypothesized mechanisms with several effects identified on diet and change in diet but none on physical activity. Patient-reported measures showed associations with both diet and physical activity but which were contrary to our expectations. Nevertheless, a few effects of patient-reported measures on change in physical activity were in line with our hypotheses.

Consistent with our hypotheses, networks that contained alters with healthful habits for diet and physical activity, and in which alters with specialized knowledge were present, were positively related to patient current diet and change in diet. However, these effects were only observed when using alter-reported data. This may suggest that underlying mechanisms for impact of networks on health behaviors are less based on how the network is perceived but more on actual behaviors of its members. This may suggest that behavioral responses to social context, rather than individual rational decision making, determined health-related life styles.

Our results on alter-reported data were in line with studies (also using alter-reported data) on social contagion, or behavioral concordance, of several behaviors 4-8. Emphasizing that the observational design of this study does not allow to make causal inferences, literature indicates there are several processes which may explain such clustering of behaviors in networks. First, homophily (‘love of the same’), which describes the tendency of individuals with similar characteristics to associate and bond with each other. Second, induction, in which behavior of one person triggers similar behaviors in another. Third, similar experienced external causes may cause individuals to share behaviors or traits 36. In our sample of middle aged and older patients, with relatively stable social networks that mostly contained family members, it may be reasonable to assume that different mechanisms may have had their effects (now or in the past). Identified effects of social capital (i.e. ‘presence of alters with specialized knowledge’) are in line with other studies showing positive effects of access to resources in networks on health behaviors and health 37. Contrary to our expectations alter-reported presence of alters with depression or depressive symptoms had a positive effect on patient diet. However, this result may be explained considering results of analyses on change in diet which showed that patients whose networks contained such individuals were more likely to have stable diet habits and less likely to improve their diet.
Table 7  Summary of results

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<th>Physical activity</th>
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<td>No change</td>
</tr>
<tr>
<td>Analytic method</td>
<td>linear regression models</td>
<td>Ordinal or two logistic regression models¹</td>
</tr>
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<td>number of alters with/who:</td>
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<td></td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Number of alters</td>
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<td>-</td>
</tr>
<tr>
<td>Healthful diet</td>
<td>-</td>
<td>*</td>
</tr>
<tr>
<td>Healthful physical activity</td>
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</tr>
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<td>Smoke</td>
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<td>-</td>
</tr>
<tr>
<td>Specialized knowledge</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Alter-reported</td>
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<td></td>
</tr>
<tr>
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<td>-</td>
</tr>
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<td>Positive</td>
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<tr>
<td>Depression or symptoms</td>
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<td>*Positive</td>
</tr>
<tr>
<td>Specialized knowledge</td>
<td>Positive</td>
<td>-</td>
</tr>
</tbody>
</table>

* = no effect, effects on change in diet were analyzed using ordinal regression, except when the assumption of parallel lines was violated logistic regression modeling was applied, these models are marked with *.
Patient-reported network characteristics provided opposing results, with no or effects contrary to our hypotheses found on diet, change in diet, and physical activity. It is difficult to compare these results to previous research as, to our best knowledge, limited network research on health behaviors reported measures of both egos (that is the person around which the social environment is constructed) and alters. However, in line with studies including both we found that patient-reported and alter-reported measures were different 19, with patient-reported measures tending to be more positive or overestimating healthful behaviors of their alters 18. Dissimilar to this research, we did not find expected associations of patient-reported measures regardless whether perceptions of other ones behaviors or traits were correct 18. However, these studies were merely conducted in other, and mostly younger, populations.

Effects contrary to our expectations then may be explained considering our specific patient sample. Several negative effects of social network characteristics were found using patient-reported measures, which are dissimilar to other studies which mostly reported positive associations 38,39. Possibly, we found different results than in previous studies due to the composition of patients’ social networks, which mostly consisted of family members. Other studies found that while social networks with friends and neighbors were related to improved health behavior 40, associations between closer social networks (such as family) were more complex, as these may be more likely to provide both positive and negative influences 40. In line, a study on older adults with chronic illnesses comparing family and friends influences on health behaviors noted that family members were more often negative sources than friends 41, e.g. by feeling criticized 42, possibly due to the involuntary nature of contacts 41.

However, although we hypothesized patients to benefit when they had more alters with particular behaviors, it may also be that the effect runs the opposite way. Negative effects of patient-reported network characteristics may then reflect patients with difficulties maintaining healthful behaviors seeking out or considering more alters as important for managing their disease. Some support for this thought can be found when comparing our results with those of a study which found that disabled individuals tended to be in contact with their family more frequently 43. Our negative effects of having more alters with healthful behaviors may then be further explained as alters capable of providing help may likely be resilient individuals, who are able to engage in healthful behaviors or who have knowledge on health.

Characteristics of the patient sample may also explain why alter-reported measures had positive effects on diet but not on physical activity. It may be that it was more readily attainable for patients to be influenced on diet than on physical activity. Alters of patients included mostly spouses and children or patients. It may be argued that especially behavior of children may be of less influence to that of patients, as these are likely to engage in other physical activities than, and possibly realistically attainable for, patients. Different effects of networks in different age groups have been described earlier 44.
Our results then, may suggest that behavioral concordance (contagion) is a less relevant factor for patients, and that rather the opposite, having alters who are more healthy than themselves, is of more importance. As such, selection of specific contacts may be more relevant for understanding health behavior of patients. This notion may be supported by our results for current physical activity, in which we only found effects of patient-reported measures but none of alter-reported measures. However, influences of contagion can still have relevance as patient-reported number of alters with healthful diet and physical activity were related to improvement in physical activity. Possibly, and although it may have been unattainable for patients to achieve behavioral concordance with their alters, contagion may still have influenced attitudes on health and behavior, leading to improvement in physical activity.

Taken together, patient-reported and alter-reported measures provided different descriptions of social networks, and had different influences on both current and changed diet and physical activity. These results may indicate that patient-reported and alter-reported network measures can be reflective of different underlying social mechanisms in networks, which may differ for specific outcomes as well. Our results may suggest that health behaviors are influenced more by actual, instead of by perception of, behaviors of individuals in networks. Furthermore, the discordance between alter-reports and patients’ perceptions of networks, as well as their opposing effects, may indicate that underlying mechanisms of networks (i.e. actual behavior of alters) represent rather implicit influences on patients’ health behaviors. However, it should be noted that this explorative study included relatively small samples of patients and alters. Therefore, future research is needed to replicate these differences and to explore rationales for, and meanings of, differences between patient-reported and alter-reported networks.

Strengths of this study included the use of validated measures of health behavior, the inclusion of patients’ alters, the use of baseline network measurement in analyses on change of health behaviors, and the comparison of patient-reported and alter-reported network measures (which has been addressed in only a few network studies). Limitations included the following. First, the observational design of the study does not allow for causal inferences between network characteristics and health behaviors. Therefore, results of this study need to be interpreted with care and future research is needed to establish causal relations between networks and health behaviors. Second, the response rate was low, the sample size of both patients and alters was small, and power in analyses was limited. Selection bias may have been present in patients and alters as well. Therefore, care is warranted for the interpretation and generalization of our results which need to be replicated in future research including larger samples. Third, we were unable to include health care professionals who participated in the RCT intervention in the alter sample. To enhance comparability of patient-reported and alter-reported characteristics, data on perception on RCT healthcare professionals were removed from the analyses. This may have caused us to miss or to have overestimated network influences. However, the
number of patients who reported an RCT healthcare professional as alters was fairly small. Also, the removal of perceptions on healthcare professionals left us with data on networks containing only persons from patients personal environment. Although it was not a specific aim of this study to focus on informal networks, it may well be that these networks will be most likely to contain contacts which are close enough to affect patients’ health behaviors while contacts with health professionals, which are less frequent, may be less likely to do so.

Conclusions

In this study we found different influences of social networks characteristics on patient diet and physical activity, with different effects of network characteristics constructed using patient-reported and alter-reported data as well. Alter-reported measures were in line with our hypotheses for diet and change in diet, but did not affect physical activity. Patient-reported measures influenced both diet and physical activity but were largely contrary to our expectations. Several of our results are different from previous research, of which few focused on comparing patient-reported and alter-reported network measures using current and changes in diet and physical activity as outcomes. Our results may suggest that effects of networks may be different when using measures as provided by patients or by their alters, and may differently affect specific outcomes. Furthermore, patient health behavior seemed to be influenced more by actual alter behaviors than by perception of these individuals’ behaviors. Identified differences between patient-reported and alter-reported measures and effects may further suggest that mechanisms underlying social networks are rather implicit ones. However, additional research is needed to replicate these findings and to further examine possible, and rationales of, differences. Future research is also warranted to determine effects of health behaviors of health professionals and of other connections outside informal networks of patients.
References


Information exchange networks of health care providers and evidence-based cardiovascular risk management: an observational study


Naomi Heijmans
Jan van Lieshout
Michel Wensing
Abstract

Background Although a wide range of preventive and clinical interventions has targeted cardiovascular risk management (CVRM), outcomes remain suboptimal. Therefore, the question is what additional determinants of CVRM and outcomes can be identified and addressed to optimize CVRM. In this study, we aimed to identify new perspectives for improving healthcare delivery and explored associations between information exchange networks of health care providers and evidence-based CVRM.

Methods This observational study was performed parallel to a randomized clinical trial which aimed to improve professional performance of practice nurses in the Netherlands. Information exchange on medical policy for CVRM (‘general information networks’) and CVRM for individual patients (‘specific information networks’) of 180 health professionals in 31 general practices were measured with personalized questionnaires. Medical record audit was performed concerning 1620 patients in these practices to document quality of care delivery and two risk factors (systolic blood pressure (SBP) and LDL cholesterol level). Hypothesized effects of five network characteristics (density, frequency of contact, centrality of CVRM-coordinators, homophily on positive attitudes for treatment target achievement, and presence of an opinion leader for CVRM) constructed on both general and specific information exchange networks were tested and controlled for practice and patient factors using logistic multilevel analyses.

Results Odds for adequate performance were enhanced in practices with an opinion leader for CVRM (OR 2.75, p<.05). Odds for achievement of SBP targets were reduced in practices who had networks with low homophily on positive attitudes for SBP and LDL targets (homophily for SBP targets: OR 0.57, p<.05 and OR 0.60, p<.05, homophily for LDL targets OR 0.59, p<.05 and OR 0.61, p <.05 in general and specific information networks respectively). No effects of network characteristics on cholesterol were found.

Conclusions Delivery of evidence-based CVRM is associated with homophily of clinical attitudes and presence of opinion leaders in primary care teams. These results signal the potential of social networks to be taken into account in further attempts to improve the implementation of evidence-based care for CVRM. Future research is needed to identify and formulate optimal strategies for using opinion leaders to improve CVRM. Future interventions may be more effective if they target a common vision on CVRM within practices.
Background

Although examples of successful change of healthcare practice exist, there is a need for additional approaches that are more consistently effective. Determinants of evidence-based practice to which implementation programs can be tailored may be identified by social network analysis. Social networks are important channels for information exchange and coordination of activities, which are both influenced by network structures and cultures. Social network analysis in health care has been used to describe and explore a range of processes in healthcare, such as social support of patients, collaboration of health professionals, and the uptake of new practices. The importance of social networks for health care delivery is illustrated by studies showing, for example, that interaction and communication patterns among health care providers can be crucial to improve patient safety, and coordination and quality of care. In this study, we explore the role of information exchange networks of primary care providers in the delivery of evidence-based cardiovascular risk management (CVRM).

Practical context

Cardiovascular disease (CVD) remains an important cause of mortality and reduced quality of life worldwide. CVD was the number one cause of death among women and the second cause of death for men in the Netherlands in 2013. A range of preventive and clinical interventions are recommended in patients with CVD or high vascular risk. Clinical practice guidelines emphasize the importance of comprehensive CVRM, lifestyle changes, and preventive drug therapy. In the Netherlands, organizational and financial conditions for providing recommended CVRM have been optimized in recent years. Among these are the publication of a multidisciplinary clinical guideline and organizational standards for general practices, the introduction of nurses in practices, nationwide supply of paper-based and online patient education tools for CVD-patients as well as the general public, and targeted reimbursement for chronic illness care in primary care. Although the quality of CVRM improved substantially, still a specific number of patients did not completely receive recommended CVRM or did not reach target values of CVRM. There is a need for new approaches to enhance evidence-based CVRM.

Theoretical background

Literature on social network analysis is expanding and has provided descriptions of social network structure, or the pattern of connections between individuals, and of network culture, e.g. shared values, beliefs, or interests of individuals who are connected. Of these a number of network characteristics were selected which were expected to be related to the implementation of evidence-based care for CVRM.

Network density describes the proportion of all possible connections in a given network that are present, and has been used as an indicator of group solidarity or cohesion.
In dense networks many members know each other and interact with each other frequently. The multiplicity of ties create opportunities for various social influence processes, such as social comparison, imitation of successful behavior \(^1, 10, 11\), and the setting of group norms \(^1\). High density has been related to fast diffusion of information\(^12\), and has been shown to improve tasks that depend on cooperation \(^13\), and coordination performance \(^14\).

A high *frequency of contact*, expected to be present in dense networks because of their multiplicity of connections, can be of importance for health care delivery, as it enhances opportunities for social influence which, in turn, can offer protection against egocentric choices \(^11, 15, 16\). The underlying mechanism is derived from game theory, which distinguishes between single-episode and repeated interactions. Experiments based on game theory showed that the dynamics of repeated contacts provided a context facilitating and enhancing development of long-term cooperation and trust \(^17, 18\). In this view, outcomes depend on the history of contact between individuals, and cooperative and trustworthy behaviors are being incentivized by the anticipation of long-term reciprocal benefits \(^18, 19\).

Network members with high *centrality* have many connections with others in the network. These individuals are expected to be influential as their number of connections allows for greater access to and control over resources \(^20\). High centrality has been associated with enhanced knowledge transfer \(^21, 22\). In CVRM in primary care in the Netherlands, individuals with high centrality are expected to be present in social networks as CVRM coordinators or case managers. Both are purposefully created to become highly central individuals in health care delivery networks.

*Homophily*, or homogeneity, is the tendency of individuals with similar characteristics to associate and bond with each other. This concept refers to the tendency of persons to assume that individuals similar to them are more likely to accept them, to be trustworthy, and have similar beliefs. As such, homophily can be considered to be a social heuristic, which aims to avoid risks of connecting with others e.g. by prevention of potential conflicts and misunderstandings and by monitoring the balance of benefits and costs of relations \(^23, 24\). High homophily may enhance uptake of information which spreads in a given network by mutual reinforcement of attitudes and behaviors \(^24\). Social networks can be homogenous on several attributes. One study showed that physicians were more likely to exchange information and to provide advice during patient treatment if their attitudes towards evidence-based medicine were similar, if they had the same specialty, worked in the same organization, and had co-authored peer-reviewed papers \(^25\). Homophily has been related to medical advice seeking of clinical staff \(^26\) and prescribing behavior of general practitioners \(^20\).

