Safety and Health at Work 6 (2015) 30–34

Contents lists available at ScienceDirect

Safety and Health at Work

journal homepage: www.e-shaw.org

Original Article

Evaluation of Coordination of Emergency Response Team through the Social Network Analysis. Case Study: Oil and Gas Refinery

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ARTICLE INFO

Article history:
Received 5 July 2014
Received in revised form
28 September 2014
Accepted 29 September 2014
Available online 14 October 2014

Keywords:
cohesion
coordination
emergency response team
social network analysis

ABSTRACT

Background: The purpose of this study was to examine the cohesions status of the coordination within response teams in the emergency response team (ERT) in a refinery.
Methods: For this study, cohesion indicators of social network analysis (SNA; density, degree centrality, reciprocity, and transitivity) were utilized to examine the coordination of the response teams as a whole network. The ERT of this research, which was a case study, included seven teams consisting of 152 members. The required data were collected through structured interviews and were analyzed using the UCINET 6.0 Social Network Analysis Program.
Results: The results reported a relatively low number of triple connections, poor coordination with key members, and a high level of mutual relations in the network with low density, all implying that there were low cohesions of coordination in the ERT.
Conclusion: The results showed that SNA provided a quantitative and logical approach for the examination of the coordination status among response teams and it also provided a main opportunity for managers and planners to have a clear understanding of the presented status. The research concluded that fundamental efforts were needed to improve the presented situations.

1. Introduction

The emergency response team (ERT) is considered the most effective approach for dealing with emergencies in industries, and for minimizing the risk of casualties and losses. Several groups and team members with different levels of experience and different roles and responsibilities work together in the ERT. It is expected from them to respond to the emergency as effectively and reasonably as possible. This response depends on effective emergency preparedness of the groups and team members. It was also found that effective preparedness requires close coordination among each of the response teams. Effective coordination itself implies the understanding of team members regarding each other's roles and responsibilities before an emergency occurs [1,2]. This understanding is achieved through coordination of services and activities among different responding teams [3]. In fact, organizations require a comprehensive understanding of different sectors regarding their roles, responsibilities, and authorities [1,4]. This helps in scheduling tasks and ensuring the proper management of activities [5]. This kind of understanding is also essential to minimize duplication of services, to facilitate communication [6], and to allow responders to know about each other's activities in specific conditions when necessary. Ideally, it will also be useful in the division of responders' responsibilities, information sharing, mutual agreements, common planning and programs, and in the elimination of the gaps in services [7], which was recognized as a basic problem in Hurricane Katrina [8].

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http://dx.doi.org/10.1016/j.shaw.2014.09.004

Lack of coordination is a challenge for the organizational performance of various groups [9,10], and has been recognized as a crucial hidden problem which has been principally ignored, and is accepted as one of the most important challenges that may lead to breakdowns to the response between teams [11], such as in large California wildfires [12]. Consequently, evaluations of coordination among response teams have gained increasing attention. Thus, before the response team enters an emergency and its members try to collaborate with each other, it is important to have an understanding of the coordination climate among teams and organizations, and to provide support, if necessary, in order to have an effective response. The purpose of this research as a case study is to conduct a quantitative assessment of the coordination status in ERT in a refinery. Therefore, the principle of *social network analysis* (SNA) was applied.

SNA is used to help decision makers and planners to identify the coordination status in different groups and organizations. Some researchers applied SNA to evaluate interorganizational relationships in medical sections. Studies have revealed that coordination of activities and development of relations are important issues in promoting medical and social services [13]. SNA has been used to assess interorganizational collaborations in the study of mental health systems [14]. In addition, in the emergency response following Hurricane Katrina, SNA techniques were successfully employed to find out the key members of multiorganizational coordination networks [15]. In response to catastrophic disasters, SNA assesses the relationship between responding organizations and their emergency coordination operations [16]. In the interorganizational network of responding to terrorist attacks, SNA identifies the major organizations that coordinate in the response system [17].

