Detection the Coordinators by using of Social Network Analysis: Case study: in an Emergency Management

Detección de los coordinadores mediante el uso del análisis de redes sociales:
Estudio de caso: en una gestión de emergencias

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Abstract

The adverse consequences of emergencies obviously support the need for integrated preparedness of operational teams at the emergency response management to do their best to response most reasonably and effectively. The main obstacle to this preparedness is the lack of coordination across the various groups which obstruct attempts for preparation. Achievement of proper coordination requires effective relationship among all team members. One way to improve coordination is to identify effective individuals that play vital roles as coordinators in the network. This survey has been done among 142 responders of the emergency management, as a case study. To identify members who occupy the central positions as coordinators, this study utilized centrality indicators including degree, closeness, and betweenness of social network analysis at the individual level. The data were collected through structured interviews and were analyzed into social network analysis program, UCINET 6.0. This study, also, performed an attempt to investigate the relationship between demographic factors and centrality indicators. Statistical analysis was performed with SPSS 16 and GraphPad. According to the findings, individuals with high mutual selections in both directions (in and out degrees) had more chance to be accepted as powerful and influential members by other members (P<0.0000). Findings of this study indicated that there is no significant relationship between demographic factors (age, material statues, education level) and centrality indicators (P>0.05).Also, there was a significant relationship between demographic variables such as work experience, type of unit and the number of the experience in the emergency situation and the centrality indicators (P<0.05). Consequently, the present research studied the relationships among the team members of the emergency management to select coordinators. The findings of this study may allow the planners and decision makers to be aware of hidden relationships in their network.

Keywords: Coordinator, Emergency response Management, Social Network Analysis

Resumen

Las consecuencias adversas de las emergencias obviamente respaldan la necesidad de una preparación integrada de los equipos operacionales en la gestión de respuesta a emergencias para hacer todo lo posible para responder de manera más razonable y eficaz. El principal obstáculo para esta preparación es la falta de coordinación entre los diversos grupos que obstruyen los intentos de preparación. El logro de una coordinación adecuada requiere una relación efectiva entre todos los miembros del equipo. Una forma de mejorar la coordinación es identificar personas efectivas que desempeñan funciones vitales como coordinadores en la red. Esta encuesta se realizó entre 142 personas que respondieron a la gestión de emergencias, como un estudio de caso. Para identificar a los miembros que ocupan los puestos centrales como coordinadores, este estudio utilizó indicadores de centralidad que incluyen el grado, la cercanía y la interrelación del análisis de redes sociales a nivel individual. Los datos se recolectaron a través de entrevistas estructuradas y se analizaron en el programa de análisis de redes sociales, UCINET 6.0. Este estudio también realizó un intento de investigar la relación entre los factores demográficos y los indicadores de centralidad. El análisis estadístico se realizó con SPSS 16 y GraphPad. Según los hallazgos, los individuos con altas selecciones mutuas en ambas direcciones (dentro y fuera de los grados) tuvieron más posibilidades de ser aceptados como miembros poderosos e influyentes por otros miembros (P <0,0000). Los hallazgos de este estudio indicaron que no existe una relación significativa entre los factores demográficos (edad, estatutos materiales, nivel de educación) y los indicadores de centralidad (P> 0.05). Además, hubo una relación significativa entre las variables demográficas, como la experiencia laboral, el tipo de unidad y el número de la experiencia en la situación de emergencia y los indicadores de centralidad (P <0.05). En consecuencia, la presente investigación estudió las relaciones entre los miembros del equipo de manejo de emergencias para

seleccionar coordinadores. Los hallazgos de este estudio pueden permitir a los planificadores y tomadores de decisiones conocer las relaciones ocultas en su red.

Palabras clave: Coordinador, Gestión de respuesta a emergencias, Análisis de redes sociales.