Social networks may contain informal *opinion leaders*. He or she represents a person who influences opinions, attitudes, beliefs, motivations, and behaviors of others \(^27\). The role is informal, because it is not necessarily linked to a position in a formalized organization.
Figure 1  Hypothesized relations

Characteristics of social networks

- High density
- High frequency of contact
- High homogeneity
- CVRM coordinator with high centrality
- Opinion leader for CVRM

Social mechanisms, formation of attitudes & behavior

- Various social influence mechanisms e.g. imitation of successful behavior, social comparison
- Protection against egocentric choices
- Uptake of information
- Knowledge transfer
- Influences opinions, beliefs, motivations, behaviors

CVRM care

- Professional performance
- Achievement of CVRM targets
Opinion leaders may be beneficial for promoting evidence-based practice as their presence has been related to speeding adoption of clinical guidelines and to adherence to guidelines for unstable angina.

These network characteristics may be considered to relate to two broad dimensions of social networks. Density, frequency of contact, and centrality provide descriptions of patterns of linkages between actors in networks, which together describe the network structure in which information and other commodities are transferred. Homophily and presence of opinion leaders relate to shared opinions and existing values and norms in networks, in other words shared views on the world. This distinction is based on general conceptualizations of structure and culture (e.g. in 31, 32). It should be noted that structure and culture influence each other (for example see 33).

This study focused on network characteristics of healthcare professionals in general practices. The aim of the study was to explore associations of network density, frequency of contact, centrality of coordinators, homophily, and presence of informal opinion leaders with aspects of quality of care delivery and clinical risk factor levels of patients. We expected that patients are more likely to receive evidence-based CVRM and reach CVRM targets in practices which have social networks characterized by high density, high frequency of contact, a CVRM-coordinator who has a high degree of centrality, high homophily on positive attitudes for achievement of treatment targets, and a consistently identified opinion leader for CVRM.

**Methods**

**Design**

This study was part of the ‘Tailored Implementation for Chronic Diseases’ (TICD) project and was an observational study on information exchange networks of health care professionals involved in CVRM. The study was performed parallel to a larger two-arm cluster randomized controlled trial (RCT), which was also part of the TICD project. The RCT’s main aim was to test a tailored intervention for improving CVRM in primary care by enhancing professional performance of practice nurses. Practice nurses have an important role in CVRM and are responsible for providing patients with consults, including advice on their self-management behaviors. The current study was an independent observational study, not a process evaluation of the trial.

**Ethical approval**

The Medical Ethical Committee of Radboud University Nijmegen Medical Centre has waived approval for both the network study and the RCT.
Study population
The sample of the social network study consisted of health care professionals and patients with high risk for CVD and established CVD.

*Health care professionals:* we included all health care professionals working in general practices participating in the RCT and who were involved in patient care. These included general practitioners, general practitioners in training, locum general practitioners, dispensing general practitioners, practice nurses (specialized in somatic and in mental health care), practice assistants, pharmacist assistants, and social workers.

*Patients:* Eligible patients were adults aged 18 or older, with high risk of CVD or established CVD and capable of providing informed consent. Patients with high risk for CVD have a risk score of 20% or higher of 10-years-morbidity and mortality due to CVD. International Classification of Primary care (ICPC) codes were used to extract eligible patients from medical records. Exclusion criteria consisted of: diabetes mellitus, pregnancy and lactation, terminal illness, cognitive impairments, and poor language skills.

Data collection procedures
Data on information exchange networks were collected using questionnaires, which had been successfully applied in previous research[^37-39]. Questionnaires were personalized and listed names of all persons involved in patient care in the participating practices. Personalizing was performed by deriving names online, which were checked for accuracy by practice nurses. Questionnaires, along with prepaid envelopes for returning questionnaires, were distributed to practice nurses during outreach visits, performed for purposes of the RCT at the start of its program. Practice nurses distributed the network questionnaires to other health professionals within practices and were asked to remind other health professionals in case of no response within three weeks. A maximum of two reminders was used.

Data on professional performance of practice nurses and patient risk factors were gathered from patients’ medical records, using the adapted Epa Cardio abstraction tool[^40], at the end of the RCT intervention period at six month follow up. Medical auditing was performed by trained research assistants. All data collection was performed between July 2013 and September 2014.

Outcomes & Measures
Main outcomes of this study consisted of one measure of quality of care delivery and two specific vascular risk factors as proxies for health outcomes. Quality of care delivery was reflected by professional performance of practice nurses, which was the target of the larger RCT this study was embedded in.

*Professional performance:* Professional performance reflected application of evidence-based recommendations for personalized counseling and education of CVRM patients by practice nurses. Professional
performance was defined dichotomously, reflecting adequate or inadequate performance. Professional performance was considered adequate when at least one of the following conditions was met:

1) There is a record in the patient’s medical file or other healthcare provider-based records that the patient has received advice on at least one lifestyle item as specified in prevailing guidelines of CVRM (diet, smoking or physical exercise) and which has been relevant for the individual patient in the previous six months. At least one target, made up maximally 15 months ago, for improving an aspect of lifestyle should be recorded. Also, practice nurses were required to make a register note when a patient has an adequate lifestyle.

2) There is a notation in the patient’s medical file that the patient has none, mild or major depressive symptoms and that the patient has been referred to E-health, a physical exercise group, or depression treatment respectively.

**Patient risk factors:**
The patient risk factors consisted of systolic blood pressure (SBP) and low density lipoprotein cholesterol (LDL). Elevated SBP was defined as SBP > 140 mmHg. Elevated LDL was defined as LDL > 2.5 mmol/l.

Other measures of the study included:

**Descriptive variables:**
Descriptive measures included type of practice (solo, duo, or group) and practice size (number of staff); these data were measured using the modified Epa cardio abstraction tool.

**Information items for constructing social networks:**
Information exchange networks were measured using personalized questionnaires for each practice with a roster format. Social networks were constructed in two ways per practice. Health professionals were asked to indicate all their social contacts from their general practice from the last 12 months for CVRM information receiving and providing on two subjects. The first subject was general CVRM: information sharing on medical policy for CVRM in general. The second subject was specific CVRM: information sharing on CVRM related to specific patients. We chose to measure both general and specific information exchange networks as contacts within these networks can be expected to differ. For example, information exchange on CVRM in general relates to most or every health professional within a practice while information exchange related to specific patients may involve mainly health professionals who are involved in the treatment of these individuals.
**Frequency of contact:**
Health professionals were asked to indicate whether they had been in contact on a 1) daily/weekly or 2) monthly/yearly basis, for each person they had shared information with.

**CVRM-coordinators:**
Health professionals were asked to list the name(s) of the person(s) responsible for coordination of CVRM within the particular practice and to name his/her profession.

**Attitudes on CVRM targets:**
Health professionals were asked to indicate on a 5-point Likert scale (1 ‘totally unimportant’ – 5 ‘highly important’) how important they considered the treatment targets ‘achievement of SBP < 140’ and ‘achievement of LDL < 2.5’ in patients for whom decisions on appropriate treatment can be considered as debatable. Therefore, it was stated that attitudes involved treatment of patients for whom the guideline for CVRM was applicable, who were elderly (80 years and older) and had a limited life expectancy (less than 5 years). Scores 1-3 were considered as disagreement, and scores 4-5 were considered as agreement with the importance of achievement of SBP and LDL targets.

**Opinion leaders:**
Health professionals were asked to provide the name and occupation of one person they considered to have a significant influence on their current practice in CVRM. Additional instructions stated that ‘this person can be anyone from inside or outside the practice, and that the influence this person has had can be either current or from the past’.

**Data-analysis**
The statistical package R (package Statnet) was used for constructing and obtaining social network parameters of practices on general and specific information exchange. SPSS (version 22) was used for all other analyses. The primary unit of analysis was practice (one network per practice) except where indicated otherwise.

Reliability of reported social network connections was investigated by examining the proportion of all possible connections that were mutually reported present or absent (reciprocity coefficients in non-directed networks). In accordance with guidelines on handling missing values, we substituted missing values on information receipt for networks with at least 60% reliability by values as provided by responses of other persons on information providing. In case of no information on connections, we indicated no contact by filling in a zero in the data. Only missing data on connections were imputed. Missing data on attitudes on CVRM targets were not imputed, therefore persons who did not provide data on attitude variables were left out on the calculation of the E-I index.
**Construction of network characteristics**

Network characteristics hypothesized to be of positive influence were: a high density, high frequency of contact, presence of a CVRM-coordinator who has a high degree of centrality, high homophily, and a consistently identified opinion leader for CVRM. All characteristics except ‘opinion leader for CVRM’ were computed and tested separately for information receipt networks of general practices on 1) CVRM in general and 2) CVRM for specific patients. Presence of opinion leaders was inferred using data from all health professionals from the specific practice, regardless of information exchange.

**Density** represented the proportion of all possible connections in the information exchange network of professionals in a practice organization that were present, and was entered as a continuous score in analyses. **High frequency of contact** was indicated by the number of contacts within a practice network occurring on a daily or weekly basis, and was entered as a continuous score in analyses. For ‘*presence of a CVRM-coordinator who has a high degree of centrality*’, we first determined whether CVRM coordinators were present within practices. In almost all practices coordinators were present, with up to three persons identified as such. We then determined which person was mentioned most often as coordinator by his or her colleagues and computed his or her centrality (total degree, which is the total number of connections providing the coordinator with information and to which the coordinator provides information) which was entered as a continuous score in analyses. In three practices two persons, a practice nurse and a general practitioner, received equal votes as coordinators. To term one of them as coordinator of the practice, we considered which type of health professional was mentioned most often as coordinator in other practices. As most practices had a practice nurse as coordinator, it was decided for these three practices to enter centrality scores of the practice nurses in the analyses.

We assessed **homophily** on positive attitudes regarding achievement of treatment goals for SBP and LDL. Homophily was calculated using the E-I index. The E-I index ranges from -1 to 1. When the E-I index is -1 all ties in the networks are between contacts who agree on the importance of achievement of treatment goals (i.e. the network is homophilous in positive attitudes), while a score of 1 indicates that all ties are between contacts who disagree with this importance (the network is homophilous in negative attitudes). A score of 0 indicates that ties in the network are between both contacts with positive and negative attitudes (the networks is heterophilous in attitudes).

For testing ‘*a consistently identified opinion leader for CVRM*’ we first computed the percentages of votes for each person as opinion leader within the practice. A dichotomous item was then created; practices in which one person was chosen as opinion leader by at least 60% of his colleagues were designated as having an opinion leader. We chose to conceptualize that only one opinion leader could exist in each practice because of their interpersonal influences on opinions. While one opinion leader may exert specific influences, two opinion leaders may spread contrary ideas which may lead to the possible spread of opposing ideas within networks.
**Statistical Analyses**
All analyses were performed two-tailed, using \( p < .05 \) indicating significance, and were based on ‘intention to treat’ with practice’s networks as unit of analysis. For comparison of social network characteristics as constructed on networks for general and specific CVRM, paired sample t-tests (T) were performed for normally distributed characteristics; for non-normal distributed characteristics, Wilcoxon tests (Z) were performed. Network effects from the hypotheses were tested using multivariate logistic regression models, with random intercepts specified for general practice. Professional performance of practice nurses, and SBP and LDL of patients, measured at 6 month follow up of the RCT were used as dependent variables.

For each outcome, 11 multivariate models were specified, testing each network effect controlled for patient and practice characteristics. Patient characteristics were entered as level 1 predictors and practice characteristics were entered as level 2 predictors in the analyses. 10 models tested the 5 network effects (density, frequency of contact, centrality of the CVRM coordinator, and homophily for positive attitudes on achievement of treatment targets for SBP and LDL) as constructed on 1. specific and 2. on general information receipt networks. One model for each outcome was used to test the effect of the presence of an opinion leader. Control variables consisted of patients’ characteristics (age, sex, patient group: established CVD versus high risk) and practice characteristics (network size, and RCT arm: control or intervention).

**Results**

**Response rates & reliability measures**
The RCT started with 44 practices, of which 10 dropped out, so that 34 practices completed the intervention program. A total of 37 practices (84%) provided network data. Of these 37, six practices had to be excluded from the analyses. Three practices provided data on their networks but not on the study outcomes as they dropped out of the RCT. Of the remaining 34 practices, three practices completed the RCT but had low response on the network questionnaires (in two practices only two professionals participated and one practice had less than 40% response). Thus, data on a total of 31 practices were available for the analyses.

From a total of 242 health professionals (from 31 practices), 186 completed network questionnaires so that the response rate was 76.9%. Average data completeness per practice was 79.5% (range: 40% - 100%). *Reliability* calculated for network connections was 81% (SD 19.7%) for general CVRM and 77.6% (SD 25.8%) for specific CVRM.

**Sample characteristics**
From the 31 practices, 14 were randomized to the RCT control arm and 17 to its intervention arm. 18 practices were solo practices, 10 duo, and 3 group practices. 17 practices were
situated in a rural area whereas 14 were from an urban area. Mean number of health professionals working within practices was 7.8 (SD 2.9).

Practice nurses (n=31) had a mean age of 42.7 years (SD 8.6), with an average of 11.9 (SD 10.3) years of working experience. 1620 patients participated, 870 (54%) were at high risk for CVD and 750 (46%) had established CVD. Mean age of high risk patients was 73 years (SD 7.3) and 31% was female. Mean age of CVD patients was 68.7 years (SD 10.9) years and 38% was female.

Description of social networks
Density
Mean density of networks connections for general CVRM information in the practices was 0.38 (SD 0.17) and 0.37 (SD 0.22) for specific CVRM information.

Frequency of contact
Mean number of total network connections for general CVRM information was 18.16 (SD 11.69), of which 51% (SD 27.37%) were high frequency contacts (contact on a daily or weekly basis). For specific CVRM information, mean number of total network connections was 17.81 (SD 13.92), of which 61% (SD 23.98%) were high frequency contacts.

CVRM coordinator(s)
CVRM coordinators were present in the majority (n=28, 90%) of the general practices; in 4 practices 80%-87.5% of the health professionals reported a CVRM coordinator was present, and in 24 practices everyone within the practices agreed on having a coordinator. Three practices had low agreement on having a coordinator, with 25%-50% of health professionals reporting a coordinator was present within their practice.

A single coordinator was present in 8 (29%) practices, 16 (57%) practices reported they had two CVRM coordinators, and 4 practices (14%) had three CVRM coordinators. Consistency of recognition of coordinators seemed to decrease when more persons were identified as coordinator; a single person was recognized as coordinator by all of his or her colleagues in 75% of practices with a single coordinator and in 63% of practices with two coordinators, while recognition by all colleagues was not obtained in practices with three coordinators.

