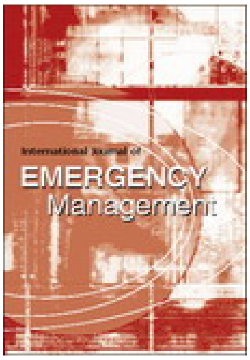

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Working memory and team-working in an emergency: the impact of response information systems

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Working memory and team-working in an emergency: the impact of response information systems

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Abstract: How does the human's limitation of limited working memory affect team-working in an emergency? This study was aimed to explore the effects through the use of a response information system (RIS). A RIS was developed and tested through standard software test matrices. A quasi-experimental study was then conducted to obtain empirical data. A total of 200 members of the fire and civil defence (FSCD) divided into two groups participated in the study. IBM AMOS based structural equation modelling (SEM) approach was used to obtain the results. This research implies that, with the emerging complexity in urban living and high-impact disasters, it has become crucial for the emergency response and rescue authority to redesign the response services for better acquisition, dissemination, and utilisation of response information.

Keywords: emergency; team performance; response information systems.

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1 Introduction

Response to emergencies is becoming more challenging due to the emerging complexity in urban living (Pal and Bhatia, 2018; Choudhary and Neeli, 2018). The emerging climate changes are also inviting increased threats of varying types of hazardous incidents (Priori et al., 2017). Emergency incidents such as fires, accidents, and other natural and man-made disasters usually drop extensive negative impacts on lives and high costs to properties in the affected community. To face such threatening impacts, the increased response capability of the emergency response agencies has become critically important (Harris et al., 2018). Generally, response capability refers to that a responding agency has sufficient human and physical resources to minimise the threats and aftermaths of an incident (Perry and Lindell, 2003). The human resource of an emergency response agency is basically composed of the members of the response team who are specially trained in elements of response activities (Perry, 2004). Usually, with better utilisation of human resource capability, an organisation can gain positive effects on its performance (Hitt et al., 2001). Emergencies often appeared with unknown operational conditions to the responders which make it unpredictable and overwhelming (Hemmatjo et al., 2017; Jones et al., 2018). Therefore, there might have the risks of capacity underutilisation of the responding members, and hence they may fail to employ their fullest selves. However, to support the utilisation of emergency response capacity, the EMISARI first evolved as the information system concept during the 1970s (Hiltz and Turoff, 1993). The concept had grown partly out of the former work at the Office of Emergency Preparedness (OEP) to obtain a departure from the general information system concept (Renner et al., 1974). Later, researchers started to concentrate on delivering the core features of the EMISARI concept through emerging technologies and handheld devices

(Turoff, 2002; Van de Walle and Turoff, 2008; Turoff et al., 2014). With such progressions, some emergency response system concepts (e.g., DERMIS) had been started to be used for supporting many of the emergency management functions such as preparedness, planning, training, assessment, response, and recovery (Turoff et al., 2004; Van de Walle and Turoff, 2008). However, there is an indication for increased attention for human-computer interaction research in the existing literature for covering the relative weaknesses of people and technology. Especially in the field of emergency response and recovery, people and technology as a team has been obtaining more attention from researchers during the last two decades (Carver and Turoff, 2007; Prasanna et al., 2013; Streefkerk et al., 2014; Nunavath and Prinz, 2017).

In this research, our focus is on the informational aspects of emergency incidents with links to the engagement and performance of the members of the emergency response team. Previous researches showed that, when people work as members of a team, their enactment at work could be affected by different factors such as usual unwillingness, social loafing (Hughes et al., 2017), ambivalent or insecure feelings (Chirumbolo et al., 2017), etc. Among the factors, the extent of insecure feelings could push them to leave out their personal selves at work. Especially in emergencies, ‘safety first’ is such a critical issue that every member of the emergency response team must follow (Hytten and Hasle, 1989). Therefore, risks may be there that the responding members could be emotionally unable to bring their personal selves at work to the extent that they were required to. Besides, choices to take an action usually associates a high level of uncertainty and time pressures in an emergency (Bohn, 1992). Hence, often, there could be a gap between the information available and the information needed to take effective action (Lipshitz and Strauss, 1997).