SNA studies and analyzes the relationships between different members and groups and structural characteristics within networks and it also provides a mathematical approach for measuring the strength of connections [18,19]. SNA plays a critical role in the determination of the degree of a team's success in achieving their goals and in the evaluation of the performance of the entire network [20]. It also plays an important role in the determination of the connections within and between parts of a network, which is known as cohesion [21–23], and it is considered an important characteristic of networks. This characteristic is measured by SNA indicators, such as density, degree, transitivity, and reciprocity, and an increase in each of these indicators enhances the cohesive level of network and improves coordination [22–25]. These indicators are explained below.

Density is a measure of the total connectedness of a network; it is the number of ties in a network as a ratio of all possible ties in a network and describes the general level of cohesion. The high value of density implies the strengthening of coordination between groups, and it increases the chance for social control of the network. If networks are denser or more cohesive, the score is 1 or 100%, which implies that all members in the network are directly connected together and a score of 0 shows that the network is entirely disconnected [21,23,25–27].

The *degree* is a measure that varies between the values of 0 and 1, with higher values representing a greater degree of centralization around one or a few members. In direct relations, the degree is divided into in- and out-degree centrality, implying the number of connections coming in and out to a given member, respectively. The high values of in- and out-degree in the whole network indicated that those limited numbers of central members have great reputations and influence other members [18,21,23,25,28]. It describes the extent to which this cohesion is organized around particular key members [23,26].

The level of *reciprocity* describes the degree to which a member has mutual connections to another member and it is an important indicator for stability of the network and development of trust among members. In direct relations with two members, if A coordinated with B, it is expected of B to have an increased tendency to coordinate with A, implying symmetric ties. This is a measure for the symmetric ties of a network. If this measure is near 0, it will correspond to low reciprocity, and values near 100% indicate high reciprocity [21,22,25].

Transitivity describes the tendency between two members in the network to be connected if they share a common mutual neighbor. In direct relations with three members, if A trusts B, and B trusts C, then A is likely to trust C without direct connections. If this measure is near 0, it will correspond to low transitivity, and values near 100% imply high transitivity, which is a key attribute of SNA [21,22,25].

2. Materials and methods

2.1. ERT

The present study was carried out in an ERT of a refinery that included seven teams composed of 152 team members, as listed in Table 1. All participants were male. Each team member undertook a set of roles and responsibilities formally assigned to him in the structure of the emergency management of the refinery. Important questions raised here are whether the response teams of the ERT have effective coordination together and if they are highly cohesive for ensuring effective response. In order to respond to these questions, the principle of SNA was utilized.

2.2. Data collection and analysis

The required data were collected through structured interviews (face to face) using a formal identification list including name, responsibility, and affiliation of each team member. Each member of the ERT was asked to choose those who they coordinated with. All selections were then recorded, archived, and analyzed as a whole network. Cohesion indicators of SNA such as density, degree, reciprocity, and transitivity were used to describe the structure of the network. This study uses binary data (absent, i.e., 0.0, and present, i.e., 1.0) and directional relations. The value is present if there be a selection within the team members. If each pair of team members does not select each other, the value of 0.0 will be allocated. The tie is directed from one member to another in a pair, i.e., it has an origin and a destination [21]. The connections for directed data are asymmetrical, because a directed line from members of rescue to firefighting will not necessarily involve a reciprocated line directed from members of firefighting to rescue. Therefore, the density was

Table 1
The structure of the emergency response team

No.	Response team	Composition
1	Firefighting	Supervisors (1), assistance (1), officers (4), firefighters (20), mechanics (2), drivers (7)
2	Rescue	Supervisors (1), rescue (3), drivers (1)
3	HSE	Managers (1), assistance (1), clerks (1), safety (10), permit (2), HSEMS (2), health (5), traffic (9), electrical (1), machine (2)
4	Medical	Supervisors (1), doctors (4), nurses (6), pharmacists (2), services (2), reception (2), drivers (3)
5	Logistic	Supervisors (1), assistance (1), maintenance and repairs (11), storekeepers (5)
6	Security	Supervisors (1), assistance (1), control (13), physics or operational (19)
7	Public relations	Supervisors (1), assistance (1), employees (4)

HSE (Health, Safety and Environment); HSEMS (Health, Safety and Environmental Management System).