Considering persons most consistently chosen as CVRM coordinator of the practice, most practices’ (n=19, 68%) coordinator was a practice nurse, 6 practices (21%) reported their coordinator was a general practitioner, while in 3 practices (11%), practice nurses and general practitioners were mentioned equally often as coordinators.

Centrality of CVRM coordinators
Centrality scores were computed for persons most often elected as CVRM coordinator. Mean centrality for general CVRM information was 6.61 connections (SD 3.38), and 7.07 connections (SD 4.97) for specific CVRM information.
**Homophily on attitudes on treatment targets**
For achievement of SBP treatment targets, an average number of 1.48 (SD 1.48) health professionals per general practice indicated to consider achievement of such targets important while on average, 3.94 (SD 1.61) health professionals per practice considered achievement of SBP targets as unimportant.

An average number of 1.39 (SD 1.36) health professionals per practice valued achievement of LDL treatment targets while an average of 3.94 (SD 1.61) health professionals disagreed with the importance of achievement of LDL targets.

Mean value of the E-I index in general CVRM information exchange networks was 0.60 (SD 0.43) regarding attitudes for achievement of SBP targets and 0.53 (SD 0.49) on achievement of LDL targets.

Mean value of the E-I index in specific information exchange networks was 0.55 (SD 0.46) for achievement of SBP targets and 0.52 (SD 0.52) for achievement of LDL targets. These values indicate that on average most reported ties were between contacts who did not value the importance of achievement of treatment targets.

**Opinion leaders**
In most cases opinion leaders were persons from within practices, with a mean of 3.7 (SD 1.8) health professionals per practice naming a within practice colleague as opinion leader and a mean of 0.7 (SD 0.97) health professionals per practice mentioning a person from outside the practice as their opinion leader.

In 10 (32%) practices an opinion leader was consistently identified, as designated by at least 60% of health professionals from practices naming a specific person as their opinion leader. In these practices, most practices (n=8) choose a general practitioner as opinion leader, one practice choose a practice nurse as opinion leader and in one practice equal votes were given to a general practitioner and practice nurse as opinion leader.

Considering data of all practices, and appointing individuals most often mentioned by his or her colleagues as opinion leader of the practice, a similar pattern was found. In most practices (n=24) a general practitioner was chosen as opinion leader, 3 practices choose a practice nurse as opinion leader, and 3 practices gave equal votes to a general practitioner and practice nurse as opinion leader. In one practice, no opinion leaders from within the practice were found.

**Comparison of network characteristics:**
The several network characteristics showed substantial variation between practices (see Table 1). They were not different for networks constructed on general or specific CVRM information exchange (density: T 0.33, p = 0.745, number of high frequency contacts: Z 1.76, p = .079, CVRM coordinator centrality: Z 0.643, p = .520, homophily on SBP targets: Z -1.10, p = .272, homophily on LDL targets: Z -0.27, p .790).
Table 1  descriptive data of networks

<table>
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<tr>
<th></th>
<th>General CVRM networks</th>
<th>Specific CVRM networks</th>
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<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
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<tr>
<td>Density</td>
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</tr>
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<td>Number of high frequency contacts</td>
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</tr>
<tr>
<td>Centrality of CVRM coordinator</td>
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<td>3.38</td>
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<tr>
<td>Homophily on SBP targets</td>
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<td>0.43</td>
</tr>
<tr>
<td>Homophily on LDL targets</td>
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<td>0.49</td>
</tr>
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</table>

Hypotheses testing

Network characteristics and professional performance

General practices with consistently identified opinion leaders had increased odds for adequate professional performance of practice nurses (OR 2.75, p < .05). None of the other network characteristics constructed on either general or specific information networks were related to professional performance.

Results for control variables in models for both general and specific CVRM were as follows. In each model, reduced odds for adequate professional performance were found for patient age and CVD patients, while female patients had enhanced odds for adequate performance. No effects of network size or trial arm were found.

Table 2  Network characteristics and professional performance

<table>
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<th>Professional performance</th>
<th>General CVRM</th>
<th>Specific CVRM</th>
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<td></td>
<td>OR</td>
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<td>Density</td>
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<td>Frequency of contact</td>
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<tr>
<td>Centrality of CVRM coordinator</td>
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<td>0.90 - 1.18</td>
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<tr>
<td>Homophily</td>
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<td></td>
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<tr>
<td>Achieve BP target</td>
<td>0.69</td>
<td>0.26 - 1.78</td>
</tr>
<tr>
<td>Achieve LDL target</td>
<td>0.71</td>
<td>0.30 - 1.65</td>
</tr>
</tbody>
</table>

Consistently identified OL for CVRM 2.75* 1.23 6.14 31 1620

Not shown in table: estimates for control variables, estimates for intercepts, and estimates for random effects. OR= odds ratio, * = p < .05, n prac = number of practices in analysis, n pat = number of patients in analysis, OL= opinion leader
Network characteristics and blood pressure

General CVRM information networks

Negative associations were found between homophily and recorded blood pressure. Homophily was measured using the E-I index, ranging from -1 (positive attitudinal homophily; all contacts are between health professionals who consider achievement of treatment targets important), 0 (contacts are between professionals who value this as well as professionals who do not value this), to 1 (negative attitudinal homophily; all contacts are between health professionals who do not consider achievement of treatment targets as important). The negative coefficient then indicates that when the E-I index increases (i.e. moves towards negative attitudinal homophily), the odds for positive SBP outcomes of patients decrease. Stated otherwise, in networks in which homophily on positive attitudes for achievement of both SBP targets (OR 0.57, p < .05) and LDL targets (OR 0.59, p < .05) was low (i.e. networks in which there were few contacts between persons considering achievement of treatment targets as important), reduced odds for positive SBP outcomes were found. None of the other network characteristics constructed on general information receipt networks were related to SBP.

Specific CVRM information networks

Low homophily on both positive attitudes for achievement of treatment targets of SBP and LDL were related to reduced odds for positive SBP outcomes of patients (OR 0.60 and OR 0.61 respectively, p<.05 for both effects). None of the other network characteristics constructed on specific information receipt networks were related to SBP.

Results for control variables in models for both general and specific CVRM were as follows. In each model, patient age was significantly related to reduced odds for positive SBP outcomes, while CVD patients had enhanced odds for positive SBP outcomes. No effects were found for patient sex, network size, and trial arm.

Network characteristics and serum cholesterol

None of the social network characteristics, constructed on either general or specific information networks, were related to LDL. Results for control variables in models for both general and specific CVRM characteristics were as follows. In the models testing homophily of SBP and LDL targets, patient age had significant positive effects on positive LDL outcomes while no effects of age were found in the other models. Female patients had significant or marginally significant reduced odds for favorable LDL outcomes in all models, CVD patients had significant enhanced odds for positive LDL outcomes in all models, while no effects were found for network size and trial arm.
### Table 3  Network characteristics and blood pressure

<table>
<thead>
<tr>
<th></th>
<th>General CVRM</th>
<th>Specific CVRM</th>
<th>n prac</th>
<th>n pat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SBP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>1.56</td>
<td>0.31</td>
<td>7.82</td>
<td>1.04</td>
</tr>
<tr>
<td>Frequency of contact</td>
<td>1.02</td>
<td>0.98</td>
<td>1.07</td>
<td>1.00</td>
</tr>
<tr>
<td>Centrality of CVRM coordinator</td>
<td>1.00</td>
<td>0.93</td>
<td>1.09</td>
<td>1.00</td>
</tr>
<tr>
<td>Homophily</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achieve BP target</td>
<td>0.57*</td>
<td>0.34</td>
<td>0.94</td>
<td>0.60*</td>
</tr>
<tr>
<td>Achieve LDL target</td>
<td>0.59*</td>
<td>0.38</td>
<td>0.92</td>
<td>0.61*</td>
</tr>
<tr>
<td><strong>Consistently identified OL for CVRM</strong></td>
<td>0.98</td>
<td>0.59</td>
<td>1.64</td>
<td></td>
</tr>
</tbody>
</table>

Not shown in table: estimates for control variables, estimates for intercepts, and estimates for random effects.

OR= odds ratio, * = p < .05, n prac = number of practices in analysis, n pat = number of patients in analysis, OL= opinion leader

### Table 4  Network characteristics and serum cholesterol

<table>
<thead>
<tr>
<th></th>
<th>General CVRM</th>
<th>Specific CVRM</th>
<th>n prac</th>
<th>n pat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LDL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>0.72</td>
<td>0.16</td>
<td>3.30</td>
<td>0.89</td>
</tr>
<tr>
<td>Frequency of contact</td>
<td>0.98</td>
<td>0.95</td>
<td>1.02</td>
<td>0.99</td>
</tr>
<tr>
<td>Centrality of CVRM coordinator</td>
<td>0.98</td>
<td>0.92</td>
<td>1.06</td>
<td>1.00</td>
</tr>
<tr>
<td>Homophily</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achieve BP target</td>
<td>1.05</td>
<td>0.63</td>
<td>1.78</td>
<td>0.85</td>
</tr>
<tr>
<td>Achieve LDL target</td>
<td>0.97</td>
<td>0.61</td>
<td>1.54</td>
<td>0.89</td>
</tr>
<tr>
<td><strong>Consistently identified OL for CVRM</strong></td>
<td>1.39</td>
<td>0.88</td>
<td>2.20</td>
<td></td>
</tr>
</tbody>
</table>

Not shown in table: estimates for control variables, estimates for intercepts, and estimates for random effects.

OR= odds ratio, * = p < .05, n prac = number of practices in analysis, n pat = number of patients in analysis, OL= opinion leader
Discussion

In this observational study we explored linkages between information exchange network characteristics of health care providers in general practices and the implementation of evidence-based care for CVRM and vascular risk factors as proxies for health outcomes. Several of our hypotheses were confirmed (see Table 5 for a descriptive summary). Low homophily of positive attitudes on achievement of treatment targets was negatively related to achievement of recommended SBP values of patients. Presence of consistently perceived opinion leaders was positively related to adequate professional performance of practice nurses. Results for network characteristics of general and specific CVRM information networks were largely similar. No effects were found of network density, frequency of contact, and centrality of coordinators on professional performance and clinical risk factors. Overall, we find some indication of impact for culture in primary care teams, but no indication for impact of network structures.

Table 5 Summary of results

<table>
<thead>
<tr>
<th>General practices will have positive outcomes if their network are characterized by:</th>
<th>Outcomes for which hypothesis was confirmed:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General CVRM networks</td>
</tr>
<tr>
<td>High density</td>
<td>n.s.</td>
</tr>
<tr>
<td>High frequency of contact</td>
<td>n.s.</td>
</tr>
<tr>
<td>Centrality of CVRM coordinator</td>
<td>n.s.</td>
</tr>
<tr>
<td><strong>Homophily on positive attitudes regarding</strong></td>
<td></td>
</tr>
<tr>
<td>Achievement of BP-targets</td>
<td>SBP</td>
</tr>
<tr>
<td>Achievement of LDL-targets</td>
<td>SBP</td>
</tr>
<tr>
<td>Consistently identified OL for CVRM</td>
<td>professional performance</td>
</tr>
</tbody>
</table>

Our hypotheses on homophily of clinical attitudes and presence on opinion leaders were confirmed. This suggests that professional views in a practice team have impact on its performance. Although we are unaware of previous research which specifically investigated network homophily on positive attitudes of treatment outcomes of patients, this effect is in line with several other studies. \( ^{28} \). Homophily may be caused by selection of similar contacts, or can be induced by repeated contacts with individuals with certain attributes. \( ^{29} \). Given that practices contain a heterogeneous group of health professionals, attitude-based homophily in our practices is unlikely to be caused by selection of similar contacts and may more likely have resulted by being part of a common context and by mutually experienced social influences. Positive effects of opinion leaders are in line with several studies. However, mixed findings on opinion leaders have been noted in current
literature. For example, educational interventions which involved opinion leaders had moderate effectiveness \(^\text{28}\), with different effects within primary and secondary care identified as well. Relatively few studies focused on mechanisms by which opinion leaders assert their effectiveness, of which understanding is therefore still limited. However, mechanisms described include generating consensus \(^\text{43}\), increasing the observability and reducing potential risk of new clinical behaviors \(^\text{44}\), and promoting efficient learning \(^\text{27}\).

Dissimilar to previous studies, we found no effect of network density, frequency of contact, and centrality of CVRM coordinators. This may indicate that network structure may have limited impact in general practices. Density and frequency of contact are theorized to have its effects as many ties and contacts can create higher levels of information sharing and provide more momentum for collaboration \(^\text{45}\). Several reasons may explain why no effect of density and frequency of contacts were found in this study. First, sizes of networks of practices in this study were rather small. It may be that a low density and frequency of contacts in small networks is already sufficient to influence its members. For example, in a practice with five health professionals knowledge may spread more readily than in a practice containing 15 health professionals, in which more contact moments may be required before information has been conceived by all network members. Second, it is possible that wider networks of healthcare professionals (contacts with health professionals from outside the practice organization and possibly also contacts from the past) were also, or more, relevant for their behaviors and views. For example, external contacts with possible influences on practice nurses may likely consist of contacts with the CVRM care group (which represent the organization of general practitioners to provide CVRM in the Netherlands according to the chronic care model, which arranges funding, and monitors performance and provides feedback). Also, many information sources on CVRM are nowadays readily available on the Internet. Possibly then, health professionals needed to rely less on information exchange with colleagues to obtain needed information. Third, results may have been influenced by the timing of measurement of information exchange. In this study, we focused on information which was not new to health professionals as implementation of adherence to CVRM guidelines has been targeted by several interventions in the Netherlands in the past. In networks in which information has had spread effectively, it is possible that a low frequency of contact is already sufficient to influence its members, leaving additional contact moments without additional value. More contacts then could even be disadvantageous as persons may waste time and effort on maintaining contacts which are unable to provide them with new information \(^\text{46, 47}\). As such, density and frequency of contact may still be relevant network characteristics for improving delivery of care and patient risk factors, but of which effects may be more relevant and observable at earlier stages of implementation and spread of new knowledge.

The well spread of, and adequate availability of, CVRM knowledge may also account for the non-significant differences between characteristics of general and specific
information exchange networks, which were contrary to our expectations. It is difficult to compare this result to previous literature as, to our best knowledge, no other studies investigated such networks. However, if all or the majority of health professionals were already equipped with adequate knowledge, there may have been no need to employ different information exchange patterns for discussing decisions on individual patients. On the other hand, it may be that specific information exchange was not recognized as such. CVRM guidelines also provide information on specific patient groups, which may have led health professionals to consider communication on treatment for specific patients as general information exchange.