Since emergencies can occur at any time and without any warning, it is expected that operational teams in the emergency response management (ERM) are effectively and reasonably prepared to respond. Ensuring a unified and well-organized preparedness requires teams to be coordinated and their members recognize as significant matters particularly during the preparedness stage. Effective coordination among various groups is critical in minimizing response time, allocating the resources properly, avoiding duplication of activities[1], mitigating adverse consequences as the core activity, and unifying and integrating the activities to ensure the most efficient use of resources for achieving the pre-determined objectives[2]. Otherwise, the lack and defects in coordination across the various groups are among the main obstacles to preparedness, which results from competition over resources, confusion in activities[3,4], and damage to teamwork[5].

- In Oxford dictionary, coordination is defined as[6] "the ability to move different parts of the body smoothly and at the same time".

- Fayol[7] pointed out that "coordination is to harmonize all the activities of a concern so as to facilitate its working and its success".

- With reference to natural disasters, coordination is defined as "an organized process of different groups of individuals with different responsibilities working together to achieve and maintain strategic plans, resources, information, activities, etc."[8] and to efficiently and logically reach some common objective[1,9] which depend on the interactions and relationships among several individuals[10].

Therefore, based on the coordination's definition from the natural disasters point of view, it is important to organize the dependencies and relations between individuals to coordinate the target wished actions. In fact, within the individuals with different duties, it seems essential to match separate activities and services and clarify responsibilities to reach a common coordination. Moreover, there must be an integrated connection between entire members of operational teams to ensure proper coordination. One way to improve the efficiency of coordination is to select effective individuals who play vital roles as coordinators. Such coordinators can also assist members of the ERM to prepare for emergencies appropriately in addition to play-

ing the role as a successful catalyst[8].

- A coordinator is defined in the Oxford dictionary as[6]: «a person whose job is to organize events or activities and to negotiate with others in order to ensure they work together effectively».

- According to the interview results in the present survey, it can be mentioned that "a coordinator is a person who cohesively organizes various teams and team members together to coordinate the activities and responsibilities to achieve the ERM objectivities as best as possible".

Based on the literature, well-trained organizational coordinators are critical factors in effectively responding to emergencies[11]. Presence of strong people in the key coordinating positions allowed to have greater efficiency in creating a coordinated response in a real environment[11], motivate others to participate and support coordination, provide confidence to use extant capabilities among different groups[12] and improve patient satisfaction in hospital settings[13]. As the research on public health section indicates[14], coordinators are effective to communicate, manage, and coordinate with the health staff and departments.

In construction projects, the role of the coordinator is critical to success and achieving the objectives of the project[15]. Also, in education programs, coordinators have effective roles to synchronize, develop, and monitor training activities and efforts[16]. In general, these research studies suggest that the efficiency and performance of the organizations are considerably affected by the central individuals as coordinators who should be particularly noticed. As such, key players should be well detected and determined to coordinate quickly and effectively in the ERM. This study, therefore, aimed to explore which team members really had this responsibility. More specifically, this case study tried to identify sets of coordinators within team members of the ERM in a refinery during 2015-2016. In order to do that, the principles of social network analysis (SNA) were chosen and applied. The present study, also, examined the associations of some demographic factors with centrality indicators among emergency responders.

In the following sections of the article, first, the SNA and centrality indicators are explained, second, the composition of the ERM is presented, third, the methodology and data analysis are presented, and at the end, the results are presented and discussed.

Social network analysis: Social network analysis (SNA) consists of actors that are connected to each other[17,18] and tries to study their relations within social networks[19-22]. SNA provides a mathematical approach to measuring the strength of relations[17,21], and plays an important role in determining the key players within individuals engaged in a network[17,18,23]. Moreover, SNA has been applied to assist the planners to recognize key players in diverse organizations. Some researchers[24,25] applied SNA to find out the key organizations of multi-organizational coordina-

tion networks, the major organizations in responding to terrorist attacks[10], and the critical individuals in criminal networks[26], the terrorist networks[27], and the agricultural and cattle networks[28]. One of the most important indicators to identify the key players in SNA is centrality which was also used in this study to identify coordinators within responders of the ERM.

Centrality
Centrality, in this study, refers to identifying the central actors in the network and demonstrating the overall importance of actors with high power and impact in the performance of the network[17,20,22,28] on whom the relations with other actors depends[29]. The important indicators of the centrality include degree, closeness, and betweenness which allow identifying the key players[17]. In the following section, these centrality indicators are explained at the individual nodes level.