In such the situations, actors generally make uncertain choices (Hu et al., 2015). They also tend to consider the first few aspects, rather than considering more relevant aspects (Wallsten and Barton, 1982; Pleskac et al., 2015). Sometimes, the responding members tend to have premature closer and avoid the generation of multiple options in stressful situations (Janis, 1983; Maule et al., 2000; Turoff et al., 2004). Since an emergency response is stressful, time-critical, and threatening to safety concerns, a supporting tool for obtaining true human-computer interaction might be useful for the responders to bring their personal selves at work to a higher extent. In recent times, capability in the elements of emergency response activities through information systems integration has got increased attention of the researchers (Tzavella et al., 2017; Basu, Aggarwal and Jana, 2017). In practice, the emergency managers have stated that, the more the emergency responders are capable of collecting, analysing, spreading, and acting on key information, the more they will be able to perform well in response activities (Carver and Turoff, 2007). Researchers in the academic community also focused on a wide range of emergency response information systems (RISs) (Turoff, 2002; Turoff et al., 2004; Kwan and Lee, 2005; Boguslawski et al., 2015; Van De Walle et al., 2014; Kavitha and Saraswathi, 2018); which basically reflect the view of capacity enhancement (i.e., RBV) through information systems resource (Andreu, 1993; Wade and Hulland, 2004).

As mentioned, the focus of this research was on inculcating the extent of self-engagement of emergency responders in a human-computer system context. The members of an emergency response team could be unable to employ their personal selves due to incapacity in the current response system to avail and process timely information, even with all the other resource available. Furthermore, from the contextual standpoint, a gap was perceived regarding the sourcing, acquisition, and dissemination of the most relevant response information in the current emergency response system. To mention precisely, the local emergency response and rescue services in developing countries are usually provided by the local police stations, medical hospitals, and the fire and civil defence (FSCD) stations. For example, in Bangladesh, the FSCD is a special purpose department that provides a major portion of response and rescue services in emergencies including fires, collapses, accidents, and other natural and man-made disasters. The core role of the members of the FSCD in the communities they serve is to minimise the harms of such hazardous incidents to lives and properties. In the current system of response to emergencies, the response information is mainly availed through traditional phone calls from bystanders near the incident location. Regrettably, the same scenes are there case of emergency response systems facilities in some other developing countries (Basu et al., 2017; Wimalaratne et al., 2017). Besides, in emergencies, informants over phone calls are usually found overwhelmed, anxious, and/or scared; which often results in the receipt of confusing information from them. With such difficulties at hand, the members of the responding teams might be unable to perform with their fullest selves at different elements of response activities. In such a reality, this research is an effort to empirically investigate the effects of the use of emergency RISs on the engagement and performance of the emergency response team members, and thereby aims to inculcate whether it enables a true human-computer interaction.

However, this research was aimed to meet four specific objectives: firstly, to understand the matter of engagement of personal selves in a team in an uncertain, time-critical, stressful, and hazardous context; secondly, to understand the need for on-time response information for effective response to emergencies; thirdly, to build a comprehensive research model for technological mediation for improving the engagement and performance of the members of the emergency response team; and fourthly, to design and develop a RIS to facilitate the test of our hypotheses in this research. To our knowledge, there is a dearth of relevant studies signifying prevention focus and the engagement of emergency response professionals, who work with the paucity of necessary response information in developing countries. To fill this evidence gap, we studied the information needs of local FSCD that might expedite the responding members' zeal of employing selves in elements of response activities. The underlying assumption is that, the FSCD members with needed response information at hand might be more capable of engaging in elements of response activities, resulting in better performance outcomes. Therefore, we mainly hypothesise that the use of a RIS enhances the responding members' level of engagement and performance in emergency response activities.

