RECIIS – R. Eletr. de Com. Inf. Inov. Saúde. Rio de Janeiro, v.6, n.2, Jun., 2012
[www.reciis.icict.fiocruz.br] e-ISSN 1981-6278

* Research in Progress

The Information Flow of the Sistema Nacional de Transplantes (National Transplant System): A Social Network Analysis[i]

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DOI:10.3395/reciis.v6i2.572en

Abstract:

This project, submitted in partial fulfilment of the requirements for a Master's in Information Science (IS), uses the Social Network Analysis method to analyse the exchange of information among the National Transplantation Coordination System (Coordenação-Geral do Sistema Nacional de Transplantes; NTCS), the National Transplant Centre (Central Nacional de Transplantes; NTC) and the Organ Notification, Harvesting and Distribution Centres (Centrais de Notificação, Captação **[MT1]** e Distribuição de Órgãos; CNCDO) to determine the structure of the National Transplant System's (Sistema Nacional de Transplantes; NTS) social network. Interviews and electronic questionnaires were used to determine the information flow channels used by the NTS to establish its social network. The leaders of the NTCS and NTS and the informal leaders of the Santa Catarina, Rio Grande do Norte, São Paulo and Ceará states were identified using the Social Network Analysis approach to ascertain the relevant metrics. The results showed that the network structure and distribution did not provide the necessary conditions for a uniform and continuous information flow that would promote the advancement of scientific and technical knowledge at the NTS.

Keywords: Social Network Analysis, information flow, National Transplant System

1. Introduction

This research focuses on finding solutions for effective knowledge dissemination and for improving the information flow between the human and nonhuman entities associated with the Brazilian organ transplant system. To this end, it examines the exchange of information within the social network formed by the National Transplant System (Sistema Nacional de Transplantes; NTS); the Department of Health, which includes the National Transplantation Coordination System (Coordenação-Geral do Sistema Nacional de Transplantes; NTCS); the National Transplant Centre (Central Nacional de Transplantes; NTC); and the Centres for Organ Notification, Harvesting and Distribution (Centrais de Notificação, Captação **[MT2]** e Distribuição de Órgãos; CNCDO) located throughout Brazil.

This study aimed to investigate the information flow facilitating the exchange of data, information and knowledge within the NTS and the contribution of this flow to the performance of the professionals involved. The efficient management of information is a strategic issue (SARACEVIC, 1995) in any organisation and is vital for the NTS. The present research considered the fundamental social actions that promote the development of people, their network of relationships and the community to which they belong. Therefore, the ultimate goal of this study was, as Barreto (2007) puts it, "to illuminate every human being through information as a mediator of knowledge" using Information Science (IS) and social network methods.

The present research consisted of representing the NTS information flow as a social network “formed by points (or nodes/vertices) representing actors and lines (or edges) representing ties or relationships” (HANNEMAN and RIDDLE, 2005; **author’s translation**). This representation allowed for the development of relationships within NTS to be understood and resulted in data describing all of the factors that contributed to the decrease in waiting time for patients on the unified transplant list in Brazil.

1.1 Problem

In recent years, Brazil has performed outstandingly in providing organ transplants. Marinho (2006) states that Brazil has the most robust public program for transplants in the world. Alexandre Padilha, the current Secretary of State for Health, also highlights this growth, asserting that "Brazil is the country that performs the most transplants in the public sector in the world [...]" (BRAZIL, 2011b). Records show that there are 548 healthcare facilities and 1,376 transplant teams in Brazil, a key factor in the country’s success (BRAZIL, 2011b). However, is the country’s high number of procedures also accompanied by a high rate of effective organ donation? If not, what influences the low rate of effective donation?

The Department of Health indicates that since 2003, the number of effective donors **[ii]** has grown from 5.00 to 9.90 per million people (pmp) (BRAZIL, 2011b). However, this value still falls short of Spain’s 32 pmp; Spain has been the transplant world record holder for 19 years (ESPAÑA, 2011; **author’s translation**). Furthermore, in São Paulo, the country’s reference state until 2010 (21.2 pmp), 66.73% of the organ donations were not converted into surgeries in 2010 (ASSOCIAÇÃO BRASILEIRA DE TRANSPLANTES DE ÓRGÃOS [BRAZILIAN ASSOCIATION OF ORGAN TRANSPLANTS], 2010). In 2011, specifically between January and September, São Paulo had the second highest organ donation rate in Brazil of 19.3 pmp. This resulted from the conversion of 1,855 potential donors into 598 effective donors, a yield of 32.23%. Santa Catarina had the highest rate in Brazil (25.4 pmp) and was more efficient than CONHD-SP, converting 287 potential donors into 119 effective donors, a yield rate of 41.46%. This is a disturbing statistic, considering that of the 5,331 potential donors in Brazil, only 1,520 actually donated, which represents a 71.70% loss of supply between January and September 2011 (ASSOCIAÇÃO BRASILEIRA DE TRANSPLANTES DE ÓRGÃOS [BRAZILIAN ASSOCIATION OF ORGAN TRANSPLANTS], 2011). Moreover, 47,373**[iii]** people were on the waiting list to receive organs in 2010 (BRAZIL, 2011c). In contrast, in Spain, despite its smaller geographic dimensions, that number was approximately 5,500 (ESPAÑA, 2011; **author’s translation**).