Degree centrality
Degree centrality refers to measuring the importance of an actor and to calculate how many relations existed between him/her and the other network actors[30]. This index implies the total number of direct connections the mentioned actor has with the other network actors[17,20] and indicates the power and influence the main actors to have in the network[22,28]. In a directed network where the connection's direction is important, the degree centrality is divided into in-degree and out-degree centralities[20,31,32]. The number of all incoming ties to a specific node is measured as the in-degree. Also, the number of out coming ties from a given node is measured as the out-degree[20,33]. For example, in a friendship network, if an actor received more incoming ties, it means that s/he has more power in the network. Also, an actor with high out coming means that s/he has great influence on other actors[17,20].

Closeness centrality
This measure focuses on the distance between a specific actor and the other actors in the network[20]. The actors with the shortest paths are considered the most significant and the most important players[17,20] and are the most influential in the network[3]. In a directed network, in-closeness is measured based on the main actor's availability for the other actors. On the other hand, out-closeness is measured based on the other actor's availability for the main actor. In an information network with high closeness, the exchange of information takes place quickly and inversely; while, in the same network with low closeness, quick information exchange is hindered[3,10].

Betweenness centrality
This indicator is based on the shortest paths that the main actor can form to link two other members or groups and function as a point of control and intermediary in the network[17,34]. In a friendship networks, for example, an actor who links the other actors, can control friendship flow and achieve more power[17]. Also, in communication networks, as another example, a high betweenness centrality actor can play the role of intermediary in the flow of

interactions among all pairs of actors and can, in addition, be considered significant[20].

The objective of this study was to determine coordinators with emphasis on centrality indicators in coordination network. So, these three indicators of centrality were used.

Participants
To address the purpose of the present study, the main structure of the emergency response management and its subsets were determined. The study was carried out in a refinery as a case study that included seven teams composed of 142 members (table 1, the number is related to the number of responders in each unit). All participants were male. One important matter was to determine the responders who played the role of coordinators in the coordination network among the team members. In order to do this, the principle of SNA was chosen.

No	Unit-Number	Composition
**Table1. The structure of the emergency response team (n=142)**
1	Fire-fighting-32	Supervisor (1), Assistance (1), Officer (4), Firefighters (18), Mechanic (2), Drivers (6).
2	Rescue-5	Supervisor (1), Rescue (3), Driver (1).
3	HSE-29	Manager (1), Assistance (1), Safety (10), Permit (2), HSEMS (2), Health (4), traffic (6), Electrical (1), Machine (2).
4	Medical-20	Supervisor (1), Doctors (4), Nurses (6), Pharmacists (2), services (2), Reception (2), Drivers (3).
5	Logistic-18	Supervisor (1), Assistance (1), Maintenance & Repairs (11), Storekeeper (5).
6	Security-32	Supervisor (1), Assistance (1), Control (12), Physics or Operational (18).
7	Public Relations-6	Supervisor (1), Assistance (1), Employee (4).

Data collection and analysis
Considering the purpose of this study, the required data were collected through structured interviews and asking open questions. Interviews helped to clarify and expand some of the issues with regard to coordination networks. Each member was asked the following questions:

  With which members of the group do you coordinate things (for example, activities, issues, responsibilities, etc.) before an emergency occurs?

  Which members have enough qualifications to be a coordinator in the ERM?

 How can coordinators assist you to coordinate your efforts and activities while interacting with other members?

This study used binary (absent, i.e., 0.0, and present, i.e., 1.0) and directed values in data analysis. The value was 1.0 if there existed a selection, otherwise, the value of 0.0 was allocated[17]. The analysis was performed using the social network analysis program UCINET (Version 6.0)[35].

The centrality indicators depended on the number of actors and the size of a network. Therefore, normalizing these measures a percentage ranging from 0 to 100 was considered, which was calculated through the number of an actor's ties divided by the maximal possible number of ties[36]. Normalizing allowed a comparison among actors from different networks of varying sizes[37]. In general, the normalized ranges of indicators were expressed from 0 to 100 as a percentage.