In contrast to other research \(^{21,22,48}\), but in line with a study on general practitioners’ prescribing behavior \(^{20}\), we found no effect of centrality of CVRM coordinators (often practice nurses) on any of the outcomes. Fattore et al \(^{20}\) provided several reasons for the lack of effect of centrality which may be applicable in this study as well. They considered Granovetter \(^{47}\) and Burt’s \(^{46}\) notion of non-redundancy for information capability of networks; performance is influenced by networks which contain high informational dissimilarity. When relationships are equal in terms of access to resources (e.g. one individual within a networks knows what other individuals know), a lack of access to new information may result. Having more contacts then, does not increase knowledge and thus does not influence other outcomes \(^{46,47}\). However, specific details of this study may also explain why we were unable to identify effects of centrality. In our sample, we found that a substantial number of practices had more than one CVRM coordinator, with varying consistency rates when two or three coordinators were present. We choose to term the most consistently chosen person as coordinator, and analyzed total degree of these persons. This approach might have obscured the effect of centrality as it may be that other coordinators were actually present and that their centrality scores mattered as well. Possible reasons for appointing more than one coordinator may include part time working employees, or the combination of coordination with other tasks. It may also be noted that in this study, at least one coordinator was present in almost all practices so that we were unable to investigate possible effects of absence of CVRM coordinators.

Strengths of the study include the substantial number of participating practices, the use of medical record data, and the use of both health professional performance outcomes and patient health outcomes. Limitations of the study include the following. First, the observational design of this design does not allow for causal inferences. Second, hypotheses were tested repeatedly, which can increase risk for type I error rate. We did not correct for this repeated testing given the explorative aim of this study and as corrections for repeated testing can come with disadvantages such as risk of enhanced type II rate. Third, practices were designated to have an opinion leader when at least 60% of healthcare workers in a practice choose a particular person as opinion leader. This cut-off of 60% may seem fairly low. However, it may be argued that 60% counts as a substantial number as network sizes were rather small. For example, in a practice with five workers, this would
mean that three workers would consider a fourth person as their opinion leader, leaving a single person 'unaffected' by the presence of the opinion leader. Fourth, the questionnaires for mapping the networks were not validated against a criterion measure. However, previous research using similar questionnaires showed that these provided feasible measurements with substantial variation. Fifth, caution is warranted to generalize results of this study to other networks than those of primary care for CVRM.

All together, we found no effects of network structure characteristics (density, frequency of contact, coordinator' centrality), while effects of network member's views (homophily of clinical attitudes and presence of opinion leaders) were related to performance. These findings may indicate that for primary care for CVRM views, or its 'culture', in general practices may be more important than network structures. However, this does not mean that network structure can be ignored, because many other studies provided evidence of influence on diffusion of information and collaboration between individuals. In addition, in this study possible explanations for the non-significant influences of network structure included the timing of measurement of information exchange patterns. Future research is needed to enhance understanding of network structure, network culture and its causal order, of which no inferences can be made in this observational study and on which disagreement exists in current literature.

Moreover, our results signal the potential of social networks to be taken into account in further attempts to improve the implementation of evidence-based care for CVRM. Future efforts may focus on individuals who are perceived as opinion leaders in practices, and use these persons as conduits for disseminating new knowledge or as providers of assistance for adhering to guidelines for providing optimal care. The use of opinion leaders to promote evidence-based practice is not new. A Cochrane review described that opinion leaders may be successful but that their identification, roles, and effectiveness showed a great variety, with different effects identified in primary and secondary care settings as well. One study noted, in line with our results, that opinion leaders could not be identified in every practice. Also, opinion leaders may not remain the same over a longer time period. Therefore, further research focusing on the specific roles and influences of opinion leaders in primary care for CVRM is likely needed in order to identify and formulate optimal strategies for using opinion leaders to improve CVRM.

Our results on homophily indicate the importance of particular and common views towards treatments goals in CVRM, which is consistent with the notion that CVRM is a team effort. Implications may be two-sided. First, our results showed that a substantial number of health professionals did not value treatment target achievement and indicated a general agreement of this negative attitude within practices. The negative relation with SBP outcomes of patients may indicate that it this negative attitude towards treatment targets which needs to be targeted in future interventions. Second, the effect of homophily underscores the importance of a common vision on CVRM within practices. Future interventions may therefore be more effective if they target the development, or
strengthening, of a common (and possibly positive) vision on CVRM within practices. Possible examples of such interventions may include the use of opinion leaders, or incorporate approaches such as relational coordination, or reciprocal learning. The latter two represent mutual reinforcement interaction processes and learning as continuous and joint give-and-take process respectively, and have been associated with improved quality of care and patient outcomes in settings which require efficient team work. Future research is needed to assess the effectiveness of such interventions, or to identify other approaches which target shared conceptions and views within networks.

Conclusions

This observational study aimed to find additional determinants for CVRM using social network analysis. Prevailing views in primary care teams, but no other social network characteristics, in information exchange networks of health professionals from practices were related to delivery of evidence-based health care.
References

General discussion


**Introduction**

Although a wide range of interventions has improved CVRM in the Netherlands, further improvements remain possible. There is a need for strategies that improve CVRM in the subgroup of patients who currently receive suboptimal CVRM. The studies presented in this thesis aimed to explore a new perspective on determinants of CVRM, to which strategies could be tailored, using a social networks approach. This chapter starts with the presentation and discussion of the main findings of this thesis, and will be followed by methodological considerations and implications for practice and future research.

**Enhancing participation rates**

In Chapter 2, we started off with a study on improving patients’ participation rates. Low participation rates create several difficulties for research and in general participation rates seem to be declining. Participation rates may be enhanced by providing choice of participation, which has been hardly investigated. Using two RCTS, we showed that participation rates of patients could be enhanced by offering choice of participation mode as compared to invitations for a postal questionnaire. Although our results indicated that providing choice of participation mode can be an appropriate approach for enhancing participation rates, results on conditional participation rate suggested that refinements in this strategy may be considered and need to be addressed in future research. Conditional participation rates were higher for no choice invitations for interviews. Therefore, a refined approach may comprise a two-sided strategy which 1) provides patients with choice of participation mode, and 2) uses of participation modes with likely high participation rates, such as interviews, in a maximum number of patients willing to do so.

To our best knowledge, only one other study has investigated choice of mode in a population with a chronic condition. Therefore, it remains to be determined in future research whether results generalize to other populations. Also, this was the first study providing choice of participation mode for participation in a social network study, so that future research is needed to investigate whether results are similar in studies with different topics.

In chapters 3 and 4, two studies were presented which were performed to explore several hypothesized influences between social networks and health behavior and clinical risk factors of patients.

**Social networks of patients**

CVRM heavily emphasizes, amongst others, healthful behaviors of patients (i.e. healthful habits for diet, physical activity, and non-smoking), providing patients with a central role in CVRM. Previous studies using network analysis provided compelling results which may help to understand and improve health behaviors (e.g.), although several limitations of
these studies were noted as well. In two studies we explored associations between social networks of patients involved in CVRM, their health behaviors and clinical risk factors. In these studies, limitations of previous research were addressed by including both patients and their alters in our studies, by controlling for psychological factors, using medical record auditing, and by examining both current and changed health behaviors. Tested hypotheses stated that patients would be more likely to engage in healthful behaviors if their networks contained (more) alters with: 1) healthful behaviors, 2) without depression, and 3) with specialized knowledge on health. The first two hypothesized network characteristics were based on contagion mechanisms, or clustering of behavior, with its associated underlying social influence mechanisms, whereas the third hypothesis was based on social capital mechanisms.

Taken overall, limited evidence was found for clustering of behaviors. This is dissimilar to previous studies which showed clustering of several behaviors and traits ⁵,⁶,⁹-¹¹. Interestingly, alter-reported network characteristics provided most support for our hypotheses while patient-reported network characteristics tended to show opposite effects. Results on the depression hypothesis were largely contrary to our expectations. However, it should be noted that the occurrence of depressive symptoms was very low in both patients and their alters. Support for influences of social capital was only found in alter-reported data. Also, results of the two studies in this thesis were inconsistent, which shows that effects are not necessarily replicated. Virtually no effects of network characteristics on clinical risk factors were found. A plausible route for influences of network characteristics is by first influencing health behavior of patients, which then result in particular outcomes of clinical risk factors. Given that only a few of our hypothesized network characteristics were related to patient health behavior, it is then not surprising that clinical risk factors were unaffected by network composition.

Our results indicate that social network characteristics had some influence on health behavior of patients. However, influences of specific network characteristics on patients’ health behavior and clinical risk factors were small and inconsistent across studies. These mixed findings may indicate the importance of possible influences of other particular network characteristics, including those of the wider personal network and the social networks in a neighborhood or local region. Also, contrary to our expectations and to previous studies ⁷,¹², patient-reported network characteristics had mostly negative (instead of positive) influences on patients’ health behavior. These negative effects may actually signal that hypothesized effects run an opposite way. As such, patients with unhealthful behavior or those having difficulties managing their disease, are in need of alters who can help them to improve CVRM. Alters capable of providing these may likely be resilient individuals, who are able to engage in healthful behaviors or who have knowledge on health. As such selection, in addition to contagion, may be a possible network influence of importance for understanding patient health behavior.
It may also be that contagion, or achieving behavioral concordance, is not readily attainable for patients or that influences are more pronounced for specific outcomes. Particularly physical activity may be considered in this regard. Alters of patients included mostly spouses and children or patients. Especially behavior of children may be of less influence to that of patients, as these are likely to engage in other physical activities than, and possibly realistically attainable for, patients 12. However, this does not mean that influences of contagion should be entirely disregarded, as they may still influence attitudes on health and behavior. Our studies provided support of this notion, with some patient-reported networks being positively related to improvement in patients' health behavior. Possible underlying mechanisms may include role modeling 7 or the provision of encouragement 12.

Results for social capital (i.e. presence of alters in networks with specialized knowledge) were inconsistent. The negative effect found in chapter 3 may be explained by the possibility of negative interactions, which may result due to provision of unwanted or mistimed information. Although only a few studies on negative effects of social networks are available, adverse influences of negativity in social relationships have been documented 13,14, and quality of relationships has been shown to significantly influence health 15.

Notably, we found differences between patient-reported and alter-reported networks and their influences on patients' health behaviors. So far, and to our best knowledge, only a few studies on health behaviors reported measures of both patients and alters. The discordance between patient-reports and alter-reports are in line with these studies. However, these were merely conducted in other, mostly younger populations 16,17. Possibly, these differences reflect different underlying social mechanisms in networks. Furthermore, the discordance between alter-reports and patients' perceptions of networks, as well as their opposing effects, may indicate that underlying mechanisms of networks (i.e. actual behavior of alters) represent influences of which patients are not explicitly aware of.

In summary, studies on patients showed that it was possible to identify some determinants for health behavior using social network analysis. However, results for specific network characteristics were mixed, different when using patient-reported or network-reported data, and different for specific outcomes. This suggest that the impact of social networks on health behavior of patients is complex and also that additional research is needed to improve understanding of the role of the social networks on patients' outcomes.

**Primary care networks**

The study on information exchange of health professionals in primary care aimed to identify new perspectives for improving healthcare delivery and explored associations between information exchange networks of health care providers and evidence-based CVRM. Information exchange on medical policy for CVRM (‘general information networks’)
and CVRM for individual patients (‘specific information networks’) of health professionals from general practices were measured with personalized questionnaires. Hypothesized effects of five network characteristics (density, frequency of contact, attitudinal homogeneity, centrality of CVRM-coordinators, and presence of opinion leaders for CVRM) constructed on both general and specific information exchange networks were tested on delivery of evidence-based care for CVRM by practice nurses and patients’ clinical risk factors (SBP and LDL).

General practices which had an opinion leader for CVRM had enhanced odds for adequate performance of practice nurses. Low homogeneity on positive attitudes for achievement of treatment targets was related to reduced odds for achievement of SBP targets in patients. All together, we found no effects of network structure characteristics (density, frequency of contact, coordinator’ centrality), while effects of network members’ views (homogeneity of attitudes and presence of opinion leaders) were related to performance. These findings may indicate that in primary care for CVRM shared views, or its culture, may be more important than network structure. This is consistent with the notion that CVRM is a team effort. Previous studies noted teamwork as a prerequisite to improve patient care, although its effects were inconsistent 18,19. Reasons for non-significant results included the possible inappropriateness of aggregating individual measures 20. Our results show that teamwork may be more accurately represented using a social networks approach. However, type of culture may also be important. Although not considered in our study, other studies indicate that different types of culture may be related to change and to maintaining quality of care 21,22. Possible types include flexible and developmental culture, and more control oriented culture 21 respectively, of which future research is needed to address its influences on quality of care for CVRM.

The main conclusion of this study was that delivery of evidence-based health care is influenced by opinion leaders and homogeneity of views in primary care teams.

**Methodological considerations**

Several strengths as well as limitations of the studies presented in this thesis need to be considered. Strengths include the use of validated measures of health behavior and use of clinical indicators abstracted from medical records. Both patients and their alters were included in the research. Analyses were controlled for several factors including psychological factors in analyses of patients’ outcomes. Also, baseline network measures were used in analyses on follow-up and change in outcomes. Furthermore, both behavioral outcomes (health behavior of patients and professional performance of practice nurses) and clinical risk factors were considered in analyses of patients and health professionals.

Limitations include the longitudinal observational design of the studies and its relatively short follow-up, which warrant care for causal interpretations of our results. In several studies, risk for selection bias should be considered as we had a low response of both patients and alters. Possibly, specific patients and alters were more inclined to participate
in the research. For patients, those with networks consisting of mostly positive connections may have been more willing to participate than those with more negative connections. Also, patients without people they considered important for handling their disease, may have felt that the topic of the research was less or not applicable on them and may therefore have been less likely to participate. For alters, it may be that those who felt highly involved were more likely to participate. As such results should be generalized with care. Results also cannot be generalized to other patient groups and primary care teams than those for CVRM. Furthermore, we were unable to include health professionals in networks of patients, and wider connections from outside their practice in networks of health professionals. Also, networks of patients and health care providers were measured with questionnaires and interviews which were not validated, although measures of health care networks have shown to be feasible in previous research 23-25.

**Implications for practice and future research**

Studies from this thesis focused on identifying additional determinants for CVRM using a social networks approach. We found that specific network characteristics of patients and health care professionals can be important for improving CVRM. However, network influences, especially in the patients studies, were not always straightforward. Taken overall, quality of connections, rather than quantity of connections, seemed to have a more important role for managing health behaviors and delivery of CVRM care.