According to Bonatelli (2009), a critical barrier to organ donation is family refusal; relatives are required to decide whether to donate their deceased love one’s organs while undergoing the strong emotional shock of their loss. However, research studies (TRANSPLANTE, 2009) show that the core issue is not rejection, but rather the lack of notification that a potential donor exists and the unpreparedness of the teams involved in the process of acquiring the organs. The data published between January and September 2011 showed that out of 5,331 potential donors, there were only 1,401 family refusals (ASSOCIAÇÃO BRASILEIRA DE TRANSPLANTES DE ÓRGÃOS [BRAZILIAN ASSOCIATION OF ORGAN TRANSPLANTS], 2011). In other words, organ donations were authorised by the families of 3,930 people (74%), a high rate, considering the emotional state of these families. These data confirm that the primary problem is not caused by family refusal.

Lima *et al.* (2010) show that absolute numbers of donations have considerably increased in recent years due to technological advancements and increasingly effective social mobilisation. However, Campos (2011) seems more hesitant, emphasising that "the increase in donations, while significant, is due to sporadic measures in some states and the commitment of transplant teams because there are no systemic or planned actions originating at the federal level.”

The first organ transplants were performed in the early twentieth century. Surgeons Aléxis Carrel and Charles Guthrie made important contributions to the development of transplant procedures, especially the technique of suturing blood vessels (SILVA NETO, [s.d.], p.4). Rocha (ROCHA, [s.d.]) believes that, for modern transplants, "the surgical technique is largely mastered [and] patient selection already follows safe international criteria.” However, after almost 90 years of medical research and practice in such procedures, individual steps still hinder the transplant process. Of the patients on the waiting list in 2009, 63% died, an extremely high rate compared to countries more aware of the significance of this issue (6% to 8%) (TRANSPLANTE, 2009).**[iv]**

The uneasiness created by these statistics led to the proposal of this study, wherein Social Network Analysis (SNA) was applied to the NTS network to answer the following question: **How is the Information Flow of the Sistema Nacional de Transplantes [National Transplant System] Structured?**

2. Theoretical Foundations

2.1 Organ Transplants

Lamb (2000) identifies the origins of tissue and organ transplants in the distant past, naming Adam as the first donor and Eve as a pioneer receiver when God used Adam's rib to create the first woman. However, most scientific records show that the first experiments dealt with blood transfusions. Lamb (2000) points out that these were unsuccessful, and incompatible blood caused several deaths, until the different blood types were discovered. Modern transplantation originated in the 1920s with Aléxis Carrel, whose study, "*The transplantation of veins and organs*," made him a pioneer in this field (TRANSPLANTE, 2009). However, the first practices and procedures for non-regenerative organs (kidneys, heart, lungs, pancreas and liver) did not appear until 1950 (LAMB, 2000).

In Brazil, organ harvesting has been performed since 1964 (Sistema Nacional de Transplantes [National Transplant System], 2001). In 1968, a heart transplant was performed for the first time in Latin America (LAMB, 2000), and in recent years, Brazil has been gaining notoriety among other nations for its successful transplants. According to the NTS (BRASIL, 2011b), in 2009, the number of solid organ, tissue and cell transplants was 20,253. In 2010, there were 21,040 such transplants, a growth of 3.8%. The data on solid organs alone show progress: 6,422 solid organs were transplanted in 2010 compared to 5,999 in 2009 (a 7% increase**[v]**). Brazil currently has the largest public program for transplants in the world and is an example for many countries, including many Latin American nations.

The Brazilian Government created the National Transplant System in 1997 under Law nº 9.434 of February 04 to establish a national policy for tissue and organ transplants and to regulate the growing number of surgeries. Under the NTS, all transplants in the country began to be performed in public or private healthcare facilities previously authorised by the National Healthcare System (Sistema Único de Saúde; NHS). The Department of Health provides 92.6% coverage through its nation-wide presence in 25 CONHD units [Organ Notification, Harvesting and Distribution Centres] (PORTAL SAÚDE, 2010).

2.2 Social Networks

Marteleto (2001, p.72) argues that social networks have existed as long as information has been available to humans. Only in recent decades have information managers begun to regard these networks as a strategic tool.

For Currás (2009, p.61; **author's translation**), a social network is a group of points connected by a series of relationships that perform certain functions and enjoy a structure and morphology of their own. For Recuero (2009), this is a metaphor for analysing the behaviour of a social group through the dynamic relations of the actors that comprise it. Therefore, social actors and their connections form social networks. According to Currás,

> ***Nodes,*** *also called* ***objects,*** *elements that, in general, refer to people that form the network, are needed to establish a network.* ***Nodes*** *unite with each other through* ***connections*** *or* ***edges****, that is, through interconnection lines whose purpose is to relate a node to the remainder of the network. (CURRÁS, 2009, p.63;* ***author's translation****)*

For Costa (2009, p.43), "the networks enabled the promotion of knowledge generation and propagation of its application through new technologies and contemporary social practices." Through connections, a social network's emerging information flow can be stabilised because social members often feel rewarded for sharing their knowledge or demonstrating their expertise. As a result, "everybody wins, because each actor will build foundations and take new actions based on information shared" (TOMAÉL; MARTELETO, 2006, p.76).