This study also examined the relationship amongst centrality indicators (Dependent variables) and demographic traits (independent variables) such as age, marital status, education level, work experience, the type of units and the number of their experience in relation to the emergency situation. Statistical analysis was performed using SPSS (version 18) and GraphPad (to draw the figures).

Results

Demographic traits of responders
The demographic information of subjects was collected during the interview (table 2). The average number of years of work experience was 11.83±2.8 with a minimum of 7 and maximum of 19 years, respectively.

Table 2. The distribution of demographic traits of responders (n=142)

	Variable	Frequency	Percent
Age (year)	<30	15	10.4
	30-40	118	81.9
	41-49	7	4.6
	50 an up	2	1.4
Material status	Married	85	59.0
	Single	57	39.6
Education level	Diploma	28	19.4
	Associate degree	53	36.8
	Bachelor	50	34.7
	Master degree and higher	11	7.6
the number of experience in the emergency situation	Less than 2 times	48	33.3
	2-4 times	64	44.4
	More than 5 times	30	20.8

The descriptive statistics of the centrality indicators
Descriptive statistics including mean, standard deviation, median, minimum, and maximum values for the centrality indicators are presented in Table 3. An analysis of degree centrality showed that the maximum in-degree equaled 54; it means that almost half of the team members selected a responder (an officer of firefighting unit- Fire-O-N) as a coordinator in the coordination network (figure 3). The minimum number of in-degree indicated that a responder in the coordination network just was selected by three percent of team members as a coordinator (table 3). These findings were similar to out-degree. The maximum out-degree equaled 52 (Table 3); this value indicated that half of team members were coordinated by a responder (an officer of firefighting unit). Also, the minimum out-degree means a responder believe only one responder has ability to be as a coordinator.

According to finding, a responder (an officer of firefighting unit) was the closest to all the other team members. As a result, in-closeness centrality implies 66.5 percent of paths led to this member. So, it can be said that the coordination distance between these members and the other team members was the shortest. Also, out-closeness implied that 66.19 percent of the paths coordinated from this member to other members in the coordination network. In fact, this member could coordinate to members in the shortest distance possible.

The largest betweenness value obtained was 72.6 (Table 3). It means that a responder (a responder of logistic, Logistic-L-S) located between 72.6 % pairs of team members to coordinate together. The obtained value of the other responder (officer of traffic, Traffic-O-M) showed this member was in 5.6 % of shortest coordination paths between other team members.

Table 3. The results of descriptive statistics of the centrality indicators

	Degree		Betweenness	Closeness	
	In	Out		In	Out
Mean	23.88	23.86	7.79	44.99	49.47
Std. Error of Mean	.933	.931	1.012	.629	.587
Median	25.50	23.00	2.600	45.60	50.36
Minimum	3	1	.00	31.40	35.78
Maximum	54	52	72.6	66.50	66.19

Figure 1 demonstrates a visualization of the in-degree indicator that represents the selection space of team members. The size of the boxes (nodes) represents the frequency of selections. According to the results, four officers of the firefighting unit, a supervisor of the rescue unit and a responder of the HSE unit (traffic section) received more incoming ties (in-degree).

529
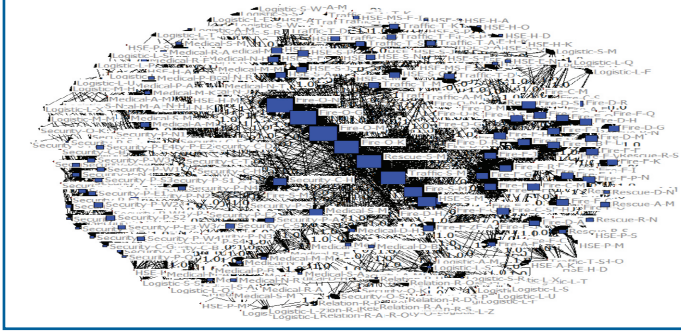
Relationship between the centrality indicators

According to the results of Pearson's correlation coefficient (table 4), there was a significant positive correlation between the centrality indicators (p<0.05). The most notable associations in this regard were observed between the out-degree and in-degree (r=0.939), while the least significant correlation was with the betweeness indicator and other centrality indicators.