**Implications for practice**
The studies on patients showed that impact of networks differed across health behaviors and health outcomes, so that the overall picture from the research is complex. However, there may be several implications for practice. Care for chronic diseases has been subject to several changes in policy and practice. The ‘participatiemaatschappij’ (participation society), which has been promoted by policy makers 26, heavily emphasizes self-management of health and disease by individuals and the role of their social networks in supporting them. This provides social networks with an increasingly important role in provision of health care related support. Our studies showed that the vast part of patients had at least one significant other considered important for managing disease and found several influences of networks on patients’ health behaviors. As such our results confirm that social networks matter for patients and that networks can be important means to support them in managing their disease.

However, our results also show that it not only important to have a network but that other processes within networks can be important as well. Several network composition characteristics were related to patients’ health behaviors, which may indicate that not all patients have networks which are equally suitable for supporting them in handling their
disease. For example, patients without alters with overall healthful behaviors had decreased odds for healthful diet habits compared to patients who did have such alters in their networks. Also, odds for patient smoking were increased in networks which contained smoking alters. Our results implicate that when involving networks in health, policy makers may need to be aware that there are patients who have networks which are less capable for supporting their health, or which may even provide negative influences on patients’ health behaviors.

When designing policy for network involvement, it may be considered that it can be important to identify patients with a less potent network and that these patients may be in need of additional attention or support to achieve and maintain adequate management of their disease. Furthermore, such differences in suitability of networks for providing support can also be indicative for a need to focus attention on enhancing equipment of networks for taking care of patients. Possible strategies may include providing information, e.g. online or in courses, and which may include education on health or information on local amenities.

We found that most reported alters were family of patients. The important role of family in care giving is consistent with other reports, showing that family members are generally the first persons to provide support. Yet, family members are also most likely to take on the highest burden of support and may be prone to overload. Therefore, resilience of networks, and the risk of over demanding networks, may need to be considered as well. Efforts to ensure or enhance network resilience may be group-based, in which provision of education and information on health can be combined. Such group-gatherings may then not only provide people with opportunities for enhancing knowledge but also for connecting with individuals involved in similar situations. To enhance accessibility of such meetings, they may be provided in the local community, which provides municipalities with an important role.

Our results may implicate that it is also important for health care professionals to consider aspects of patients’ social networks when counseling on patients’ health behaviors. In accordance, other studies showed that social support was a factor which needed to be considered in counseling and supporting self-management in primary care. As such, health professionals may ask patients about people they consider important for handling their disease or encourage patients to bring these persons along to consultations. This may provide them with relevant information to understand patients’ current health behavior. For example, we found that smoking of patients and their alters was related. Such information may be relevant for health professionals to assess whether certain patients may be more likely to have difficulties to improve their health behaviors. Also, need for additional support may be indicated by this information to which treatment plans can be tailored. Additionally, involvement of alters in consultations may provide alters with additional knowledge and comprehension of patients’ situations which enhances their capacities to take care of patients.
Our finding that patients’ perception of their alters health-related behaviors does not necessarily comply with alter-reported behaviors may be particularly relevant when considering network influences and involvement of persons important to patients. Identified differences entailed that patients’ health behaviors were improved by alter-reported behaviors but not by patients’ perception of alters’ behaviors. This underlines the importance of retrieving information by alters themselves in addition to patients’ subjective evaluations of their network characteristics. However, it seems a challenge to implement the involvement of alters in settings in which care providers focus on the needs and preferences of individual patients, such as primary care.

In line with results on patients, we found influences of specific network characteristics for delivery of CVRM by health care professionals as well. Network culture was associated with indicators of quality of care while no effects of network structure were found. As such, our results indicate that interventions aimed at network structure may be of little benefit for improving delivery of care for CVRM in general practices, although future research is needed to confirm this conclusion. On the other hand, shared attitudes on treatment targets seem an important determinant which can be considered in future interventions in two ways. First, designs of interventions should consider attitudinal homogeneity in networks as possible facilitating or hindering factor of success of the program. Second, interventions may target particular attitudes and views. For instance, they may use group work to enhance the impact of continuing education.

**Implications for future research**

Our studies on patients provide a number of directions and suggestions for future research. For improving participation rates, offering choice of participation mode can be used. However, future research may also assess our recommendation of a refinement of this strategy. This refinement combines the provision of choice of participation mode and the usage of modes with likely high participation rates (such as interviews) in patients without preference for provided modes.

Research has paid increasing attention to associations between social networks and health. Our results confirm roles of social networks in health behaviors and provided several suggestions for future research. Although we confirmed hypothesized influences of specific network factors, other results of our studies indicated the possibility that other factors may be relevant as well. These include the possible role of selection of connections, which may explain our results on perception of networks which were contrary to our expectations. We found that patients were less likely to have healthful behaviors if they perceived their networks to contain alters with healthful behaviors. This provided input for the hypothesis that patients in need of support possibly select resilient connections (i.e. alters with healthful behaviors) as such individuals may likely be capable of providing them with assistance and help. Future research is needed to explore the role of selection,
as well as its relative importance compared to effects of contagion as considered in our studies. Also, further research is needed to verify whether contagion has specific effects on in different age groups and in healthy and patient populations. Additional studies are warranted to determine whether specific behaviors (e.g. physical activity) are more sensitive to effects of contagion than other behaviors. Furthermore, our results on social capital indicate the possible importance of negative interactions within networks.

Additional research is also warranted to replicate and understand different influences of patient-reported and alter-reported network characteristics. Overall, our results suggested that behavioral responses to the social context, rather than individual rational decision making, determined patients’ health behaviors. Future network studies may consider including patients’ personal and cognitive factors, and their possible interaction with network factors, to improve understanding of this relation. Also, identified differences between alter-reported and patient-reported networks suggest that measuring networks using only ego-data may lead to results which are not reflective of all possible network influences. Although including both patients and alters in research requires additional effort and resources, our results indicated that it is to be recommended for future studies to include both in the research. Furthermore, influences of connections with health professionals, as well as possible interactions between patients’ informal social networks and patients’ connections with health professionals, remain to be investigated.

Our hypotheses were based on a number of theorized underlying mechanisms of social networks, e.g. social contagion and its underlying social influence processes, and social capital. However, the longitudinal observational design of our studies included a relatively short follow-up period so that care is warranted when drawing causal inferences. Also, most previous network studies used only observational designs. Therefore, to enhance understanding of which causal mechanisms are relevant and under which circumstances, future studies should use longitudinal designs with longer follow-up periods as these are more equipped for disentangling effects of network composition and change in networks. Longitudinal studies using measurements at multiple time points would also be suitable for capturing possible dynamics of connections in networks.

Our studies also provide several suggestions for future research on social networks of health care professionals. Future research should focus on determining shared attitudes and beliefs in primary care networks and ways to address these, for example, by providing information and education. While strategies to target particular attitudes of individual health care professionals are available, it is likely that particular approaches are needed to change and maintain particular attitudes within a given social network. Such approaches may include interactive learning processes such as for example relational coordination and reciprocal learning, which have been associated with quality of care and patients outcomes in settings requiring efficient team work 30. Future studies may also consider
identification of different types of culture, e.g. flexible and control oriented types, and its possible different effects on achieving change in care and in maintaining quality of care.

Presence of opinion leaders in primary care practices was positively related to delivery of CVRM and future studies may use these persons as conduits for disseminating new knowledge or as providers of assistance for adhering to guidelines for providing optimal care. However, additional research on opinion leaders is needed as previous research indicated great variety in the identification, presence and stability, and effectiveness of opinion leaders in health care settings. Therefore, future studies are warranted on specific roles and influences of opinion leaders in primary care for CVRM to inform future interventions on optimal strategies for using these persons to further improve CVRM care.

Although we found no effects of network structure, future research on structural characteristics of networks is needed. The lack of effects of network structure on delivery of CVRM care in our study was dissimilar to previous studies on diffusion of information and collaboration between health care professionals, and may be the result of our focus on information which had been widely implemented in current care. Also, many information sources on CVRM are nowadays readily available, e.g. on the Internet. Therefore, future studies are needed to determine effects of network structure when implementing new knowledge and practices. Furthermore, future studies will need to determine effects of connections outside primary care practices.

Conclusion

In sum, this thesis aimed to identify additional determinants for improving CVRM using a social networks approach. We found that aspects of social networks were related to patients’ health behavior and to delivery of CVRM care by health care professionals. Our results on patients provide some practical implications and multiple suggestions for future research. More clean-cut results were found for health care professionals, with two potential determinants for CVRM identified. Although additional research is needed on several accounts as well, results on homogeneity may be used in new efforts targeting quality of primary care for CVRM.
References


Appendix
Appendix A1:  
Basic network questions for patients

Please note that we use the term ‘condition’ in questions for patients with a high risk for CVD and ‘disease’ for patients with established CVD.

Information regarding your condition or disease

We would like to ask you which persons gave you information regarding (a high risk for) cardiovascular disease.

1. Who gave you information about your condition or disease and its treatment?

Please think about information of the treatment of your condition/disease, e.g. which medication you need, symptoms and risk factors of this condition/disease, and information about diet and physical activity. Multiple answers are possible.

- General practitioner
- Nurse or practice nurse from your general practice
- Home care employee
- Spouse
- Son
- Daughter
- Friend
- Neighbor
- Acquaintance

Someone else, namely: ..........................................................

2. Who gave you information about handling your condition or disease?

Please think about information on e.g. handling concerns or problems you have because of your condition/disease, or about finding someone to talk about these. Multiple answers are possible.

- General practitioner
- Nurse or practice nurse from your general practice
- Home care employee
- Spouse
- Son
- Daughter
- Friend
- Neighbor
- Acquaintance

Someone else, namely: ..........................................................
3. **Who gave you information about practical help for your condition or disease**

Please think about information regarding, for example, doing groceries or small tasks in and around your home, e.g. provided by volunteers, welfare workers, home care, or domestic help. *Multiple answers are possible.*

- General practitioner
- Nurse/practice nurse from your general practice
- Home care employee
- Spouse
- Son
- Daughter
- Friend
- Neighbor
- Acquaintance

Someone else, namely: ………………………………………………

156
Appendix A2:
Network questionnaire for health care professionals

Questionnaire for health professionals

Information networks
1. We are interested in professional contacts between health care providers who are involved in cardiovascular risk management (CVRM). Please indicate in the scheme below to whom you have **given information** or from whom you have **receive information** in the past 12 months regarding:

1) Medical policy for CVRM in general, including special groups, such as patients of 80 years and older or with co-morbidity.
2) CVRM for a specific patient, e.g. when treatment is ineffective

→ We also would like to ask you to indicate how often you’ve had contact for sharing information.
Please fill in a 1 for ‘daily or weekly’ and 2 for ‘monthly or yearly’

→ We’ve already filled out names for persons from your general practice. Would you please fill out names for other persons you have shared information with?

<table>
<thead>
<tr>
<th>1. CVRM medical policy</th>
<th>How often contact for sharing information?</th>
<th>2. CVRM for a specific patient</th>
<th>How often contact for sharing information?</th>
</tr>
</thead>
<tbody>
<tr>
<td>I gave information or received information from:</td>
<td>I gave to:</td>
<td>1= daily or weekly</td>
<td>2=monthly or yearly</td>
</tr>
</tbody>
</table>

**Persons within your general practice (names are listed for each general practice):**
- General practitioner
- General practitioner 2
- General practitioner 3
- Practice nurse 1
- Practice nurse 2
- Practice nurse 3
- Practice assistant 1
- Practice assistant 2
- Practice assistant 3

**Other professionals if applicable**

---

158
1. CVRM medical policy

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>How often contact for sharing information?</th>
<th></th>
<th></th>
<th>How often contact for sharing information?</th>
</tr>
</thead>
<tbody>
<tr>
<td>I gave information or received information from:</td>
<td>I gave to:</td>
<td>I received from:</td>
<td>1 = daily or weekly</td>
<td>2 = monthly or yearly</td>
<td>I gave to:</td>
</tr>
</tbody>
</table>

**Persons outside your general practice:**
- Other general practitioners
- Other practice nurses
- Other practice assistants
- Dietician
- Physical therapist
- Psychologist
- Cardiologist
- Pharmacist
- Other, please specify

1b. In order to optimize knowledge on information flows of CVRM, we would ask persons from outside your general practice some questions as well. Therefore, we ask you to provide contact details (address, telephone number, or an e-mail address) of these persons. We emphasize that this information will be treated confidentially.

If you prefer not to provide contact details, please skip this question.

Contact details:
2. Who is responsible for coordination of CVRM in your practice?

2b. We also would like to ask some questions to this person(s). Therefore, we ask you to provide contact details (address, telephone number, or an e-mail address) of these persons. We emphasize that this information will be treated confidentially.

If you prefer not to provide contact details, please skip this question.

Contact details:

3. Can you name one person (not an organization) who you consider to have a significant influence on your current practice in CVRM? This person can be anyone from inside or outside your general practice, and the influence this person has had can be either current or from the past.

Please also provide a name an function.

Name:

Function:

3b. We also would like to ask some questions to this person. Therefore, we ask you to provide contact details (address, telephone number, or an e-mail address) of this person. We emphasize that this information will be treated confidentially.

If you prefer not to provide contact details, please skip this question.
4. We are interested in your opinion regarding recommendations for treatment of older patients (80 years and older) who receive care according to the CVRM guideline, and who have a limited life expectancy (less than 5 years). Would you please indicate how important you consider:
- A change towards the treatment target, e.g. some reduction in blood pressure even though the treatment target has not been achieved
- Achieving the treatment target

Encircle a number:
1 = very unimportant, 2 = unimportant, 3 = neutral, 4 = important, 5 = very important.

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Importance of change towards treatment target (1-5)</th>
<th>Importance of achieving treatment target (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Aim at SBP &lt; 140 mm Hg in patients with a 10 years risk of cardiovascular mortality or morbidity ≥ 20%</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2 Aim at SBP &lt; 140 mm Hg for patients with CVD</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3 Aim at LDL cholesterol &lt; 2.5 mmol/l in patients with a 10 years risk of cardiovascular mortality or morbidity ≥ 20%</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>4 Aim at LDL cholesterol &lt; 2.5 mmol/l for patients with CVD</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>5 Provide lifestyle advice for modifiable risk factors</td>
<td>n.a.</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

The End
Appendix A3: Network questionnaire for alters of health care professionals

Information networks

Questionnaire for health professionals
**General information**

1. What is your date of birth?  
   -  

2. You are?  
   - Female  
   - Man  

3. What is your occupation?  

4. How long have you been active in this profession?  
   -  

5. How long have you been working for the organisation you’re currently working for?  
   -  

---

164
1. We are interested in professional contacts between health care providers who are involved in cardiovascular risk management (CVRM). Please indicate in the scheme below to whom you have **given information** or from whom you have **receive information** in the past 12 months regarding:

1) Medical policy for CVRM in general, including special groups, such as patients of 80 years and older or with co-morbidity.
2) CVRM for a specific patient, e.g. when treatment is ineffective

→ We also would like to ask you to indicate how often you’ve had contact for sharing information.