Social network analysis interests researchers from various scientific fields because of its interdisciplinary aspect and because its "analytic focus lays on relationships and interactions between individuals, as a way of understanding the relational structure of society" (MARTELETO and TOMAÉL, p. 82, 2005). In summary, social networks promote the necessary conditions for relationships between people, groups of professionals, institutions and governments (WITTER, 2009, p.172), establishing knowledge exchange through information flow and promoting the intellectual development of its members.

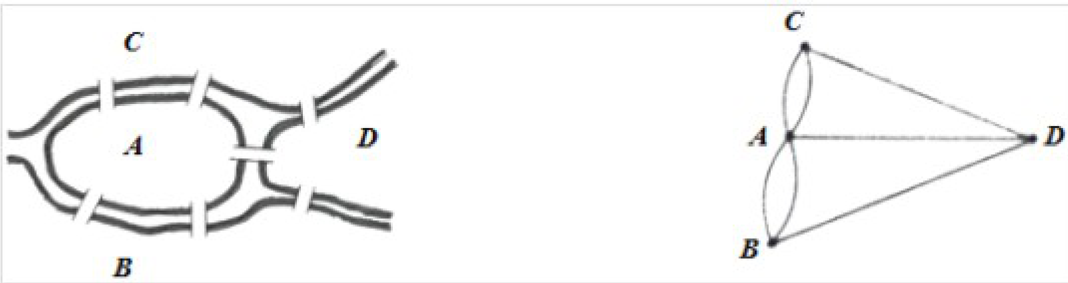
2.3 Social Network Analysis (SNA)

Understanding a given group of individuals or organisations and their relationships as a social network enables all of the members of the group to be analysed as actors whose social actions are motivated by information obtained through their connections with the remaining network actors. Therefore, the main purpose of the SNA methodology is to detect and interpret the patterns of social relationships existing among the actors (Nooy, Mrvar and Batagelj, 2005).

Hanneman and Riddle (2005) present two ways to represent the relationships between network actors: matrices and graphs. Originating from mathematics, matrices represent a rectangular array of a set of elements in rows and columns (i, j). When **matrices** are applied in sociology, specifically to social networks, the actors are arranged in horizontal and vertical dimensions. Hanneman and Riddle (2005) orient "shipments" (sender) in lines (*i*) and "incoming items" (recipient) in columns (*j*). If the main diagonal is zero (0), then there are no loops, or self-ties—no connections circling back to the actor from which they stem. The **adjacency** (or binary) **matrix** is used to examine the presence or absence of relationship between two actors. It is either nil (0) when there are no connections between two nodes or one (1) when there are one or more connections. In other words, the value one (1) indicates that a connection was sent from one actor in a line (*i*) to one in a column (*j*), or that an actor from one column received a connection from an actor in a line. **Graphs** are also used to represent the structure of a social network. According to Nooy, Mrvar and Batagelj (2005) and Hanneman and Riddle (2005), such graphs are also known as sociograms. They graphically represent the structure of a group based on an old mathematical theory proposed by Leonhard Euler.

Leonhard Euler (1707-1782) became the father of graph theory by proposing a topographic solution for the Seven Bridges of Königsberg problem, which was based on an area of Königsberg where the River Pregel formed two islands (Figure 01, left) accessed by seven bridges.

Figure 1 – A park in Königsberg (left) and the graph of the problem of the bridges over the river (right)



Source:(HARARY, 1972)

Euler developed a graphical representation (Figure 1, right) and proved with his theory that it was impossible for anyone to cross the seven bridges without repeating at least one of them. He determined that such a feat would only be possible if each node (point) were linked to an even number of connections, which was not the case in Königsberg, where the points had an odd number of nodes (HARARY, 1972; BOAVENTURA NETTO, 1996; RECUERO, 2009).

3. Methodological Procedures

According to the goals presented in Richardson (2008), this is an exploratory research study that aimed to understand the emerging information flow in the NTS social network. The methodological approach used by this study was Social Network Analysis (SNA). Following Silva and Menezes (2001), the present study has a qualitative/quantitative nature. This is appropriate when applying SNA, according to

Marteleto and Tomaél (2005). While the quantitative approach provided an overview of the situation, the qualitative research targeted particular issues of actor behaviour and technical visits that were not possible to interpret using numbers and statistics.

First, the NTS team performed interviews and transcribed the responses to the electronic questionnaires**[vi]** sent to the General Coordination System of the NTS, the National Transplant Centre and the NTS's state and district units throughout the country. Using the collection tools, we sought to determine which of the following communication channels each actor was using to relate with the others: a) Technical Visit; b) Scientific Event/Meeting; c) Training/Orientation; d) Video or Web Conference; e) Fraternisation; f) Development of Academic Research; g) Telephone Call; h) E-mail; i) Fac-Simile (fax); j) Conventional Correspondence (mail, etc.); k) Social Network Provider (Orkut, Twitter, Facebook, etc.); l) Instant Messenger (MSN, ICQ, Yahoo! Messenger, etc.); m) Chat Rooms; or n) No Contact. The respondent could also indicate other types of relations not mentioned by the collection tool.