2 Key concepts and definitions

As intended, this research is an attempt to study the team members' engagement and performance in emergency response, by incorporating a RIS in a causal model. In the way to serve this purpose, the following key concepts relating to the informational aspect of the response to the emergency, and engagement and performance of the members of responding teams on elements of response activities are identified and discussed. Some of the key terms and concepts that are discussed were concerned not just with defining terms but also with enunciating our intent to rationalise the emergence of initialising arrangements for greater capacity utilisation of human assets in the research field understudy.

2.1 Response information in emergencies

An emergency by its nature is unexpected and overwhelming (Gebbie and Qureshi, 2002). Gauging its initial magnitude and obtaining highly accurate information has been always crucial for ensuring better support and services (Comfort and Zagorecki, 2004). For example, the response professionals have to acquire some critical details of the incident (Yi and Özdamar, 2007) to activate the primary response initiatives (i.e., dispatching of supporting response resources such as rescue equipment, personnel resources, specialised rescue team, etc.). By practice, they obtain the information from the caller nearby an incident (Paoletti, 2009). Whilst, it has been a usual reality for them to have a series of calls on the same incident from several callers (Pettersson et al., 2004). Therefore, it becomes difficult for the responders to avail and ensure concrete basic information from such the calls. According to Whalen and his colleague, during a call for help from the caller(s), an operator follows the following five step structure for obtaining necessary information (Whalen and Zimmerman, 1987):

a identification

b what for the call is

c interrogative series

d the response to the request for help

e closing.

Specifically, the primary information includes- the caller(s) information, the location, the problem to response, available routes, resource sourcing, etc. Some other information such as geospatial information, occupancy type, and structure, response plan map, presence of hazardous substances, priorities, and opportunities, and other constraints such as exceptions and challenges are also critical for responders to make the response decisions more effective. Typically, the response resources and personnel, once dispatched, cannot be withdrawn. Besides, it has been always difficult for responding units to use paper-recorded information regarding an affected occupancy within the prescribed dispatch timeframe to the scene. Therefore, any usage of inaccurate and obscure information on incident scenarios would be threatening to the safety concerns of responding members (Menard et al., 2003).

In addition, the information in emergencies is often received with inadequacy, incompleteness, and ambiguity (Doyle and Johnston, 2011). Hence, the receivers become bound to perceive the scenario based on limited information, those have come first (Harrald and Jefferson, 2007). They also have to rely heavily on intuitive reactions (Matzler et al., 2014) and previous experience (Lipshitz et al., 2001). Consequently, decisions made in action typically have time pressures and ground uncertainties (Marold et al., 2012). It also intensifies the insecurity feelings of emergency responders (Comfort et al., 2001). Research showed that, the actors might engage in habitual routines in performing their parts when they feel less secured (Rico et al., 2008). Therefore, a possibility of workaround climate could be constructed (Dunford and Perrigino, 2018). According to Gersick and Hackman, by habitual routine, members of the team usually operate without conscious attention, evaluation, or choice. They also function automatically and show a self-sustaining tendency. Their perpetual existing pattern of behaviour result in miscode of the situation at hand and they eventually fail to produce innovative performance (Gersick and Hackman, 1990). Thus, the team members' extent of engagement at work harshly diminishes with working through the habitual routine.

However, the above discussion showed that, focus needs to be given to the sourcing, availability, and authenticity of response information to facilitate better response efforts in a time-constrained, unsafe and mysterious situation. Therefore, an information system facilitating the supply of required response information resources might be useful to obtain better engagement and performance of responding members. Virtually, it reflects the resource-based view (RBV), which emphases the organisation's ability to exploit the internal resources (Prahalad and Hamel, 1991). Thus, the information resource might meet the part of the job demands (Bakker and Demerouti, 2007) of the responding members, and hence, engagement of their efforts (Bakker et al., 2007) at the elements of the response activities might be increased.

