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Use of social network analysis in maternity care to identify the profession most suited for case manager role

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ABSTRACT

Objective: To improve Dutch maternity care, professionals start working in interdisciplinary patient-centred networks, which includes the patients as a member. The introduction of the case manager is expected to work positively on both the individual and the network level. However, case management is new in Dutch maternity care. The present study aims to define the profession that would be most suitable to fulfil the role of case manager.

Design: The maternal care network in the Nijmegen region was determined by using Social Network Analysis (SNA). SNA is a quantitative methodology that measures and analyses patient-related connections between different professionals working in a network. To identify the case manager we focused on the position, reach, and connections in the network of the maternal care professionals.

Setting: Maternity healthcare professionals in a single region of the Netherlands with an average of 4,500 births/year.

Participants: The participants were 214 individual healthcare workers from eight different professions.

Measurements and Findings: The total network showed 3948 connections between 214 maternity healthcare professionals with a density of 0.08. Each profession had some central individuals in the network. The 52 community-based midwives were responsible for 51% of all measured connections. The youth health doctors and nurses were mostly situated on the periphery and less connected. The betweenness centrality had the highest score in obstetricians and community-based midwives. Only the community-based midwives had connections with all other groups of professions. Almost all professionals in the network could reach other professionals in two steps.

Introduction

A patient-centred network approach in health care has growing interest because, of the reported positive effects (Cunningham et al. 2012). The key element of a patient-centred network approach is that the involved healthcare professionals work together with the patient as a team member (Ekman et al. 2011). A patient's satisfaction regarding their care and the patient's perception of control are shown to increase through active patient participation (Van Royen et al. 2010; Ekman et al. 2011; Den Breejen et al. 2014; de Labrusse et al. 2016). A patient-centred network approach is debated in Dutch maternity care; it is explicitly mentioned in leading Dutch reports as an important strategic component to improve Dutch maternity care (Zwangerschap en geboorte 2009, Nederland and Zorg 2016). Maternity care in the Netherlands has midwifery care as a standard, with in addition specialised secondary and tertiary obstetric care (Amelink-Verburg and Buitendijk 2010; Geerts et al. 2014; Perdok et al. 2015; Perined 2016).The involvement of secondary and tertiary care (for advice or referral) for pregnant women has recently risen to 58% (Perined 2016). After birth, maternity assistants take care of the mother and child for

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up to ten days, mainly at the home of the newborn. Afterwards, the youth health department doctors and nurses take over. All of these professionals work autonomously, which implies that Dutch maternity care is fragmented and poorly coordinated (Geerts et al. 2014; Scholmerich et al. 2014; Perdok et al. 2015). To improve maternity care, the goal is to work, with an interdisciplinary approach in patient-centred networks, together with the pregnant women. The network would be coordinated by a case manager. Working in well-coordinated health professional networks is associated with improved quality of care, increased patient satisfaction, improved efficiency and decreased care costs (Minkman et al. 2009; Tahan and Campagna 2010; Wensing et al. 2010; Novelli et al. 2012; Wynia et al. 2012; Den Breejen et al. 2014; Scholmerich et al. 2014; CMSUK 2015; Kroll-Desrosiers et al. 2016). A case manager's role when coordinating a network is internationally emphasised (Tahan and Campagna 2010). Case management is a method that works on two complementary levels. On an individual level, the case manager provides advice or a referral and works in partnership with the healthcare professionals and the pregnant woman to refine the care plan and process. At a network level, the case manager has a central position and collaborates with multiple healthcare professionals, which provides continuity between professionals and organisations (Minkman et al. 2009). Case management is used in different healthcare settings (Minkman et al. 2009; Tahan and Campagna 2010), but would be new in Dutch maternity care. However, it has not yet been defined which profession should fulfil this role of case manager.

Social Network Analysis (SNA) is a study method used to quantitatively measure the connectedness between professionals in a healthcare network. With SNA techniques you can empirically describe, graph, and analyse the structure of the network (Scott et al. 2005). Because case management is expected to work on the levels of the pregnant women and the maternity network, we hypothesized the case manager needs: to have a central position in the network, to reach each professional within only a few contacts, and to have connections with many professions or organisations. In the present study, we used SNA to explore the profession that would be most suitable to fulfil the role of case manager in Dutch maternity care, which is based on the position, reach and connections in the network. Even though this is a Dutch study, the findings can contribute internationally to the broader themes of patient-centred care, the role of the case manager and the position of midwives in maternity care (Schroeder et al. 2012; National Collaborating Centre for for, W. s., Children's 2014; Vedam et al. 2014; de Labrusse et al. 2016; Kroll-Desrosiers et al. 2016).