Of the 27 federation units of Brazil, there was no CONHD in the state of Roraima. In addition, the state of Tocantins had recently inaugurated its Centre at the time the questionnaire was circulated. Thus, for this network analysis, the Roraima centre was excluded from and the Tocantins centre was included in the electronic questionnaires sent. Importantly, a deliberation was necessary because Tocantins was still being integrated in the system. The 27 federal units, the NTCS and the NTC totalled 29 network actors, although seven of the Centres did not respond to the questionnaires sent (Amapá, Ceará, Espírito Santo, Goiás, Minas Gerais, Pernambuco and Rio de Janeiro). The researchers and the NTCS team contacted each of these units five times via e-mail and telephone, seeking to emphasise the collaborative aspect of the research and the necessity of each Centre's participation. Although they all verbally expressed commitment to providing adequate feedback, there was no effective response.

For these reasons, the entire network was considered in the study, including all 29 actors (participant Centres, nonparticipant Centres and absent Centres). The seven non-respondent states were considered nonparticipant Centres, and the states of Roraima and Tocantins were considered absent Centres. After the data were collected, the values were input into a meta-matrix using the UCINET computer program. **[vii]**

UCINET is a proprietary software for Windows that is used to perform social network analysis. It has a free trial period of 90 (ninety) days, beyond which time one must purchase the proprietary license. Version 6, the most current version, was downloaded on December 26, 2011, and we sought to use it during the free trial period given the budget constraints of this research. This program was used for all network modelling and to find all of the relevant metrics for each approach proposed. Once modelled, the networks were exported to a program called Pajek**[viii]** so that the images (graphs) could be designed. Pajek a non-commercial, open-access program for Windows developed in 1996 for analysing small networks and large networks of millions of nodes. It allows the user to develop graphical images that visually present the information flow behaviour found in the social network. The Pajek64 2.05 version was used to transform the edges (guided connections) into lines (single line) and to design both the graphs used in the analyses and the final layout of the graphs presented herein. This process of converting edges into lines is called symmetrisation.

Although the two programs are independent and comprehensive, we used both to perform all of the network analysis steps because, while UCINET employed a more intuitive operation to transcribe the data and obtain the questionnaire metrics for the composition of the matrices related to each network, Pajek provided greater freedom for designing the graphs before they were exported as images for subsequent analyses.

4. Network Analyses

Having collected the data, we obtained a non-symmetrised, binary and complete network. This network included the 29 actors comprising the NTS, with directed connections, that is, (A;B) ≠ (B;A), and non-valued connections, which only describe whether a connection exists between the two nodes. The network modelled in UCINET was then modified in Pajek using the Kamada-Kawai layout on the Separate Components mode.**[ix]** Both procedures revealed an expansive network. Because 14 different communication channels were identified through the electronic questionnaires, we envisioned that the communication media used could be regarded as strength indicators of the relationship between a given pair of actors. Thus, two social networks, here called **A** and **B,** were prepared in the following modulations:

Consider two nodes **v1** and **v2,**

Network A – If the value of the number of interactions found between **v1** and **v2** is equal to or higher than three (3), there will be an edge (directed connection) linking the two nodes. For values lower than three, there will be no connection;

Network B – If the value of the number of interactions found between **v1** and **v2** is equal to or higher than seven (7), there will be an edge (directed connection) linking the two nodes. For values lower than seven, there will be no connection.

This approach enabled us to scrutinise the network under two conditions in which the relationship intensity was directly proportional to the number of ways that the actors were connecting. This allowed us to assess not only the network structure but also to identify which actors developed cohesive and intense connections with each other, how they behaved and what the ramifications were for the information flow structure of the network as a whole.

4.1 Network A

This section presents a directed (non-symmetrised) and non-valued (binary) square matrix (29x29) where the actors are listed alphabetically (in words rather than initials). The following network matrix (Figure 2) was obtained using the previously discussed modulations for the number of connections found:

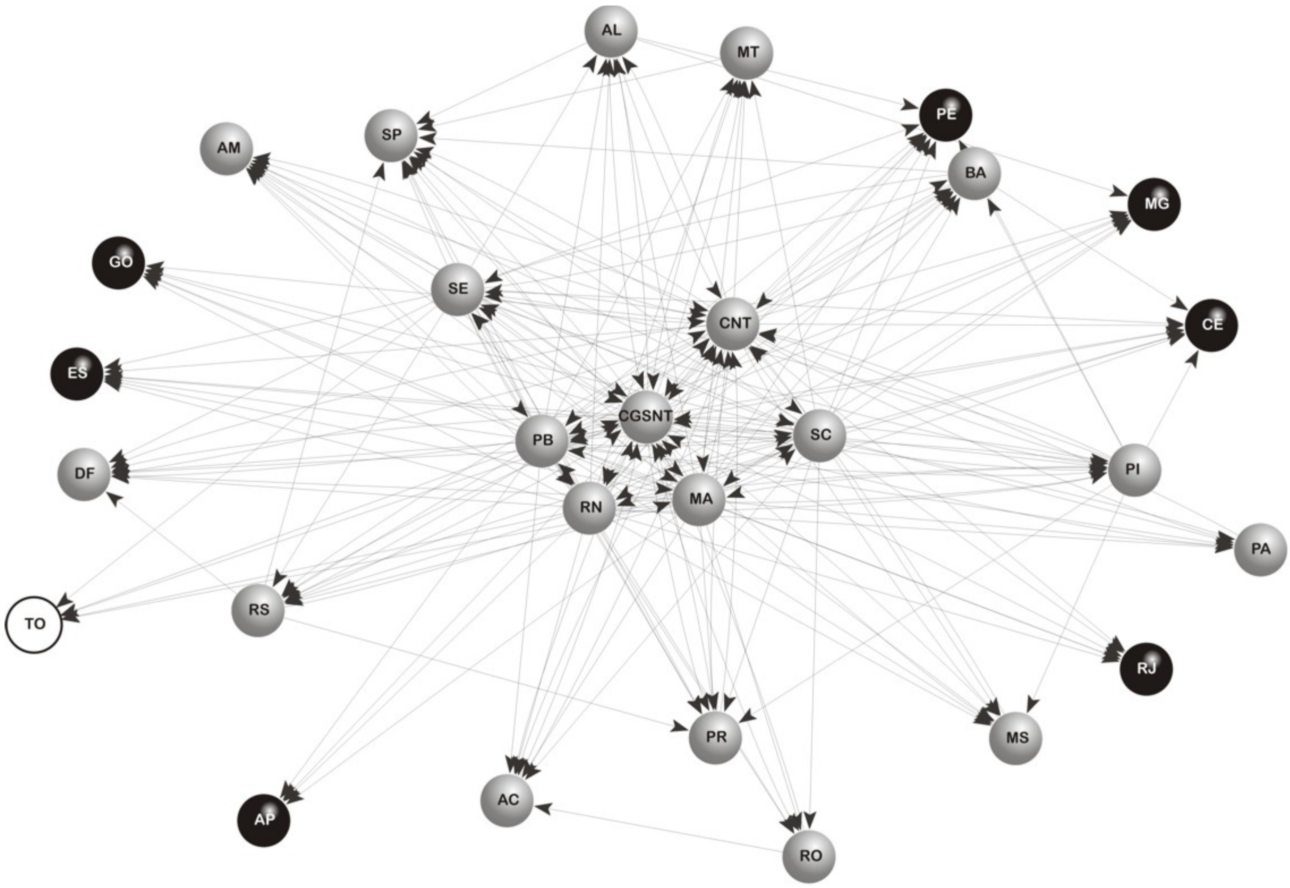
Figure 2 – Combined Matrix A

		1 A	2 A	3 A	4 A	5 B	6 C	7 D	8 E	9 G	10 M	11 M	12 M	13 M	14 P	15 P	16 P	17 P	18 P	19 R	20 R	21 R	22 R	23 R	24 S	25 S	26 S	27 T	28 C	29 C
1	AC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
2	AL	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1
3	AP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
5	BA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1
6	CE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	DF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
8	ES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	GO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	MA	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
11	MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
12	MS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
13	MG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	PA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
15	PB	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1
16	PR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
17	PE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	PI	0	0	0	0	1	1	0	0	0	1	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0	1	0	1	1
19	RJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	RN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1
21	RS	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	1
22	RO	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
23	RR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	SC	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	1
25	SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
26	SE	0	1	0	1	1	1	1	1	0	1	0	0	0	0	1	1	1	1	0	1	1	0	0	1	1	0	1	1	1
27	TO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	CGSNT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1
29	CNT	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0

Source: Developed by the authors

The values equal to zero (0) indicate an absence of connections, while those showing one (1) indicate the presence of relationships between actors. Because there are no loops (self-ties), the main diagonal is nil. After producing the matrix, the graph regarding representing the matrix was designed (Figure 3). The advantage to the graphic representation is that the central actors, the intermediate actors and those closest to the network periphery can be immediately identified visually.

Figure 3 – Combined Graph A



Source: Developed by the authors

In Figure 3, the NTCS, the NTC and CONHDs are highlighted in grey, and the CONHDs from whom no feedback was received are highlighted in black. The CONHDs of Roraima and Tocantins are highlighted in white for the reasons previously discussed. Six (6) actors are found in the centre of the graph: NTCS, NTC, MA, PB, RN and SC. Those nodes, which represent the centre of the network, are the ones with the highest degree of centrality because they receive the most information traffic.

Next, it was necessary to determine the relevant **metrics** that would quantitatively represent what was occurring in the social network and enable the analyst to draw conclusions and determine the next steps in the analysis. In this situation, there are metrics for the network as a whole, for actors and for connections. However, they were not addressed separately but were input precisely as required to address the considerations presented herein**.**

The **Degree** of an actor describes the related node's surroundings, or "the number of connections that fall on him" (NOOY, MRVAR AND BATAGELJ, 2005, p.63; **author's translation**). However, in a network where the connections follow directions (directed), the degree is divided into an **Indegree** and an **Outdegree**. In this context, the outdegree of a node represents the number of edges outgoing from it, and the indegree indicates the number of incoming connections. The degree measures how connected a given actor is to the network as whole and how many connections it has. While the outdegree, according to Hanneman and Riddle (2005), indicates the node's effect on the network, the indegree, according to Nooy, Mrvar and Batagelj (2005), suggests how prestigious an actor is compared to other group members.