Please fill in a 1 for ‘daily or weekly’ and 2 for ‘monthly or yearly’

→ We’ve already filled out names for persons from your general practice. Would you please fill out names for other persons you have shared information with?

<table>
<thead>
<tr>
<th>1. Medical policy CVRM</th>
<th>2. CVRM For a specific patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often contact for sharing information?</td>
<td>How often contact for sharing information?</td>
</tr>
<tr>
<td>I gave information or received information from:</td>
<td>I gave to:</td>
</tr>
</tbody>
</table>
+-------------------------+-------------------------+-------------------------|
| I gave to: | I received from: | 1 = daily or weekly | 2 = monthly or yearly |
| GP1 | Names | | |
| GP2 | | | |
| GP3 | | | |
| PN1 | | | |
| PN2 | | | |
| PN3 | | | |
| PA1 | | | |
| PA2 | | | |
| PA3 | | | |
| Persons outside a general practice: | | | |
| Other GPs | Names | | |
| Other PNs | | | |
| Other PAs | | | |
| Dietician | | | |
| Physical therapist | | | |
| Psychologist | | | |
| Cardiologist | | | |
| Others, please specify: | | | |

---

165
1b. In order to optimize knowledge on information flows of CVRM, we would to ask you share information with some questions as well. Therefore, we ask you to provide contact details (address, telephone number, or an e-mail address) of these persons. We emphasize that this information will be treated confidentially.

If you prefer not to provide contact details, please skip this question.

Contact details:

---

2. Is someone responsible for coordination of CVRM in your organization? If yes, who is this person?

---

2b. We also would like to ask some questions to this person(s). Therefore, we ask you to provide contact details (address, telephone number, or an e-mail address) of these persons. We emphasize that this information will be treated confidentially.

If you prefer not to provide contact details, please skip this question.

Contact details:

---

3. Can you name one person (not an organization) who you consider to have a significant influence on your current practice in CVRM? This person can be anyone from inside or outside your organization, and the influence this person has had can be either current or from the past.

Please also provide a name an function.

<table>
<thead>
<tr>
<th>Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function:</td>
</tr>
</tbody>
</table>
If you prefer not to provide contact details, please skip this question.

Contact details:

4. We are interested in your opinion regarding recommendations for treatment of older patients (80 years and older) who receive care according to the CVRM guideline, and who have a limited life expectancy (less than 5 years). Would you please indicate how important you consider:
   - A change towards the treatment target, e.g. some reduction in blood pressure even though the treatment target has not been achieved
   - Achieving the treatment target

Encircle a number:
1 = very unimportant, 2 = unimportant, 3 = neutral, 4 = important, 5 = very important.

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Importance of change towards treatment target (1-5)</th>
<th>Importance of achieving treatment target (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Aim at SBP &lt; 140 mm Hg in patients with a 10 years risk of cardiovascular mortality or morbidity ≥ 20%</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2 Aim at SBP &lt; 140 mm Hg for patients with CVD</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3 Aim at LDL cholesterol &lt; 2.5 mmol/l in patients with a 10 years risk of cardiovascular mortality or morbidity ≥ 20%</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>4 Aim at LDL cholesterol &lt; 2.5 mmol/l for patients with CVD</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>5 Provide lifestyle advice for modifiable risk factors</td>
<td>n.a.</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

The End
Appendix A4:
Network questionnaire for patients

Questionnaire for patients (at risk for) cardiovascular disease

Living together with cardiovascular disease
Additional information

Please note that the original version of this questionnaire is in Dutch and intended to be used for participants who speak Dutch.

For patients at risk for CVD, we use the terms 'at risk for CVD' and 'condition' where appropriate.
For patients with established CVD, we use the term 'CVD' and 'disease' where appropriate.
Information about (high risk for) cardiovascular disease

1a. This question is about which persons gave you information about (high risk for) cardiovascular disease.
   Please indicate which persons gave you information in the past 12 months on the following subjects:

1) (High risk for) Cardiovascular disease and treatment
   Here you can think about information about what your (high risk for) cardiovascular disease exactly is about, treatment of your condition/disease, and information about lifestyle. E.g. which medication you need or about other important lifestyle matters such as smoking, diet, and physical activity.

2) Handling your condition or disease
   Here you can think about information when you’re feeling worried, about handling concerns or problems you have because of your condition/disease or its treatment. Or information about finding someone to talk about this.

3) Practical help
   Here you can think about information regarding, for example, help for doing groceries, or for doing small tasks in and around your home, for example provided by volunteers, welfare workers, home care or domestic help.

Please do this for each person by:
   - ticking the box in the column “no contact”, if you have not been in contact with this person in the past 12 months.
   - Filling out a number for how often this person gave you information on subject 1, 2, or 3 in the past 12 months.

We’ve filled out names for health care providers from your general practice. Other names do not need to be filled out. However, if you have received information from health care providers who are not already listed, please indicate the type of health care providers who have provided information to you.

Example:
If you haven’t been in contact with your general practitioner and your practice nurse provided you in the past 12 months:
   4 times with information on subject 1 ‘CVD & Treatment’
   1 time with information on subject 2 ‘Handling your condition/disease’
   no information on subject 3 ‘Practical help’
You can indicate this as follows:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not been in contact</td>
<td>How often?</td>
<td>How often?</td>
<td>How often?</td>
</tr>
<tr>
<td>General practitioner H. Aarts</td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practice nurse P. Steun</td>
<td></td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
## Information about CVD

<table>
<thead>
<tr>
<th>Persons from your general practice &amp; hospital</th>
<th>Information in past year about:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. CVD &amp; treatment</td>
</tr>
<tr>
<td>General practitioner  <em>Names are prelisted</em></td>
<td>Not been in contact</td>
</tr>
<tr>
<td>Practice nurse</td>
<td></td>
</tr>
<tr>
<td>Practice assistant</td>
<td></td>
</tr>
<tr>
<td>Practice assistant</td>
<td></td>
</tr>
<tr>
<td>Dietician</td>
<td></td>
</tr>
<tr>
<td>Physical therapist</td>
<td></td>
</tr>
<tr>
<td>Cardiologist</td>
<td></td>
</tr>
<tr>
<td>Pharmacist</td>
<td></td>
</tr>
<tr>
<td>Psychologist</td>
<td></td>
</tr>
<tr>
<td>Home care</td>
<td></td>
</tr>
<tr>
<td>Social worker</td>
<td></td>
</tr>
<tr>
<td>Lifestyle coach</td>
<td></td>
</tr>
<tr>
<td>Others, please specify:</td>
<td></td>
</tr>
</tbody>
</table>

1B. Who do you consider to be the central care provider for treatment of your disease? This is the first person you would approach in case of uncertainties or troubles regarding your condition/disease.
### Information about CVD

1C. Please indicate who gave you information, and how often, on:
1) (high risk for) CVD & treatments, 2) handling your disease, 3) practical help.
This question concerns which persons from your personal environment gave you information.

**Please do this for each subject by filling out a:**
1 = when this person gave you information on a daily/weekly basis
2 = when this persons gave you information on a monthly/yearly basis
When you did not receive information, please leave the boxes empty.

We would like to ask you which persons this concerns for each category. Please specify this in a way which feels comfortable for you. For example, if you would like to specify in the category 'Family' that you have received information from one of your children, you can write down that this concerned information provided by your 'son' or 'daughter'.

<table>
<thead>
<tr>
<th>Persons from personal environment</th>
<th>Type of person</th>
<th>Information about:</th>
<th>1 = daily or weekly, 2 = monthly or yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner</td>
<td></td>
<td>1. CVD &amp; Treatment</td>
<td>1</td>
</tr>
<tr>
<td>Family 1</td>
<td></td>
<td>2. Handling your disease</td>
<td>1</td>
</tr>
<tr>
<td>Family 2</td>
<td></td>
<td>3. Practical help</td>
<td>1</td>
</tr>
<tr>
<td>Family 3</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Friend 1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Friend 2</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Friend 3</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Acquaintance 1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Acquaintance 2</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Acquaintance 3</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Others, please specify:</td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

1D. How many of these people hold a job in health care or have been educated to do so?
For example a physician, nurse, practice nurse, or practice assistant? Fill out the number in the box:
Important others

2A. Can you name one person who is most important to you for handling your disease or lifestyle?

This person does not need to be important for any specific reason, does not need to be mentioned in question 1, and does not need to be part of your personal environment.

2B. We would like to ask some questions about this person:

a. Is this person:
   - Man
   - Female

b. How old is he/she (approximately)?
   - years

c. How long do you know each other?
   - years

d. Are you...
   - Family
   - Friends
   - Acquaintances
   - Others, namely

e. Do you think he/she smokes?
   - Yes
   - No

f. Do you think he/she holds a healthy diet?
   - Yes
   - No

g. Do you think he/she has enough physical exercise?
   - Yes
   - No

h. What kind of occupation does he/she have?

i. Did you mention this person in question 1c about persons from your personal environment who provide you with information?
   - Yes
   - No
Appendix

3A. Are there other persons who you consider to be important for handling your disease or life style?

These persons do not need to be important for a specific reason. These persons do not need to be mentioned in previous questions. However, the persons you name here should be part of your personal environment.

You are allowed to name up to three persons.

**Person 1:**

**Person 2:**

**Person 3:**

3B. The next question are about the persons you named in question 3A:

**PERSON 1:**

a. Is this person:  
   - □ Man  
   - □ Female

b. How old is he/she (approximately)?  

   □ □ years

c. How long do you know each other?  

   □ □ years

d. Are you ...  
   - □ Family  
   - □ Friends  
   - □ Acquaintances  
   - □ Others, namely

   □ □

e. Do you think he/she smokes?  
   - □ Yes  
   - □ No

f. Do you think he/she holds a healthy diet?  
   - □ Yes  
   - □ No
## Important others

- **g.** Do you think he/she has enough physical exercise?
  - □ Yes
  - □ No

- **h.** What kind of occupation does he/she have?

- **i.** Did you mention this person in question 1c about persons from your personal environment who provide you with information?
  - □ Yes
  - □ No

### PERSON 2:

- **a.** Is this person:
  - □ Man
  - □ Female

- **b.** How old is he/she (approximately)?
  - ________ years

- **c.** How long do you know each other?
  - ________ years

- **d.** Are you ...
  - □ Family
  - □ Friends
  - □ Acquaintances
  - □ Others, namely

- **e.** Do you think he/she smokes?
  - □ Yes
  - □ No

- **f.** Do you think he/she holds a healthy diet?
  - □ Yes
  - □ No

- **g.** Do you think he/she has enough physical exercise?
  - □ Yes
  - □ No

- **h.** What kind of occupation does he/she have?

- **i.** Did you mention this person in question 1c about persons from your personal environment who provide you with information?
  - □ Yes
  - □ No
Important others

PERSON 3:

a. Is this person:  
☐ Man  
☐ Female

b. How old is he/she (approximately)?  

years

c. How long do you know each other?  

years

d. Are you ...  
☐ Family  
☐ Friends  
☐ Acquaintances  
☐ Others, namely

☐ Yes  
☐ No

f. Do you think he/she holds a healthy diet?  

☐ Yes  
☐ No

g. Do you think he/she has enough physical exercise?  

☐ Yes  
☐ No

h. What kind of occupation does he/she have?

i. Did you mention this person in question 1c about persons from your personal environment who provide you with information?  

☐ Yes  
☐ No

4. How many of the persons you consider to be important for handling CVD and who you have mentioned in questions 2 and 3 know each other?
Important others

5. We would like to ask some questions to the persons who you consider important for handling your disease or lifestyle.

On this page, information and instructions are provided about our request on spreading questionnaires to alters of patients.

This is the end of this questionnaire

Thank you so much for your participation!
Appendix A5:
Network roster for alters of patients

Sharing information about (high risk for) CVD

1a. This question is about which persons you gave information about (high risk for) cardiovascular disease.
Please indicate which persons you gave information to in the past 12 months on the following subjects:

1) (High risk for) Cardiovascular disease and treatment
Here you can think about information about what (high risk for) cardiovascular disease exactly is about, treatment of this condition/disease, and information about lifestyle. E.g. what is a high blood pressure? Or about other important lifestyle matters such as smoking, diet, and physical activity.

2) Handling condition or disease
Here you can think about information when someone feels worried, about handling concerns or problems someone has because of his/her condition/disease or its treatment. Or information about finding someone to talk about this.

3) Practical help
Here you can think about information regarding, for example, help for doing groceries, or for doing small tasks in and around home, for example provided by volunteers, welfare workers, home care or domestic help.

⇒ Please do this for each subject by filling out a:
0 = when you did not give information
1 = when you gave a person information on a daily/weekly basis
2 = when you gave a person information a monthly/yearly basis

Example:
If you gave your acquaintance:
About 1 "Disease&treatment" no information
About 2 "Handling condition or disease" monthly or yearly information
About 3 "Practical help" daily or weekly information
you can indicate this as follows:

<table>
<thead>
<tr>
<th>Person/name</th>
<th>Information about:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 = not, 1 = daily or weekly, 2 = monthly or yearly:</td>
</tr>
<tr>
<td></td>
<td>Disease &amp; treatment</td>
</tr>
<tr>
<td>Acquaintance</td>
<td>J. Janssen</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquaintance</td>
<td>J. Janssen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sharing information about (high risk for) CVD

Per group (family, friends, and acquaintances), you are allowed to specify up to three persons.