Methods

Ethics

The medical ethical committee of the Radboud university medical center, The Netherlands approved the study protocol (CMO No. 2011/381). The study is registered at the Dutch Trial Register (NTR, TC=4063).

Setting

The study was performed in Nijmegen, a single regional collaborative area in the Netherlands with an average of 4500 births a year and over 220 healthcare professionals involved in maternity care. Table 1 lists the different healthcare professionals involved in maternity care in the Nijmegen area. Primary care was provided by: community-based midwives (a), maternity care assistants (b), and youth health doctors and nurses (c). Secondary and tertiary care was provided by obstetricians (d), obstetricians in training (e), hospital-based midwives (f) and paediatricians (g).

Table 1
Healthcare professionals involved in maternity care in the Nijmegen area, the Netherlands.

Profession	N	Work setting
Community-based midwives	52	11 community based midwife practices
Obstetricians	19	2 hospitals [a]
Obstetricians in training	31	2 hospitals [a]
Hospital-based midwives	29	2 hospitals [a]
Paediatricians	21	2 hospitals [a]
Maternity care assistants	5	1 maternity assistants organization
Youth health doctors	24	1 youth health organization [b]
Youth health nurses	45	1 youth health organization [b]
Total	**226** **%**	

[a] One with only secondary care and one with both secondary and tertiary care
[b] Working in fourteen offices

a. Community-based midwives are qualified to provide full prenatal and perinatal care to all women with uncomplicated pregnancies. In case of risk factors or complications, women are referred to secondary or tertiary care (Perdok et al. 2015).
b. The maternity care assistants support the community-based midwives during childbirth and subsequently take care of the mother and the new born in their home for up to ten days postpartum (van Teijlingen 1990). They collect essential health information and report it to the community-based midwives, who are responsible for medical care.
c. The youth health department doctors and nurses then take over, supporting the parents and screening for any signs of abnormal development in the child.
d. Obstetricians are responsible for secondary and tertiary maternity care.
e. Obstetricians in training work independently but are still under the supervision of obstetricians.
f. Hospital-based midwives are responsible for about half of the births in secondary and tertiary care (Perined 2016) and are supervised by the obstetricians (in training).
g. Paediatricians provide secondary and tertiary care in the hospital.

Every hospital offers secondary care. Tertiary care takes place in centres with a neonatal intensive care unit and an obstetric high care department. In 2014, 86% of all pregnant women started their maternity care in a primary care setting. Of these women, 51% started and 29% eventually ended birth in a primary care setting (Perined 2016). After birth, medical care was under the supervision of a community-based midwife, and 96% of all women received care from a maternity care assistant at home (Perined 2016). The paediatrician was involved in the care of the new born in 31% of cases. Hospitalisation for a new born was necessary in 17% of cases (Perined 2016). Overall, the Dutch system involves numerous referrals during pregnancy or during and after birth. Healthcare professionals in maternity care work in a regional multidisciplinary collaboration within the catchment area of one or more hospitals. Within this organisation, they make joint protocols and distinctive appointments regarding referrals in (acute) situations.

Data collection

All healthcare professionals in maternity care in the area of Nijmegen were invited by a personal e-mail to fill out a questionnaire. The questionnaire contained a list of names of all 226 professionals involved, including their job title and place of work. Participants were asked to indicate the professionals they have had medically orientated contact for at least one patient in the last six months. Nonresponders were -invited again after two weeks. If the response of a health professional was missing, it was in some cases substituted by the