In the network shown, the NTCS and the states of Maranhão, Paraíba and Rio Grande do Norte have an outdegree of 27, followed by the NTC with an outdegree of 24 and Santa Catarina with an outdegree of 23. At 19, the NTCS leads with the highest number of indegrees, followed by the NTC with 17 and São Paulo with 11. The outdegree values indicate the number of actors each actor has connections to, and the indegree values indicate the most central nodes of the network, as previously seen in Figures 2 and 3.

Connectivity describes how a graph is connected. According to Boaventura Netto (2006), this concept indicates how likely it is that information will move from one node to another through existing connections. This measure allows comparisons between networks of similar aspects. For example, it can be used to determine if a given graph 1 is more connected than a graph 7. To further analyse this measure, Boaventura Netto (2006) applies **Connectivity,** which is the measure that assesses how the network and actors behave when the intermediate nodes are removed. This measure reveals the number of nodes that must be removed for a given actor **A** to be prevented from reaching another actor **B**. Understanding this metric is useful for determining how much the network or an actor affect the further dissemination of information.

The NTCS, NTC and São Paulo showed the highest values of connectivity, with 19, 17 and 11, respectively (the highest values in their columns *j*). This means that many intermediate actors must be removed to hinder the information flow from any actor to the NTCS, NTC or CONHD-SP. At 19, Maranhão, Paraíba and Rio Grande do Norte have the highest outgoing connectivity (highest values in lines *i*). The NTC follows with 18; the NTCS and Santa Catarina both have maximal connectivity values of 17. These values indicate how strongly connected the above-mentioned actors are to the remaining actors and, consequently, to the network as a whole.

The concept of **Reciprocity** can be applied to the directed data of dyadic relations (pairs of actors). Reciprocity assesses how involved actors from one asymmetric (non-symmetrised) network are and to what degree network edges represent incoming relationships. Hanneman and Riddle (2005; **author's translation**) advocate that the higher the reciprocity values are, the more stable and balanced the network tends to be. They claim that reciprocity values answer the following questions: "What percentage of actor pairs has reciprocal ties?" and "What proportion of edges are part of a reciprocal relationship?"

For Network A, dyad-based reciprocity was found to be 0.3036 and edge-based reciprocity was found to be 0.4658. Thus, out of all of the actor pairs that have some connection, only 30.36% are involved in reciprocal relationships. However, out of all of the existing edges, nearly half (46.58%) are reciprocated connections. Despite the low value of dyadic reciprocity, a result due in part to the CONHDs not effectively involved in the research, it is somewhat surprising that nearly half of the network connections represent a two-way communication.

Betweenness, according to Marteleto (2001), indicates how much an actor intermediates, or acts as a "bridge," for the information. According to the Marteleto (2001), "a subject may not have many contacts or establish weak ties, but may have a key significance in the mediation of exchanges" (p.79). Thus, an intermediate actor assumes the power to interfere in network circulation, granting him power over effective communication. We found the following metric values: NTCS = 180.27; NTC = 100.47; SC = 14.19; PB, RN, and MA = 6.10; and SE = 6.04. Compared to the NTCS and NTC, the values of intermediate actors are low, indicating a well-connected network whose individual actors have low effective communication interdependence.

When one wishes to know the distance from one point to another in a network, one must identify the lowest value possible. **Geodesic Distance** is a concept that shows the distance between any two actors (HANNEMAN and RIDDLE, 2005). However, the shortest distance between any two points is not always the most appropriate measurement for several reasons. Hanneman and Riddle (2005) state, "If there is another way, the two actors may use it, even if that way is longer and 'less efficient'" (**author's translation).** This practice may expand the value of **Betweenness**.

In such cases, the **Betweenness Flow** measures the degree to which actors are intermediaries of information flow (in all possible paths). Analysing Network A, we found that NTCS (201.42), NTC (182.22), MA (30.40), SC (17.67), PB (17.62), RN (17.48) and SP (16.87) are the actors that mediate communication through non-geodetic paths. In general, we realised that NTCS, NTC, SC, RN, PB and MA are the most central actors. Information comes from, goes to or simply passes through these actors the most, giving outstanding power within the social structure. However, as previously discussed, we also sought to determine how those and other actors would behave in a network that required nodes to have at least seven connections to be considered relevant or strongly connected. This is the approach taken in the analysis of Network B.