Please indicate which type of persons these concern in a way which feels comfortable to you. For example, you can write down:

- a description, e.g. your ‘mother’ or ‘best friend’
- Names or initials

<table>
<thead>
<tr>
<th></th>
<th>Description or name</th>
<th>1. Disease or condition &amp; treatment</th>
<th>2. Handling condition or disease</th>
<th>3. Practical help</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0 = not, 1 = daily or weekly, 2 = monthly or yearly</td>
<td>0 1 2</td>
<td>0 1 2</td>
<td>0 1 2</td>
</tr>
<tr>
<td>Partner</td>
<td></td>
<td>☐ ☐ ☐</td>
<td>☐ ☐ ☐</td>
<td>☐ ☐ ☐</td>
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<tr>
<td>Family 1</td>
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<td>☐ ☐ ☐</td>
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<tr>
<td>Family 2</td>
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<td>☐ ☐ ☐</td>
<td>☐ ☐ ☐</td>
<td>☐ ☐ ☐</td>
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<tr>
<td>Family 3</td>
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<td>Friend 1</td>
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<tr>
<td>Friend 2</td>
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<td>☐ ☐ ☐</td>
<td>☐ ☐ ☐</td>
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<tr>
<td>Friend 3</td>
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<td>☐ ☐ ☐</td>
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<td>☐ ☐ ☐</td>
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<tr>
<td>Acquaintance 3</td>
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<td>☐ ☐ ☐</td>
<td>☐ ☐ ☐</td>
<td>☐ ☐ ☐</td>
</tr>
<tr>
<td>Others, namely:</td>
<td></td>
<td>☐ ☐ ☐</td>
<td>☐ ☐ ☐</td>
<td>☐ ☐ ☐</td>
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<td>PATIENT CHARACTERISTICS</td>
<td>SBP</td>
<td>LDL</td>
<td>BMI</td>
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<tr>
<td>-------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td>95%CI</td>
<td>n</td>
<td>OR</td>
</tr>
<tr>
<td>Age</td>
<td>1.06***</td>
<td>1.03</td>
<td>1.08</td>
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<td>1.71</td>
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<td></td>
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<td></td>
<td>Low</td>
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<td>Relation</td>
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<td>Employed</td>
<td>0.44**</td>
<td>0.26</td>
<td>0.74</td>
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<td></td>
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<td>1.75</td>
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<td>CVD</td>
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<td>MMAS</td>
<td>1.02</td>
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<td>PHQ</td>
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<td>0.66</td>
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<td>1.34</td>
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*Total scores of the PAM, MMAS, and PHQ-9 were entered in analyses to assess influences of patient activation, medication adherence, and depressive symptoms respectively.
### NETWORK COMPOSITION

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<th>Presence of alter(s) with/who are:</th>
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<th>OR (95% CI)</th>
<th>n</th>
<th>OR (95% CI)</th>
<th>n</th>
<th>OR (95% CI)</th>
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<td>150</td>
<td>0.36</td>
<td>100</td>
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<td>71</td>
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<tr>
<td>Overall healthful behavior</td>
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<tr>
<td>Without depressive symptoms</td>
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<td></td>
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<tr>
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<td>0.63</td>
<td>155</td>
<td>0.05</td>
<td>2.96</td>
<td>102</td>
<td>0.64</td>
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<tr>
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<td>75</td>
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<td>3.63</td>
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</tbody>
</table>

*total scores of the PAM, MMAS, and PHQ-9 were entered in analyses to assess influences of patient activation, medication adherence, and depressive symptoms respectively.*
### APPENDIX B2: Bivariate estimates of negative social network composition and clinical risk factors

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<thead>
<tr>
<th></th>
<th>SBP Bivariate</th>
<th>LDL Bivariate</th>
<th>BMI Bivariate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR 95% CI n</td>
<td>OR 95% CI n</td>
<td>OR 95% CI n</td>
</tr>
<tr>
<td>Physically inactive alter(s)</td>
<td>1.09 0.60 2.03 150</td>
<td>1.11 0.53 2.37 100</td>
<td>1.61 0.66 3.93 71</td>
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<tr>
<td>Alter(s) with unhealthful diet</td>
<td><strong>2.21</strong> 1.16 4.21 156</td>
<td>1.19 0.50 2.85 103</td>
<td>1.56 0.41 5.91 74</td>
</tr>
<tr>
<td>Smoking alter(s)</td>
<td>0.82 0.36 1.87 157</td>
<td>1.54 0.37 6.37 105</td>
<td>0.32 0.07 1.5 74</td>
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<tr>
<td>Alter(s) with overall unhealthful behavior</td>
<td>1.07 0.52 2.17 154</td>
<td>1.29 0.58 2.83 103</td>
<td>1.81 0.62 5.3 73</td>
</tr>
<tr>
<td>Alter(s) with depressive symptoms</td>
<td>1.24 0.62 2.50 155</td>
<td>1.55 0.46 5.23 102</td>
<td>1.97 0.65 5.97 74</td>
</tr>
<tr>
<td>Alter(s) without specialized knowledge</td>
<td>1.37 0.51 3.17 75</td>
<td>0.87 0.15 4.96 53</td>
<td>1.00 0.12 8.12 35</td>
</tr>
</tbody>
</table>
APPENDIX B3 Deviations from the study protocol

This study has an associated study protocol (see also Chapter 2), of which we needed to make some deviations in the statistical analyses.

First, hypotheses were tested in a different form than stated in the protocol. Instead of testing that ‘a high number of alters’ with certain behaviors were related to patient’s health behavior and health status, we tested the influence of ‘the presence of alters’ with certain behaviors. ‘A high number of alters’ was originally formulated as the count of the number of alters with certain behaviors. As few alters had more than one alter with behaviors of interest, variables became too skewed to be entered into the analyses. Therefore, variables were dichotomized, contrasting having one or more alters with specific behaviors versus not having alters with specific behaviors in patients’ social networks. Concomitant with the alternative construction of network variables a shift in phrasing of hypotheses to ‘presence of alters with certain behaviors’ was made.

Second, we did not test the hypothesis that ‘alters with particular behaviors who are also connected among each other’ would be positively related to patient’s health behaviors and health status. Interconnectedness of alters was measured. However, data showed that almost all alters were connected among each other, thus leaving this variable with too little variation to be used in the analyses. Considering that most reported alters were family of patients, it is not surprising that interconnectedness was high.

Third, in the study protocol we noted that we would use risk score as outcome for high risk patients. This outcome was omitted from the research as we were unable to collect sufficient data for calculating risk scores. Instead of risk score, body mass index was used as outcome for both high risk patients and patients with established CVD.
Summary
Summary

Chapter 1
In the first chapter we introduce the topics of this thesis. The studies aimed to identify additional determinants for cardiovascular risk management (CVRM) using a social networks approach. We considered patients with high risk for cardiovascular disease (CVD), with established CVD, people that patients regarded important for handling their disease (alters), and health care professionals from general practices.

Chapter 2
Chapter 2 provides the study protocol of the studies in this thesis. It describes the network studies on patients and health care professionals which aimed to identify additional determinants for CVRM by examining roles of social networks of patients and health care providers in outcomes and quality of CVRM. Also, a description for a randomized controlled trial (RCT) aiming to enhance participation rates of patients is included in the study protocol.

Studies on both patients and health care providers had longitudinal observational designs. Data on social networks were to be collected with personalized questionnaires and telephone interviews. It was planned to include approximately 900 patients with high risk or with CVD and their alters, and 300 health professionals from 30 general practices as well as their connections outside practices. Patients participated in the studies either by questionnaires or in interviews, health care professionals participated by questionnaires.

Patients outcomes consisted of health behaviors (diet, physical activity, and smoking) and clinical risk factors (systolic blood pressure, cholesterol, and risk score). Quality of CVRM was to be indicated by professional performance of practice nurses and patients clinical risk factors. Patients health behaviors were to be measured with postal questionnaires whereas medical record auditing was planned for collecting data on clinical risk factors and professional performance of practice nurses.

Chapter 3
In chapter 3 results were presented of two randomized controlled trials which aimed to improve participation rates of patients by providing choice of participation mode. Although previous suggested that offering choice of mode can improve participation rates, only few head-to-head trials have compared choice of participation mode using telephone interviews and postal questionnaires as modes of interest.

Two trials were embedded in a larger study on CVRM in primary care. Patients with CVD and high risk for CVD recruited for the larger study were invited to participate in an additional survey on social networks, using invitations with and without choice of participation mode. Primary outcome was participation rate. Other outcomes of interest were participation rate conditional on willingness to participate, and initial willingness to participate. In trial 1 we compared outcomes after choice of participation mode (interview
or questionnaire) with invitations for participation in a telephone interview. In Trial 2 results for choice of participation mode were compared with postal questionnaires.

In Trial 1 no differences were found in participation rates (65% vs 66%, \( p = 0.853 \)) although conditional participation rate was highest for interviews (90% vs 72%, \( p < .01 \)). Initial willingness to participate was higher when choice of participation mode was provided (90% versus 73%, \( p < .01 \)). In Trial 2 participation rate and conditional participation rate was higher when choice of participation mode was provided (59% vs 46%, \( p < .01 \) and 66% vs 53%, \( p < .01 \), respectively). No differences were found for initial willingness to participate (90% vs 86%, \( p = 0.146 \)).

It was concluded that offering choice of participation mode had benefit on participation rates compared to invitations to participate in questionnaires, but not when compared to invitations to participate in telephone interviews.

**Chapter 4**

In chapter 4 results were presented from a longitudinal observational study which aimed to explore linkages of patients’ social network composition with health behaviors and clinical risk factors.

This study was embedded in a project aimed at improving CRVM in primary care. 657 vascular patients (227 with cardiovascular disease, 380 at high vascular risk), mean age 72.4 (SD 9.4) years, were recruited as well as individuals patients considered important for dealing with their disease, so called alters (n=487). Network composition was measured with structured patient questionnaires. Patient and alter questionnaire data were used to measure health behavior (physical activity, diet, and smoking). Clinical risk factors (systolic blood pressure, LDL cholesterol level, and body mass index) were extracted from patients’ medical records. Six logistic regression analyses, using generalized equation estimations, were used to test three hypothesized effects of network composition (having alters with healthful behaviors, without depression, and with specialized knowledge) on six outcomes, adjusted for demographic, personal and psychological characteristics.

We found that having alters with overall healthful behavior was related to healthful patient diet (OR 2.14, 95%CI: 1.52-3.02). Having non-smoking alters in networks was related to reduced odds for patient smoking (OR 0.17, 95%CI: 0.05-0.60). No effects of presence of non-depressed alters were found. Presence of alters with specialized knowledge on CVRM was negatively related to healthful diet habits of patients (OR 0.47, 95%CI 0.24-0.89).

Taken together, diet and smoking, but not physical exercise and clinical risk factors, were associated with social network composition of patients with vascular conditions. In this study of vascular patients, controlling for both personal and psychological factors, fewer network influences were found compared to previous research. Further research is needed to examine network structure characteristics as well as the role of psychological factors to enhance understanding health behavior of patients involved in CVRM.
Chapter 5

In chapter 5 results were presented of a longitudinal observational study which explored associations of social network characteristics of cardiac patients with current and changed diet and physical activity, using data of both patients and individuals who patients considered important for managing their disease (alters). This provided the opportunity for comparing effects of patient-reported and alter-reported network characteristics.

The study included 189 patients (81 with cardiovascular disease, 108 at high vascular risk) and 175 alters. Networks were measured in structured telephone interviews. Questionnaires were used to measure patients' and alters' health behaviors. Patients' health behavior was measured at time of interviews and at 6 months follow-up. Multivariate linear regression analyses, using generalized equation estimations, were used to test three hypothesized effects of networks (having a high number of alters with: healthful behaviors, depression, and specialized knowledge) on current diet and physical activity. Ordinal and logistic regression analyses were used to assess changes in diet and physical activity.

We found positive effects on diet for alter-reported number of alters with healthful diet (b 2.45, p<.05), healthful physical activity (b 2.35, p<.05), and specialized knowledge (b 3.40, p<.05). Negative effects were found of patient-reported number of alters with healthful physical activity (b -2.46, p<.05) and overall healthful behavior (b -2.42, p<.05). For change in diet, similar patterns were found for alter-reported network characteristics while patient-reported characteristics had no effects.

For physical activity we found no effects of alter-reported network characteristics. Negative effects were found of patient-reported network size (b -1.24, p<05), number of alters with overall healthful behavior (b -1.19, p<05), and alters with CVRM knowledge (b -0.89, p<05) on current physical activity. However, number of alters with healthful diet (OR 7.92, p<05) and healthful physical activity (OR 9.85, p<.05) were related to improvement in physical activity.

Overall, network effects differed between diet and physical exercise, current and changed behaviors, and between patient- and alter-reported networks. Our results may suggest that health behaviors are influenced more by actual, rather than by perception of, behaviors of individuals in networks.

Chapter 6

In chapter 6 results were presented of a longitudinal observational study in which we aimed to identify new perspectives for improving healthcare delivery and explored associations between information exchange networks of health care providers and evidence-based CVRM.

The study was performed parallel to a RCT which aimed to improve professional performance of practice nurses in the Netherlands. Information exchange on medical policy for CVRM (‘general information networks’) and CVRM for individual patients (‘specific information networks’) of 180 health professionals in 31 primary care practices
were measured with personalized questionnaires. Medical record audit was performed concerning 1620 patients in these practices to document quality of care delivery and two risk factors (systolic blood pressure (SBP) and LDL cholesterol level). Hypothesized effects of five network characteristics (density, frequency of contact, homogeneity on positive attitudes for treatment target achievement, centrality of CVRM-coordinators, and presence of opinion leaders for CVRM) constructed on both general and specific information exchange networks were tested and controlled for practice and patient factors using logistic multilevel analyses.

We found that general practices who had an opinion leader for CVRM had enhanced odds for adequate performance of practice nurses (OR 2.75, p<.05). Low homogeneity on positive attitudes for SBD and LDL targets in both general and specific information networks was linked to reduced odds for favorable SBP outcomes (SBP OR 0.57, p<.05 and OR 0.60, p<.05, LDL OR 0.59, p<.05 and OR 0.61, p <.05 in general and specific networks respectively). No effects of network characteristics on cholesterol were found.

It was concluded that delivery of evidence-based CVRM is associated with opinion leaders and homogeneity of clinical attitudes in primary care teams.

Chapter 7
The general discussion of this thesis is provided in chapter 7. We start with the summary and discussion the main findings of the studies from this thesis. After this, we consider methodological strengths and weaknesses of the studies. Finally, implications of the studies are discussed.

Overall, we found that specific network characteristics of patients and health care professionals can be important for improving CVRM. However, network influences, especially in the patients studies, were not always straightforward. Taken overall, quality of connections, rather than quantity of connections, seemed to have a more important role for managing health behaviors and delivery of CVRM care.

Our results on patients provide some practical implications. The confirmation of the importance of social networks for supporting management of disease is particularly important given recent changes in care for chronic diseases and the concomitant emphasis on self-management of patients and the role of networks in supporting them. However, our results also show that not all patients have networks which are equally suitable for providing such support. This may need to be considered when designing policy for network involvement, or in providing counseling on patients’ health behaviors. Also, identified differences between patient-reported and alter-reported networks signal the importance of retrieving information by alters themselves in addition to patients’ subjective evaluations of their network characteristics. However, future research on several accounts is warranted, for which multiple suggestions are provided.
More clean-cut results were found for health care professionals, with two potential determinants for CVRM identified. Although additional research is recommended on health care professionals as well, results on homogeneity may be used in new efforts targeting quality of primary care for CVRM.
Samenvatting
Samenvatting

Hoofdstuk 1
In het eerste hoofdstuk introduceren we de onderwerpen van dit proefschrift. De studies waren erop gericht om, met behulp van een sociale netwerk benadering, aanvullende determinanten voor cardiovasculair risicomanagement (CVRM) te identificeren. Hierbij betrokken wij patiënten met hart- en vaatziekten (HVZ), met hoog risico op HVZ, mensen die patiënten belangrijk vonden voor het omgaan met hun ziekte (alters) en gezondheidszorgprofessionals uit huisartspraktijken.