Table 4. The results of correlation coefficient among the centrality indicators

	Degree		Closeness		Between
	Out	In	In	Out	
Out degree		.939	.754	.854	.454
In degree	.939		.758	.814	.465
In closeness	.754	.758		.759	.460
Out-closeness	.854	.814	.759		.572
Betweenness	.454	.465	.460	.572	

*. P(two-tailed)<0.0001, Significant (alpha=0.05): Yes

Demographic factors relationship with centrality indicators

The result of the Independent-Samples T-test indicated that there was no significant difference for centrality indicators between two groups of married and single status among responders (P>0.05). One-way variance test was used to analyze the differences among centrality indicators and the education level. The results showed having higher education level had no significant effect on the centrality indicators (P>0.05). Also, there was no association between age and centrality indicators (P>0.05). In other words, the age does not have a critical role to play in accepting or selecting individuals as coordinators. This finding suggests that for the role of coordinator, there are more important characteristics.

The correlation analysis had been carried out to test the relationship between work experience as a demographic factor and the centrality indicators. The analysis showed years of work experience as a factor having positive correlation and the significant level with the centrality indicators, exception the betweenness indicator (table5). For

instance, out-degree showed the correlation value at .419 and the significant level at 0.000, respectively. This positive value in this correlation revealed that when a responder showed a higher number of work experiences, the probability of choosing as a coordinator will be more. This is due to the possibility that the increase in the number of experience may cause more skill of responders toward creating correct relationships and interactions among responders.

Table 5. Summary of correlation among the centrality indicators and work experience

	Experience
Out degree	.419**
In degree	.355**
Out closeness	.397**
In closeness	.493**
Betweenness	.153*

**. P(two-tailed)<0.0001, Significant (alpha=0.05): Yes
*. P(two-tailed)>0.05, Significant (alpha=0.05): No

One of the findings in this study was the analysis the number of experience in the emergency situations and centrality indicators. The One-way variance test results indicated responders who had more experiences in the emergency situation have a significant association with centrality indicators, (P<0.05). This finding revealed when a respondent entered into the emergency situation, his experience and in return his selection as a coordinator will be more. According to the result, there was no significant correlation between the betweenness centrality and the emergency experience (P>0.05).

The One-way variance test results indicated there was a significant relationship between the centrality indicators and the type of units (table 6). It means, responders who are involved in some units such as fire unite had more chance to be considered as a coordinator (P<0.05). However, there was no significant correlation between the betweenness centrality and the type of unit (P>0.05). In this analysis, there was no significant correlation between fire and rescue units in the in-degree indicator (P>0.05), it means the responders in both units have equal chance to be considered as a coordinator. Also, there was considerable significant correlation between the fire and other units (P<0.05).

Table 6. One-way variance test between the in-degree indicator and the type of unit (firefighting)

	Rescue	HSE	Medical	Relation	Security	Logistic
Mean difference	-.95	6.45	8.95	26.25	12.58	22.63
sig	1.00	.030*	.003*	.000*	.000*	.000*

*The mean is significant at the 0.05 level.