2.2 Engagement

Engagement is defined as the combination of loyalty, commitment, productivity, and ownership feeling (Wellins and Concelman, 2005). William Kahn is the earlier researcher who defined engagement as the bringing of one's personal selves, and disengagement as they leave out of that selves during a work performance (Kahn, 1990). Engagement is used to refer to both the role performance and affective states from a psychological viewpoint (Macey and Schnaider, 2008). While, engagement as a psychological state has embraced several concepts, including job role attraction, emotional connection, positive organisational orientation, and enthusiasm to be productive (Kahn, 1990; May et al., 2004; Swanberg et al., 2011).

Moreover, engagement as a term has got a variety of definitions and conceptualisations (Christian et al., 2011). Such as, it has been regarded as work engagement (Schaufeli et al., 2002), role engagement (Kahn, 1990; May, Gilson and Harter, 2004; Rich et al., 2010; Reio and Sanders-Reio, 2011; Soane et al., 2012), multidimensional engagement (Saks, 2006; Selmer et al., 2013), self-engagement (Britt et al., 2005), job engagement (Bailey et al., 2015), etc. Interestingly, there is also the evidence of attribution to folk theory to define engagement as the common intuitive sense of a person's work motivation (Macey and Schnaider, 2008). In this study, as mentioned, particularly the focus is on the extent of engagement of the members of a team facing characteristically time strained, uncertain, and risky task perspectives.

There are however several studies describing the benefits of job engagement (Bailey et al., 2015), while few studies have investigated the antecedents of it (Saks, 2006; Shuck et al., 2011). Researches such as Schaufeli and Salanova stated that antecedents for engagement included the variables that impact the job characteristics and the type of climate and emotional states at the workplace (Schaufeli and Salanova, 2007). Shuck investigated the engagement with three antecedents, including job fit, affective commitment, and psychological climate (Shuck et al., 2011). Job fit is defined as the extent to which one's personality and values fit with his/her current job (Resick et al., 2007). A good job fitting experience includes having the necessary physical and emotional resources to complete a job (Harter et al., 2003), which results in originate psychological meaningfulness (Kahn, 1990; Resick et al., 2007). While, the affective commitment is termed as an emotive connection, and a sense of belonging with one's job, or/and work setting. The affective bond of people to the work setting signifies dedication, loyalty, and satisfaction (Rhoades et al., 2001). Also, affective commitment emphasises the emotional connection with work and closely parallels the emotional qualities of job engagement (Macey and Schneider, 2008; Saks, 2006). Whereas, the perception of a work environment in relation to the person's well-being is defined as psychological climate (Brown and Leigh, 1996) which significantly influences the development of work-related attitudes (Kahn, 1990; Harter et al., 2002). However, the measures of these antecedents can be obtained: Job fit, through Person-Organization Fit Scale (Resick et al., 2007); affective commitment, through Affective Commitment Scale (Rhoades et al., 2001; Allen and Meyer, 1990; Meyer and Allen, 1997; Meyer et al., 1993; Mowday et al., 1982); and psychological climate, through Psychological Climate Measure (PCM; Brown and Leigh, 1996). Another concept, such as behavioural engagement, implies the extent of one's engagement to work; which is the tendency of people to contribute to work roles (Harrison et al., 2006; Newman et al., 2010). It is the construct reflected by focal performance and citizenship behaviour (Borman and Motowidlo, 1993), or the withdrawal behaviours (Hulin et al., 1985). The behavioural engagement, however, builds theoretically in a straightway upon inducement-contribution theory (March and Simon, 1958), social exchange theory (Thibaut and Kelley, 1966), and equity theory (Adams, 1965). Thus, it can consider as the anthology of the motivational process, signifying more work inputs with a positive attitude to work, and poor work input with worse job environments (Weiner et al., 2012). The attitude-engagement model also specifies a broad conceptualisation of job attitudes and behavioural engagement (Ajzen and Fishbein, 1977). Some empirical studies have evidenced that, broad job attitudes predict broad behavioural criterion, and there are large within-persons variability in both job attitudes and behavioural engagement (Harrison et al., 2006; Glerum, 2017).