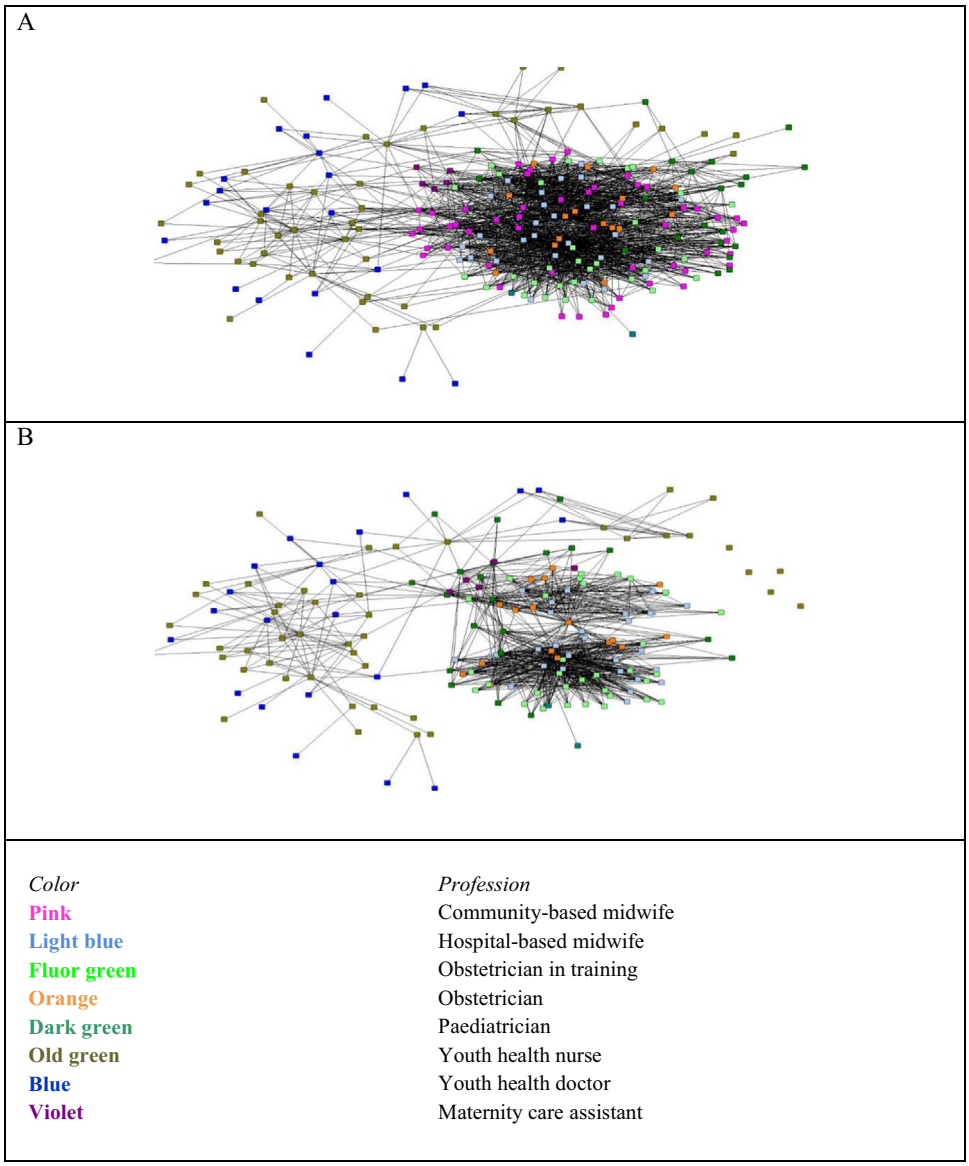

Fig. 1. Visual display of A: the total network of maternity care professionals in the region with 3,948 ties and a density of 0.08, and B: the network excluding community-based midwives with 1,938 ties and a density of 0.06.

response of other health professionals in the network. Substitution meant that, when one professional indicated that they had contact with another professional, we assumed this contact was mutual even when the second professional showed no response. This method of substitution is commonly used in network analysis (Scott, 2000).

Data analysis

For this study we used Social Network Analysis (SNA), a quantitative methodology that measures and analyses connections between people, in our study between healthcare professionals in patient care (Milward and Provan 1998). SNA combines the concept of the sociogram (a visual representation of relationships in a social group) with elements of graph theory (mathematical structures to model pair wise relations between objects) to analyse patterns of interaction between people in networks (Scott 2000). SNA has its origin in the social sciences, but it is also applicable and has proven surplus value in healthcare (Scott et al. 2005; Chambers et al. 2012). In SNA, the network structure is described in terms of nodes (individual health professionals) and ties (the connections between them). Description of the network data involves visual analysis of network diagrams produced using a specific software program, NetDraw (Borgatti 2002). The software converts matrices of network data into diagrams and individual nodes using complex algorithms. We used UCINET v6 (Borgatti et al. 2002) for constructing networks and obtaining network parameters, and SPSS 20 (SPSS Inc., Chicago, IL, USA) for conducting statistical analyses.

To analyse the visual network we made different diagrams of the network data: the total network and excluding each profession. Analysis of the network characteristics was carried out by applying several measures for each profession. We analysed every parameter per person, and then clustered the professionals from the same profession in subgroups and calculated the average per subgroup. We normalised the scores to account for differences in network sizes between our subgroups. The normalised scores control for differences in the structural layout elements of a network, such as size. We examined the following five network parameters:

a. The **degree centrality** coefficient is the actual number out of all possible connections for an individual. The score is expressed as a proportion and can vary from 0 (every member is connected to all other members) to 1 (all members are connected to only 1 member).