Hoofdstuk 2
In hoofdstuk 2 staat het studie protocol van de studies in dit proefschrift. Het beschrijft de netwerkstudies over patiënten en gezondheidszorgprofessionals. Deze waren erop gericht om aanvullende determinanten voor CVRM te identificeren door middel van het onderzoeken van invloeden van sociale netwerken van patiënten en gezondheidszorgprofessionals op uitkomsten en kwaliteit van CVRM. Daarnaast bevat dit hoofdstuk een beschrijving van een randomized controlled trial (RCT) die erop gericht was om participatie van patiënten te verbeteren.

De studies naar zowel de patiënten als gezondheidszorgprofessionals hadden longitudinale observationele designs. Data over sociale netwerken waren gepland om verzameld te worden door middel van gepersonaliseerde vragenlijsten en met telefonische interviews. Het was gepland om ongeveer 900 patiënten met HVZ of een hoog risico hierop en hun alters en 300 gezondheidszorgprofessionals uit 30 huisartspraktijken en hun connecties buiten huisartspraktijken te includeren. Patiënten deden met ofwel vragenlijsten ofwel via interviews mee in de studies, gezondheidszorgprofessionals namen deel via vragenlijsten.

Voor patiënten gebruikten wij de volgende uitkomsten; gezondheidsgedrag (dieet, fysieke activiteit en roken) en klinische risicofactoren (systolische bloeddruk, cholesterol en risico score). Kwaliteit van CVRM werd geïndiceerd door professionele prestatie van de praktijkondersteuners en door klinische risicofactoren van patiënten. Gezondheidsgedrag van patiënten werd gemeten met vragenlijsten die per post verzonden werden. Voor het meten van klinische risicofactoren en professionele prestaties van praktijkondersteuners werd gebruik gemaakt van audits van medische dossiers van patiënten.

Hoofdstuk 3
In hoofdstuk 3 worden de resultaten gepresenteerd van twee randomized controlled trials die erop gericht waren om participatie van patiënten te verbeteren door middel van het geven van keuze over de participatie wijze. Ondanks dat eerder onderzoek al liet zien dat participatie verbeterd kon worden door het geven van keuze over de participatie wijze, bestaan er weinig studies die zich richten op de vergelijking van participatie
wanneer potentiële deelnemers mogen kiezen tussen participatie via een telefonisch interview en middels vragenlijsten die per post ontvangen worden.

Twee trials werden ingebed in een grotere studie over CVRM in de eerstelijnszorg. Patiënten met HVZ en een hoog risico hierop die meededen in de grotere studie, werden uitgenodigd om mee te doen in een aanvullend onderzoek naar sociale netwerken. De uitnodigingen waren zo ontworpen dat zij juist wel of niet keuze over de participatie wijze gaven. De primaire uitkomst was het participatie ratio. Andere uitkomsten waren het participatie ratio conditioneel op bereidheid om deel te nemen, en initiële bereidheid voor deelname. In trial 1 vergeleken we de uitkomsten na het geven van keuze over de participatie wijze (interview of vragenlijst) met uitnodigingen voor deelname via een telefonisch interview. In trial 2 werd keuze voor participatie wijze vergeleken met uitnodigingen voor deelname via een vragenlijst.

In trial 1 vonden we geen verschillen in participatie ratio’s (65% vs 66%, p = 0.853) hoewel het conditionele participatie ratio het hoogste was voor interviews (90% vs 72%, p < .01). Initiële bereidheid voor participatie was hoger als keuze werd geboden over de participatie wijze (90% versus 73%, p < .01). In trial 2 waren het participatie ratio en het conditionele participatie ratio hoger als mensen keuze hadden over de participatie wijze (59% vs 46%, p < .01 and 66% vs 53%, p < .01, respectievelijk). Er werden geen verschillen gevonden voor initiële bereidheid tot participatie (90% vs 86%, p = 0.146).

De conclusie van dit onderzoek was dat het geven van keuze over participatie wijze een verbetering gaf in vergelijking met uitnodigingen om deel te nemen via vragenlijsten maar niet vergeleken met uitnodigingen om deel te nemen via telefonische interviews.

**Hoofdstuk 4**

In hoofdstuk worden de resultaten gepresenteerd van een longitudinale observationele studie die gericht was op het exploresen van relaties tussen compositie van sociale netwerken van patiënten met gezondheidsgedrag en klinische risicofactoren.

Deze studie was ingebed in een project dat gericht was op de verbetering van CVRM in huisartspraktijken. 657 vasculaire patiënten (227 met HVZ, 380 met hoog risico op HVZ), met een gemiddelde leeftijd van 72.4 (SD 9.4) jaar, werden geïncludeerd samen met mensen die patiënten belangrijk vonden voor het omgaan met hun ziekte; dat zijn hun alters (n=487). Netwerk compositie werd gemeten met gestructureerde vragenlijsten. Data van patiënten en alters uit vragenlijsten werden gebruikt om gezondheidsgedrag (fysieke activiteit, dieet en roken) te meten. Klinische risicofactoren (systolische bloeddruk, LDL cholesterol en body mass index) werden uit medische dossiers van patiënten geabstraheerd. Zes logistische regressie analyses, met behulp van generalized equation estimations, werden gebruikt om drie hypotheses over effecten van netwerk compositie (het hebben van alters met adequaat gezondheidsgedrag, zonder depressie en met gespecialiseerde kennis) op zes uitkomsten, gecorrigeerd voor demografische, persoonlijke en psychologische kenmerken te testen.
Samenvatting

We vonden dat het hebben van alters met algeheel adequaat gezondheidsgedrag gerelateerd was aan gezond dieet van patiënten (OR 2.14, 95%CI: 1.52-3.02). Het hebben van niet-rokende alters in sociale netwerken was gerelateerd aan verlaagde odds voor roken door patiënten (OR 0.17, 95%CI: 0.05-0.60). Er werden geen effecten van de aanwezigheid van niet-depressieve alters gevonden. De aanwezigheid van alters met gespecialiseerde kennis over CVRM was negatief gerelateerd aan adequate dieet gewoonten van patiënten (OR 0.47, 95%CI 0.24-0.89).

Totaal bekeken, waren diët en roken maar niet fysieke activiteit en klinische risicofactoren geassocieerd met compositie van sociale netwerken van patiënten met vasculaire aandoeningen. In deze studie waarin gecontroleerd werd voor zowel persoonlijke als psychologische factoren, werden minder netwerk invloeden gevonden dan in eerder uitgevoerd onderzoek. Aanvullend onderzoek is nodig naar zowel netwerk structuur karakteristieken als psychologische factoren om kennis over gezondheidsge- drag van patiënten betrokken in CVRM te verbeteren.

Hoofdstuk 5

In hoofdstuk 5 worden de resultaten gepresenteerd van een longitudinale observationele studie die associaties exploreerde tussen karakteristieken van sociale netwerken van hart-patiënten en huidige en veranderde gewoonten voor dieet en fysieke activiteit. Hierbij werd gebruik gemaakt van zowel data van patiënten als van mensen die patiënten belangrijk vonden voor het omgaan met hun ziekte (alters). Deze aanpak gaf ons de gelegenheid om effecten van patiëntgerapporteerde en altergerapporteerde netwerk karakteristieken te vergelijken.


We vonden positieve effecten op diët voor de volgende altergerapporteerde netwerk karakteristieken; aantal alters met gezond dieet (b 2.45, p<.05), gezonde fysieke activiteit (b 2.35, p<.05) en met gespecialiseerde kennis (b 3.40, p<.05). We vonden negatieve effecten van de volgende patiëntgerapporteerde karakteristieken: aantal alters met adequate fysieke activiteit (b -2.46, p<.05) en algeheel adequaat gezondheidsgedrag (b -2.42, p<.05). Voor verandering in diët werden gelijksoortige patronen gevonden voor altergerapporteerde netwerk karakteristieken terwijl de patiëntgerapporteerde karakteristieken geen effect hadden.
Voor fysieke activiteit vonden we geen effecten van altergerapporteerde netwerk-karakteristieken. Negatieve effecten werden gevonden voor de volgende patiënt-gerapporteerde karakteristieken: netwerkgrootte ($b =-1.24, p<0.05$), aantal alters met algemeen adequaat gezondheidsgedrag ($b =-1.19, p<0.05$) en alters met CVRM-kennis ($b =-0.89, p<0.05$) op huidige fysieke activiteit. Echter aantal alters met adequaat dieet (OR 7.92, $p<0.05$) en adequate fysieke activiteit (OR 9.85, $p<0.05$) waren gerelateerd aan verbeteringen in fysieke activiteit.

Algemeen genomen verschildden de netwerkeffecten tussen dieet en fysieke activiteit, tussen huidige en veranderde gedragingen en tussen patiënt- en altergerapporteerde netwerken. Onze resultaten zouden kunnen suggereren dat gezondheidsgedrag meer beïnvloed wordt door werkelijke, in plaats van gepercipieerde, gedragingen van mensen binnen een netwerk.

**Hoofdstuk 6**

In hoofdstuk werden de resultaten gepresenteerd van een longitudinale observationele studie waarin we het doel hadden om nieuwe invalshoeken voor het verbeteren van gezondheidszorg te identificeren. Daarvoor exploreerden we associaties tussen informatie-uitwisselingnetwerken van gezondheidszorgprofessionals en evidence-based CVRM.

Deze studie werd parallel uitgevoerd aan een RCT die het doel had om professionele prestaties van praktijkondersteuners in Nederland te verbeteren. Informatie-uitwisseling over medisch beleid voor CVRM (algemene informatiennetwerken) en CVRM voor specifieke patiënten (specifieke informatiennetwerken) van 180 gezondheidszorgprofessionals uit 31 huisartspraktijken werden gemeten met gepersonaliseerde vragenlijsten. Audit van medische dossiers werd uitgevoerd voor 1620 patiënten uit deze praktijken voor het documenteren van de kwaliteit van zorg en twee risicofactoren (systolische bloeddruk (SBP) en LDL cholesterol niveau). Hypothesen over de effecten van 5 netwerk karakteristieken (density, frequentie van contact, homogeniteit van positieve attitudes voor het behalen van behandelingsdoelen, centraliteit van CVRM coördinatoren en de aanwezigheid van opinieleiders voor CVRM) die werden geconstrueerd op zowel algemene als specifieke informatie-uitwisselingnetwerken, werden getest en gecontroleerd voor praktijk- en patiëntfactoren met behulp van logistische multilevel analyses.

We vonden dat huisartspraktijken waarin een opinieleider aanwezig was, verhoogde odds hadden op adequate prestaties van praktijkondersteuners (OR 2.75, $p<0.05$). Lage homogeniteit voor positieve attitudes voor het behalen van streefwaarden voor SBP en LDL in zowel algemene als specifieke informatie-uitwisselingnetwerken was gelinked aan verlaagde odds voor gunstige SBP uitkomsten (SBP OR 0.57, $p<0.05$ en OR 0.60, $p<0.05$, LDL OR 0.59, $p<0.05$ en OR 0.61, $p<0.05$ in respectievelijk algemene en specifieke netwerken). Er werden geen effecten van netwerk karakteristieken op cholesterol gevonden.
We concludeerden dat het geven van evidence-based CVRM geassocieerd was met opinieleiders en homogeniteit voor klinische attitudes in teams uit huisartspraktijken.

**Hoofdstuk 7**

Hoofdstuk 7 betreft de algemene discussie van dit proefschrift. We beginnen met de samenvatting en bespreking van de hoofdbevindingen van de studies uit dit proefschrift. Daarna bespreken we de methodologische sterke en zwakke punten van de studies. Uiteindelijk worden de implicaties van de studies besproken.

Globaal vonden we dat specifieke karakteristieken van netwerken van patiënten en gezondheidszorgprofessionals belangrijk kunnen zijn voor het verbeteren van CVRM. Maar ook blijkt dat, vooral in de studies naar patiënten, netwerkinvloeden niet altijd eenduidig zijn. Algemeen genomen lijkt het erop dat de kwaliteit van de connecties tussen mensen, meer dan de kwantiteit van de connecties, een belangrijke rol hebben bij gezondheidsgedrag en het leveren van zorg.

Onze resultaten over patiënten leiden tot een aantal praktische implicaties. De bevestiging van het belang van sociale netwerken voor het ondersteunen van ziektemanagement is vooral belangrijk gezien recente veranderingen in de zorg voor chronische ziekten en de bijkomende nadruk op zelfmanagement van patiënten en de rol van netwerken voor het ondersteunen van hen. Maar onze resultaten laten ook zien dat niet alle patiënten netwerken hebben die even geschikt zijn voor het geven van dergelijke ondersteunen. Het zou belangrijk kunnen zijn om dit in acht te nemen bij het ontwikkelen van beleid waarin netwerken betrokken zijn of bij het geven van counseling over gezondheidsgedrag van patiënten. Ook signaleren de gevonden verschillen tussen patiënt- en alter-gerapporteerde netwerken het belang om aan alters zelf informatie te vragen als aanvulling op de subjectieve evaluaties van netwerkcarakteristieken van patiënten. Toch is het ook erg belangrijk om in de toekomst op diverse fronten meer en aanvullend onderzoek uit te voeren, hiervoor geven we meerdere suggesties.

De resultaten voor gezondheidszorgprofessionals gaven een eenduidiger beeld waarmee we twee potentiële determinanten voor CVRM konden identificeren. Hoewel we ook voor hen aanvullend onderzoek aanbevelen, zouden onze resultaten voor homogeniteit mogelijk gebruikt kunnen worden in nieuwe pogingen om de kwaliteit van CVRM in de huisartspraktijk te verbeteren.
Dankwoord
**Dankwoord**

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De allerbelangrijkste persoon staat helemaal als laatste in mijn lijstje, Alex Lehr. Samen hebben wij al een lange weg afgelegd. Van stellingkast nummertje zoveel naar twee proefschriften in de boekenkast. Hadden we dat ooit mogen dromen? Ik ben blij dat jij, al dan niet samen met een grijze trol of zwarte maki, altijd naast en/of achter mij hebt gestaan. Zonder jou had ik dit allemaal niet kunnen, en niet eens willen, doen. Ik zeg: laten we kijken wat er allemaal nog meer op ons pad komt, samen hebben we het goed. Dank je wel dat je jij bent, ik hou heel veel van je.
Curriculum vitae


Na een periode actief te zijn geweest binnen het experimentele onderzoek op de afdeling Medische Psychologie van het Radboudumc Nijmegen, zette zij vanaf 2012 haar carrière voort op de afdeling IQ healthcare van het Radboudumc als promovenda.

Momenteel is zij werkzaam als data-analist van het team Audit en Interne controle bij de gemeente Utrecht.