However, the pioneer researcher of engagement, Kahn, emphasised on the psychological conditions (Kahn, 1990; Brown and Leigh, 1996). It regulates the degree of engagement or disengagement of a person, which was an ethnographic study covering interview of sixteen financial professionals, 16 summer camp counselors, and 32 employees (Kahn, 1990). Some recent researchers also emphasised a lot on psychological states in the study of engagement (Swanberg et al., 2011; Reio and Sanders-Reio, 2011; Selmer et al., 2013). From a worrying work perspective, such as with time constraints, uncertainty, and risk, people need to understand that, the job is well fitted to him or her, the roles and responsibilities are clearly stated, and the job is meaningful to them (Sauter et al., 1990). Therefore, negative psychological manifestations can be prevented (Affleck, 1999; Burns et al., 2016). Khan, in his research, included meaningfulness, safety, and availability as the three vital dimensions of psychological conditions regulating the degree of engagement. Meaningfulness refers to the feeling that one's effort is worthwhile and useful. Safety is feeling that the work situation is trustworthy, predictable, and the 'sense of being able to show and employ self without fear of negative consequences'. While, availability is the feeling that one can drive physical, intellectual, and emotional energies into role performance (Khan, 1990).

Yet, research showed that, the work perspectives that are perceived as psychologically safe impact performance. It frees the actors to focus on desired work outcomes and enables them to use the available resources (Brown and Leigh, 1996; O'Neill and Arendt, 2008). There are also lot of evidences in the literature that inculcated numerous drivers and barriers to job engagement (Robertson-Smith and Markwick, 2009). Whilst, the existing body of literature lacks empirical investigation pertinent to the team members' engagement of personal selves, especially in a situation with high time strains and uncertain ground realities.

2.3 Team performance

In response to emergencies, team effort has been viewed as the traditional solution (Franke et al., 2010). But the responders could have lost control over many aspects of their own work in the team with the feelings of uncertainty during an emergency. Besides, the available strains evolving from an emergency may result in cognitive overload and depletion (Broadhurst, 1959; Schaufeli and Bakker, 2004), which may negatively affect their performance (Lepine et al., 2005; Klein and Boals, 2001; Leroy, 2009). By definition, effective teamwork leads to create knowledge, minimise errors, and enhance productivity, satisfaction, and other pertinent outcomes (Salas et al., 2017). The traditional I-P-O framework of team performance usually contains an input, throughput, and outputs (Hackman, 1983; Hackman, 1987; McGrath, 1984; Nieva et al., 1985; Salas et al., 2008a; Steiner, 1972; Tannenbaum et al., 1992). The measures of team performance outcomes usually include performance outcomes and affective outcomes (Mathieu et al., 2008).

Performance outcomes: Defining and measuring team performance outcomes has been viewed as one of the difficult aspects of team literature and there are diverse conceptualisations regarding this. Such as, Salas and colleagues suggested studying team performance outcomes based on efficiency, quality, accuracy, quantity, and effectiveness (Salas et al., 2008a); while Lim and Klein viewed measure of performance outcome on accuracy (Lim and Klein, 2006), and Seers and colleagues take the quality of exchange relationship as the measure of performance outcome (Seers et al., 1995). Whereas, efficiency has been used as a measure of performance outcome of teams by researchers in different fields, including sports team (Moreno and Lozano, 2012; Lee, 2017), human-tech team (Gombolay et al., 2015), production team (Seers et al., 1995; Xun, 2009), medical team (Cima et al., 2011), military team (Espevik et al., 2011), firefighting team (Akay et al., 2016; Ma, 2012), etc. Efficiency has been viewed also as a critical indicator in the case of working with limited resources during an emergency (Subash, 2004). In previous studies, performance outcomes of teams also have been studied in different ways in different studies (Hackman, 1983; Moreland and Levine, 2002; Sundstrom et al., 1990; Cohen and Bailey, 1997). With linkages to information systems, various dimensions of performance outcomes have been considered, such as quality, efficiency, and timeliness (Janz et al., 1997; Choi et al., 2010). While, these can be measured objectively based on the operational outcome or measured subjectively based on respondents' perceptions (Hexmoor and Beavers, 2002). In this study, team performance outcomes were measured using the subjective approach.