4.2 Network B

By restricting the number of connections between actors that would be considered relevant in the analysis to seven, we found the following combined matrix:

Figure 4 – Combined Matrix B

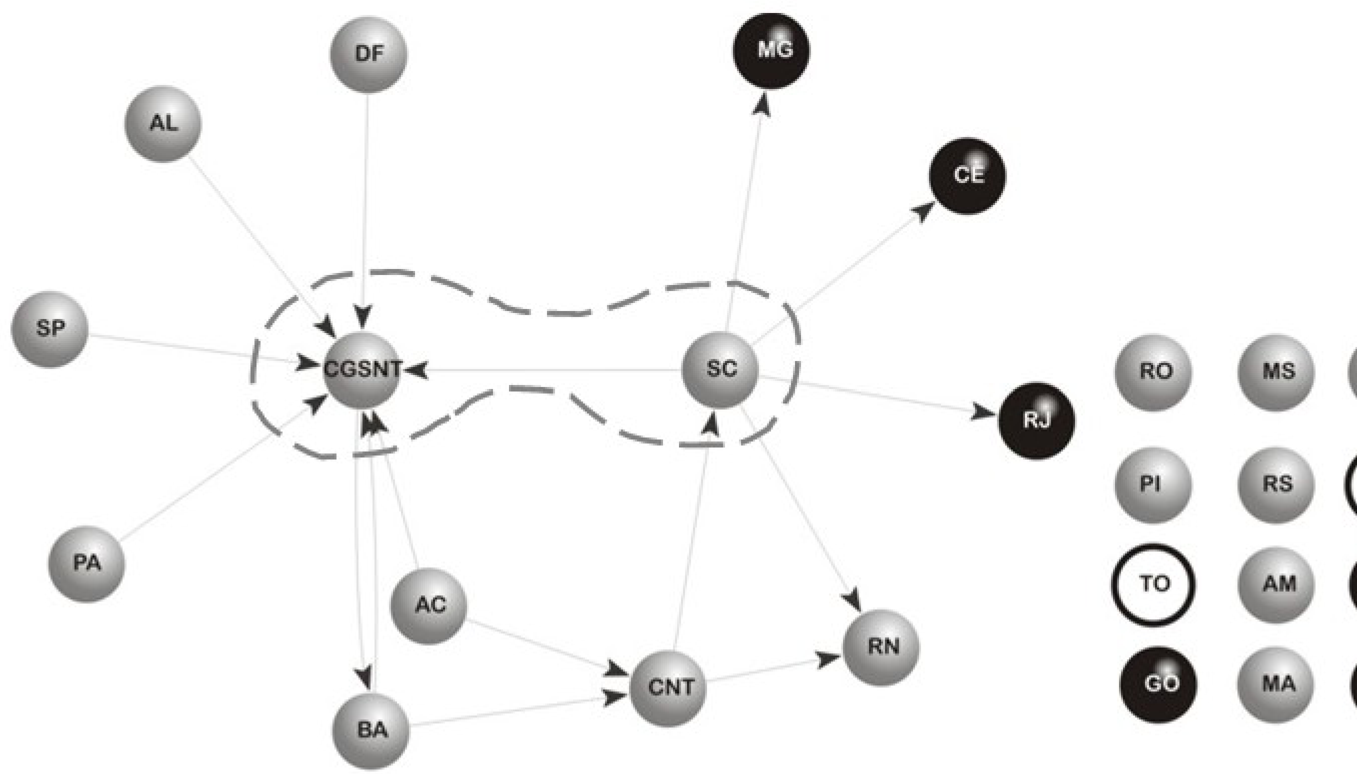
		1 A	2 A	3 A	4 A	5 B	6 C	7 D	8 E	9 G	10 M	11 M	12 M	13 M	14 P	15 P	16 P	17 P	18 P	19 R	20 R	21 R	22 R	23 R	24 S	25 S	26 S	27 T	28 C	29 C
1	AC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
2	AL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
3	AP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	BA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
6	CE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	DF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
8	ES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	GO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	MA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	MS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	MG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	PA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
15	PB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	PR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	PE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	PI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	RJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	RN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	RS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	RO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	RR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	SC	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0
25	SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
26	SE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	TO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	CGSNT	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	CNT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0

Matrix has 29 rows, 29 columns, and 1 levels.

Source: Developed by the authors

The binary values 1 not only indicate that there is a relation between the actor from line (*i*) and the actor from column (*j*), but also suggest a reasonably strong interaction between them, based on the network as a whole. The infrequency of these ties simultaneously suggests the network's high level of centrality. For further analysis, a graph was developed to complement the initial findings (Figure 5).