People with a score of 0 are on the periphery of the network and do not change the network if they are removed. People with a score of 1 are very important in the network. In a communication and collaboration network, a higher degree of centrality may be associated with higher status, influence, and better coordination of care.

b. The **betweenness centrality** is the number of pathways in the network that an individual is 'in between' two other individuals, or, how likely is this person to be the most direct route between people in the network. This measure indicates how frequently an individual serves as an intermediate between others. The maximum would be reached if the individual is the central person and all pathways between others will flow through this person. Individuals with a high betweenness centrality have an intermediating role in the transfer and assessment of information. The betweenness centrality is commonly used to identify boundary spanners (Long et al. 2013).
c. The **reach centrality** is the number of professionals that an individual can reach, divided by the steps that are necessary to reach an individual. Therefore it is a useful measure of how close each actor is to all others. A score of 1, 0.50, 0.33 and 0.25 indicates that everybody in the network is reached in one, two, three and four steps, respectively.
d. An **isolate** is a node (individual) in a network that is not connected to any other node in the network.
e. **Density** is the number of connections in a network divided by all possible connections. Unlike previous parameters, density measures not the individuals, but the whole network, making it a network measure. The density score is expressed as a percentage and can vary from 0 to 1. If all healthcare professionals were connected to everyone, then the network would be measured as 1. To capture the collaboration *between* and *within* the groups of professionals, we calculated the density within a group with the same profession and between individuals with a different profession. The density between professions focuses on the connectedness between one profession and another profession (*e.g.* community-based midwives with paediatricians). Density within professions focuses on connectedness inside the group of the professionals with the same profession (*e.g.*only community-based midwives, only paediatricians),.

Findings

The response rate for this study was 45% (101 out of 226). By using substitution we analysed 214 healthcare professionals (95%) connected in the present network. The analysis revealed 3948 ties (connections) in total.

Fig. 1A presents the visual display of the total network. It shows all 3948 connections between the 214 maternity healthcare professionals in the area. Every point represents one healthcare professional. The density of the network is 0.08. Each profession had some individuals in a more central place in the network. Fig. 1B presents the same network, but *with the exclusion* of the community-based midwives. The figure contains 162 professionals, 1.938 connections and a density of 0.06. The community-based midwives were responsible for 51% of all ties and a25% increase in density.

Table 2 lists the network parameters for each profession. **Degree centrality** varied from 0.015 (youth health doctors) to 0.421 (hospital-based midwives). The higher the score, the more central position in the network was taken. The hospital-based midwives, obstetricians, community-based midwives and obstetricians in training had a score above 0.09. The paediatricians had a score of 0.06. Finally, we found the lowest scores in youth health doctors and nurses, and maternity care assistants, which was below 0.06. **Betweenness centrality** (the most direct route between others) ranged from 0.159 (obstetricians in training) to 1.337 (obstetricians) and a score higher than 1.000 was shown by obstetricians (1.337) and community-based midwives (1.031). This betweenness centrality is commonly used to identify boundary spanners. **Reach centrality** was mainly 0.5, and most professionals reached every other person in the network in two steps. Only the youth health doctors and youth health nurses needed three steps to reach every professional in the network (0.33). **Isolates** were only visible in the subgroup of youth health doctors (12%).

The **density** of the whole network was 0.08. The density of the network with exclusion of community-based midwives was 0.06. The calculation of the density *between* and *within* the professions can be found in Table 3. The highest scores between groups were seen between community-based midwives and hospital-based midwives (0.262), followed by community-based midwives and obstetricians (0.256). Several groups had no patient-related contacts with other professions (0.000). Only the community-based midwives had connections with every other group of professionals. The maternity care assistants had the highest number of connections within their group (0.700).

Discussions

In this study we used Social Network Analysis (SNA) to get insight into the current maternity network and to explore which profession(s) in Dutch maternity care would suit the role of case manager. In the visual diagram of the total network we found one large cluster with professionals working in the hospitals and the community-based midwives, which was surrounded by youth health doctors and nurses, and maternity care assistants on the periphery. Furthermore, each profession had individuals with a more central position than others. Different studies showed that central individuals are important for implementations or the diffusion of information because the individual

Table 2
Network parameters for each profession.