Affective outcomes: Researchers regarded affective outcomes as one of the important outputs in the study of teams (Scott and Wildman, 2017). There are a number of variables considered, such as the satisfaction of the team members and the viability of the team. Satisfaction as the team affective outcome is defined as the members' positive affective orientation towards the work and environment; which can be measured through self-report studies (Matheu et al., 2008). The affective disposition on satisfaction includes the positive affectivity in one end, which includes the eagerness, pleasures, and high energetic involvement; and negative affectivity on the other end, which includes distress, nervousness, and unpleasant involvement in the job (Fairbrother and Warn, 2003). Also, satisfaction becomes negatively affected when people guess stresses about their work (Hoboubi et al., 2017). Aside from satisfaction, confidence has been studied by several researchers as the outcome of information system use, especially within the field of emergency support and services (Levy and Taji, 2007; Baroni et al., 2014; Lawrence et al., 2002; Berner and Maisiak, 1999; Padmanabhan et al., 2006; Geldermann et al., 2009). While, team confidence is one of the important emergent states of teams, which can be regarded as both the input and the proximal outcome (Marks et al., 2001). Thus, team confidence is merely not the end result, rather emerges immediately when the team starts functioning and begins contributing to team performance. One very significant finding on the study of team confidence is that, team members perform better with confidence in perspective with lower task ambiguity than when there is high task ambiguity (De Dreu and Beersma, 2010). Therefore, it has been always needed to present a problem with lower ambiguity to support the team for better performance and affective outcomes.

However, in the study of the team, researchers considered a wide range of variables including socialisation, trust, confidence, and attitudes as the team affective outcomes concerning the perceived effectiveness of team processes (Salas et al., 2008a). Van Der Vegt and colleagues included satisfaction and commitment as the affective responses in their study on intragroup interdependence and job complexity (Van Der Vegt et al., 2000). Also, Marks and colleagues regarded commitment, and Landy and Conte regarded satisfaction as the team affective outcome variable (Marks et al., 2001; Landy and Conte, 2004).

Furthermore, there is a lot of evidence that technological association enables better team functioning (Bailie et al., 2016; Mathieu et al., 2000; Colquitt et al., 2002; Endsley and Jones, 2001; Harrald and Jefferson, 2007; Paris et al., 1999). With a concentration on teamwork, the research understudy also aimed to examine such effects in the current research field, which is supposed to be one of the pioneering investigations from the perspective of developing countries.

3 Theoretical framework

We now seek to understand the specific issues through which the use of a RIS impacts the responding members' engagement and performance through its interaction in situational complexity. The response information is critical to diagnosis the facts within an emergency. According to Norikoshi and colleagues, the availability and proper sharing of response information contribute to positive feelings (Norikoshi et al., 2018). In a research in 2018 Parsa and Hassall showed that, actors with system support yield well predictions and enhanced performance in situationally atypical events (Parsa and Hassall, 2018). However, the system support (i.e., information systems) for addressing atypical events can be felt in several ways, such as data acquisition, processing, development of knowledge component, decision support, etc.

Therefore, we treat the information system (IS) as an interaction input along with situational complexity. In doing so, system theory was used to get the focus, which rests on one of the key notions that, a system is surrounded by the environment. More specifically, we consider the basic I-P-O framework of the team which is fundamentally a system theory, to study the performance of teams (McGrath, 1964). However, it's to be noted that, the focus was only on the situational context and team support resource among the other input variables (Mohammed and Katherine, 2007; Forsyth, 1998). As conceptualised in the resource-based view (RBV), the installation of IS in an emergency department such as FSCD can be mostly considered as capacity development attempts. Ignoring the effects of the use of IS from the situational complexity context may lead to an unassessed value of IS on the responding members' engagement and performance in emergencies. Therefore, the focus was also given on the question of the value of Burney's VRIO framework (Barney, 1995), to study the outcomes of resource capability in exploiting situational complexity for obtaining better engagement and performance of the responding members.