Figure 5 – Combined Graph B

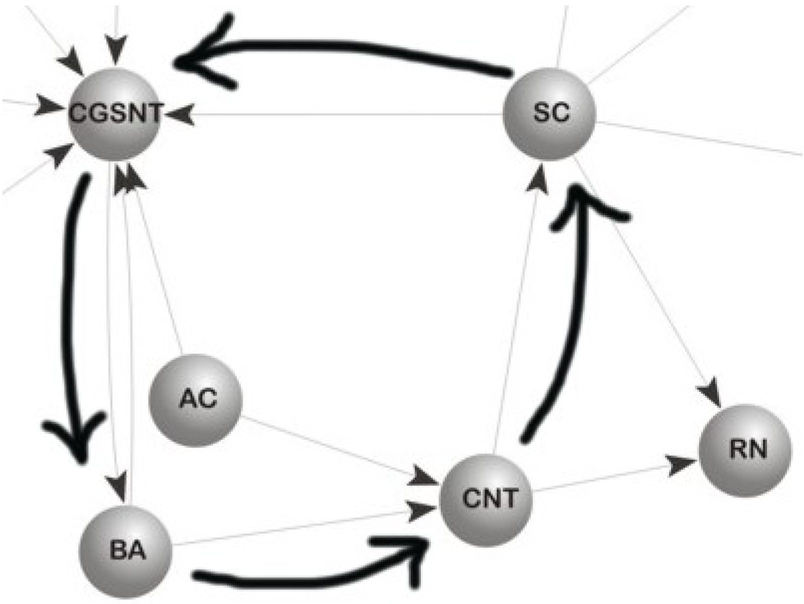


Source: Developed by the authors

Network B only has two actors competing for ascendency in the social structure's centre: the NTCS and CONHD-SC. While the NTCS has the most prestige, with the highest incoming information flow, the state of Santa Catarina sends content to more members, including the NTCS itself, and only receives from a "former" leader, the NTC.

The NTCS and the Santa Catarina centre compete for the most outdegrees and indegrees, and, despite not being at the network centre, the NTC is also strategically well placed because it manages to send to or receive information from the network leaders (the NTCS and Santa Catarina), as seen in the following diagram (Figure 6):

Figure 6 – Graph centre in detail



Source: Developed by the authors

The information flow therefore relies on a circuit favouring not only the NTC but also Bahia. The directions indicated show that all of the favoured nodes reach all of the other favoured nodes, an advantage that Acre and Rio Grande do Norte do not have. This strategic position is emphasised by the intermediation values. In its relationship with the centre nodes, the NTC shows an index of 35. This indicates that there are 35 possible paths through the NTC between pairs of actors in the whole network. The NTCS places second, with 32 paths, followed by Bahia, with 31, and Santa Catarina, with 26. These results indicate that, despite not being in the network centre, the NTC holds the greatest power to decide when and whether the information will go to its destination.

5. Analysis and discussion

Despite the risks of analysing a complete and directed social network in which several of the actors did not respond to the collection tools, we were able to reach satisfactory conclusions by making the necessary adjustments when needed. Dividing the strength of the relationships into two restriction levels was in this case effective because the pairs who maintained ties through three (3) communication channels were not treated the same as the pairs that exchanged information in seven (7) different ways. Having treated the pairs thus, we determined that identifying redundancy would be another efficient way of analysing participation in the social system because it would reveal the intensity of the connection between two nodes. Furthermore, we believe in the potential contribution of the current research to the development of a forward-thinking outlook, made possible by the forecasting element of the network, which would show when the connections between actors were weakening.

Even with the absence of seven of the states and the RR and TO centres, we decided to include all of the network actors to create a global and preliminary map while also inclusively levelling the NTCS and the NTC, which are nation-wide bodies, with the local CONHDs to allow observation of the network behaviour and thus "calibrate" the research viewpoint to a productive and accurate path that would outline the best and most appropriate future steps indicated by this study.

Although it was theoretically expected that the information dynamics would be supported on the NTCS and NTC axes, on several occasions, the National Transplant Centre did not effectively participate in the information flow of the network as a whole, allowing states, including São Paulo, Santa Catarina and Rio Grande do Norte, to be better ranked than the NTC.

Generally speaking, the complete network is extensive, with a relatively high density considering the aforementioned absences. Individually, the NTCS, the NTC and the CONHDs of RN, SC and SP predominated in terms of centrality, prestige, proximity or intermediation, representing common destinations for information and vitally contributing to the structural support of this complete network. However, the initially reasonable network structure and distribution did not provide the necessary conditions for a uniform and continuous information flow that would promote the advancement of scientific and technical knowledge at the NTS.

6. Final remarks

The NTS organ harvesting process is clearly too complex to be considered only from one perspective, and future research on the topic should take more factors into consideration. This study has shown, in general, how much the actors are (or seek to be) involved in the network's information flow. This information could be used to increase the performance of states that did not have satisfactory pmp indexes but do have a significant level of participation in the network dynamics.

This study also aimed to provide the groundwork for a doctoral project assessing the management of information and communication in social network services or the growth of the technical and scientific knowledge of CONHDs by observing the information flow within a social network provider exclusively administered for such a purpose.

Notes

[i] This study is part of a Master's thesis in the Information Science Program at PFU (Paraíba Federal University).

[ii] An individual from whom at least one organ is used on a receiver is considered an effective donor.

[iii] No further recent data were available.

[iv] No access was gained to documents with further updated statistics.

[v] No further recently published statistics for 2011were found.

[vi] Developed on Google Spread Sheets*,* which enabled the preparation, delivery and quantification of the answers received from the questionnaires.

[vii] Software developed by Lin Freeman, Martin Everett and Steve Borgatti.

[viii] Software developed by Vladimir Batagelj and Andrej Mrvar.

[ix] This is the best visual arrangement of the actors and their ties.

[MT1]Please ensure that the name is "Centrais de Notificação, Capacitação e Distribuição de Órgãos". It seems that the correct name is "Centrais de Notificação, Captação e Distribuição de Órgãos".

[MT2]Please ensure that the name is "Centrais de Notificação, Capacitação e Distribuição de Órgãos". It seems that the correct name is "Centrais de Notificação, Captação e Distribuição de Órgãos".