Normalized	C-BM	H-BM	OiT	O	P	YHN	YHD	MA
Degree Centrality (SD)	0.095 (0.082)	0.421 (0.106)	0.090 (0.071)	0.154 (0.136)	0.060 (0.048)	0.025 (0.025)	0.015 (0.013)	0.056 (0.014)
Betweenness Centrality (SD)	1.031 (1.702)	0.799 (1.782)	0.159 (0.427)	1.337 (2.775)	0.451 (0.819)	0.619 (1.224)	0.183 (0.416)	0.196 (0.185)
Reach Centrality (SD)	0.492 (0.050)	0.522 (0.060)	0.487 (0.039)	0.533 (0.076)	0.445 (0.060)	0.371 (0.047)	0.293 (0.117)	0.463 (0.019)
Isolates (%) (SD)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	12.0 (0.332)	0.0 (0.000)

C-BMCommunity-based midwives
H-BMHospital-based midwives
OiTObstetricians in training
OObstetricians
PPaediatricians
YHNYouth health nurses
YHDYouth health doctors
MAMaternity care assistants

Table 3
Density in the network, between en within professions.

	C-BM	H-BM	OiT	O	P	YHN	YHD	MA
C-BM	***0.084***[a]							
H-BM	0.262	***0.206***[a]						
OiT	0.083	0.218	***0.167***[a]					
O	0.256	0.250	0.199	***0.243***[a]				
P	0.018	0.061	0.057	0.185	***0.271***[a]			
YHN	0.033	0.000	0.000	0.000	0.004	***0.054***[a]		
YHD	0.004	0.000	0.000	0.002	0.010	0.060	***0.010***[a]	
MA	0.169	0.007	0.000	0.012	0.000	0.013	0.000	***0.700***[a]

Results between professions
C-BMCommunity-based midwives
H-BMHospital-based midwives
OiTObstetricians in training
OObstetricians
PPaediatricians
YHNYouth health nurses
YHDYouth health doctors
MAMaternity care assistants
[a] Results within professions

has more interest and the capacity to connect with other professionals (Wensing et al. 2010; Long et al. 2013). In the change to a patient-centred network, it would contribute if these strengths should be used by central individuals who are given a specific task or role.

When we excluded the midwives from the network, the visual diagram showed a less connected network and the appearance of isolated members. Furthermore, the two hospitals were no longer one cluster and the youth health doctors and nurses were almost disconnected from the two hospitals.

The betweenness centrality is commonly used to identify boundary spanners (Long et al. 2013) which we related to case management. Two professions had a high betweenness centrality: the obstetricians and the community-based midwives. We hypothesised that for case management the connections *between* other professions or organisations are more important than *within* the profession or organisation. Therefore, we measured the density between professions. This density showed that the community-based midwives were the only profession that had connections with every other profession. Based on the aforementioned findings, we conclude that the community-based midwives are essential in connecting different professionals in the maternity network and therefore are preferable to fulfil the role of case manager. Additional arguments to these findings are related to the tasks of a case manager in maternity care, *i.e.* the coordination of care, continuity of care and communication with the pregnant woman. A high score in connections is important: however good communication skills, content and approachability are also important. Communication, the provision of information and medical care are the specialties of primary care professionals. However, the community-based midwives are the only ones who fulfil all aspects during pregnancy and childbirth. Dutch midwives are in fact educated to be a medical expert, coach and counsellor, communicator, and health promoter as defined in the professional profile of Dutch midwives (Aitink et al. 2014).

To the best of our knowledge this is the first study that quantitatively describes a complex maternity care network in a complete area. Previous social network studies focused on the collaboration between professionals in regular healthcare teams (Keating et al. 2007; Wensing et al. 2010; Weenink et al. 2011). Previous collaboration studies in maternity care focused on the cooperation between mostly two professions like obstetricians and midwives (Geerts 2014; Scholmerich et al. 2014; van der Lee et al. 2014; Perdok et al. 2015), or maternity care assistants and midwives (van Teijlingen 1990). In the present study we focused on the cooperation within a complex maternity network between all professions from different organisations. By using SNA, we created visual and quantitative insight regarding the connectedness between maternity care professionals.

We realise this study knows some shortcomings. We measured the maternity network only once, and the optimum of connections or the density of a network is unknown. Additionally, the network in this study is based on inter professional connectedness on the level of a patient,: however specific information on the quality of the connections is lacking. Furthermore, although 95% of the professionals were eventually connected in the network after substitution, the initial response rate was only 45%.

Conclusions

A network approach in maternity care provides quantitative insight into the positions of the professions in the netwok, including central individuals who are important for a well functioning cooperative network. This knowledge can be used in the transition to a patient-based care network. Therefore, SNA offers opportunities to measure development over time in a network or to measure how the network characteristics are linked to the relevant aspects of maternity healthcare. Community-based midwives in this study revealed high scores in connectivity which makes us believe that they are essential in connecting the different professionals in the network. Their skills and close position to pregnant women, gives us plausible reason to believe that community-based midwives are suitable to fulfil the role of case manager in Dutch maternity care.

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