Discussion

n this study, four officers of the firefighting unit received more incoming ties (in-degree) which means that they had more power in the coordination network and were accepted as coordinators by half of the other team members. Correspondingly, theses members, who had higher in-degrees, demonstrated greater influence over a larger number of team members (out-degree). These members were able to use their power to influence other members and coordinate effectively in activities through cohesive approaches. Synthesizing the past body of research, members with both high in and out degrees, as the transmitter and receiver, perform the role of the carrier, facilitate the information flow in the network[17], facilitate inconsistencies and create changes to establish cooperation between actors in the network[42]. Subsequently, these members with high in and out degrees could perform the role of the receiver in the network and be effective to create coordination among members. Actors with high betweenness in an influential position have the ability to take control of the coordination flow or even terminate the relationship between members and hinder their coordination. In this study, members of logistic and traffic among other members had more relationship with others. They were the gatekeepers of coordination network and were somehow powerful in controlling coordination among members. Some researchers suggest that presence of bridge plays a critical role in facilitation and control of information exchange flow or resources[1,29]. The finding of this study showed that few members with strategic position served as mediator. Thus, based on the present study findings, there existed a very low number of powerful brokers in the coordination network. In addition, a member is important if he/she has more direct and less indirect links and is closest to all other members of the group through fewer intermediaries [20]. In a successful relationship, members must have reciprocal connections in the lowest distance. This characteristic which is measured by closeness centrality and is recognized as an essential characteristic of coordinator shows the influence of an actor over team members in the network[20]. In this directional coordination network, the officer of firefighting with high in-closeness implied that team members could easily coordinate with him through the shortest distance. Also, this member with high out-closeness could facilitate coordination with other team members in the shortest distance. Generally speaking, members with the highest closeness implied that the coordination of activities and responsibilities occur quickly with the lowest barrier. In fact, these members simply achieved coordination. These close connections offer opportunities to have discussions over policies, objectives, activities, and to solve any possible ambiguities and misunderstandings[1]. Likewise, in clinical teams, a coordinator is a qualified nurse who controls and supports medical staff in procedures, actions, and re-

lationships[43]. Also, the difference between the minimum and maximum values of degree was notable. This indicated that key players were distinct in the coordination network. However, this difference was lower in closeness which means the members had almost equally appropriate level of access to each other. Looking at the correlation coefficient, high positive relationships between in and out degree centrality indicators were found (r=.939). It demonstrated that the most influential members affected the other members more. It can be mentioned that by fostering the influence of some members on the other team members, their prestige might increase. This finding was similar to closeness results (r=.759); so as, high positive correlation between in and out closeness centralities implied that the access distance of members to coordinators and vice versa were relatively suitable. Also, the findings showed moderate correlation between betweenness and other indicators. Similar to the past research results, significant correlation among three centrality indicators were not found due to the numerical and conceptual reasons[44,17]. Considering the few numbers of studies conducted in this field, the present area needs further investigation and discussion in future studies. The results of the study revealed that the fire-officer of firefighting unit, for instance, acquired the most selections as a coordinator. To validate the finding, the relevant and available documents and investigations were also considered. The documents indicated that the selected person had a 15-year experience, an academic degree in firefighting engineering and more than 8 experiences in the emergency situation. Moreover, the survey of statistical analysis demonstrated that some demographic factors such as the number of experience in the emergency situation, the type of unit and work experience were regarded as important factors ($p<0.05$). Thus the responders with sufficient knowledge muse have adequate experience in industrial areas. It leads to having more relationships with the reliance of the knowledge and past experience and it is considered as a significant source (Weng, 2009, Jaques, 2007, Míka, 2001), which are considered as important factors to choice key players in different research studies[45-47]. In general, the findings of this study may allow the planners and decision makers to be aware of hidden relationships in their network and to coordinate the activities and services to affect the coordination network according to the goals of ERM more efficiently. This consequently can lead to proper utilization of human resources. Effective use of key members might facilitate the achievement of organizational objectives and employment of the work-force skills and abilities efficiently. In fact, the use of talented members may enable organizations to develop strong relationships to exchange information and reach the considered objectives[49] with emphasis on the participation of members and mutual relationships[50] as factors essential to creating coordination among members. One limitation of this study was that the study was only performed in a refinery as a case study. Also, the few numbers of studies conducted in this field. Consequently, this study can be regarded as a basic pilot to motivate further research; although, the present study's limitations need to be addressed by future studies.

This study tried to identify members with higher power and influence as coordinators in the ERM. To identify such members, three centrality indicators of SNA including degree, closeness, and betweenness were utilized at the individual level. The results of this study indicated that the centrality indicators had a strong positive correlation together. This study, also, examined the associations of some demographic factors with centrality indicators among emergency responders. Findings of this study indicated that there is no significant relationship between independent variables such as age, marital situation, education level and centrality indicators. Also, there was a significant relationship between variables such as work experience, type of unit and the number of the experience in the emergency situation and the centrality indicators.

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533