4 Methods

Both the qualitative and quantitative approach were used to obtain the results of this study. The qualitative study included interviews with six persons who have years of experience in team functioning in the field of response and rescue services. Basically, our purpose with the qualitative study was to enrich the consistency and suitability of this study within the research domain under study and to explore the realities out there regarding the response information availability in a developing country perspective. The interviewees were selected through a convenience sampling technique, and the interviews were intended to serve three definite objectives:

a identifying the concepts and procedures that might not be reported or recognised in literature

b having insights into the types of information and knowledge that are required to be incorporated in the RIS to meet the objectives under this study

c evaluating the worthiness of the concepts identified in the review.

However, the interview with each of the members lasted approximately forty to sixty minutes. With the view to transforming it into text, each of the interviews was recorded and transcribed verbatim. The topic guide for the interview consisted of five sections. Firstly, participants were asked to opine on the major constraints they face duly when they respond to an emergency incident. Section 2 explored the major input requirements for an incident to response decisions and actions to undertake. Section 3 included the question relating to what the participants do together facing an incident. In the final section, they were asked to opine on a hypothetical new way they want to get and would opt to continue, refine or remove.

The quantitative study in this research included 200 FSCD members from local workstations. The participants comprised of firefighters, sentries, leaders, station officers (SOs), senior station officers (SSOs), assistant directors (ADs) and deputy directors (DDs) of the FSCD department. The total participants in the quantitative study were divided into two groups and were invited to participate in emergency response scenarios. For one group, the traditional system to obtain response information was trailed. While another group was provided with the RIS. In both the cases emergency response scenarios were presented with associated ambiguity and ground uncertainty. Through a structured questionnaire, both groups were asked to record their scores on a 7-point Likert scale. The data were finally entered to obtain Analysis of Moment Structures (AMOS)-based data analysis (Arbuckle, 2016), preceded by recoding into the SPSS program. A two-step procedure was followed, which includes the assessment of the measurement model by examining its properties and estimation of the structural model.

5 The response information systems

The use of information technology has been viewed as essential assistance for tracking important cues, safety requirements, and communication (Bailie et al., 2016). Especially, access to and availability of usable response information are always critically important for emergency responders (Von Lubitz et al., 2008; Sterlacchini et al., 2018). During the last two decades, the development and integration of emerging information technology tools in elements of emergency response activities have got lots of attention among researchers (i.e., GIS: Akay et al., 2011; FMIS: Wybo, 1998; WFDSS: Calkin et al., 2011). Whereas, during the primary study into the research field understudy, a shortcoming was found with the current system of sourcing and obtaining the primary response information to act on. The traditional phone call is still the primary tool to obtain the basic (i.e., location, route, water source, etc.) and other crucial response information (i.e., geospatial data, occupancy structure, response plan map, etc.). Therefore, chances could be there that the responding members operate without conscious attention, evaluation or choice and eventually engage in a habitual routine.

For inculcating the engagement of responders' personal selves and response performance, the design of system with ground reality and its trial could be an effective way. In the backdrop to the objectives, this research therefore implemented and evaluated the performance of an emergency RIS with an emphasis on its capacity to supply critical response information in time. Using the RAS metrics (Osebor et al., 2017; Rolnitzky, 2011) the designed system was found to be efficient and effective, as its reliability stood within 62.7% to 70.0% while its availability stood at 99% with a downtime of 3.65 days/year from a two months study. Black-box testing was also conducted to examine the functionality of the system in different platforms including the device types, operating systems, browsers, and network connection types. The results of the black-box test showed that the system takes an average loading time of 1s for alphanumeric contents, 3.5 s for images and graphics with the standard 4G network connection. For loading map and navigation, it took an average loading time of 5.5 s (Table 1). However, during the quantitative study into the field, we used the 4G connection.

6 The research model and hypotheses

The hypotheses under this study were constructed based on the key discussion included in key concepts and definitions. To support the hypotheses, the study includes necessary discussion on related theories and prior researches. As mentioned in the theoretical framework, the I-P-O framework was used together with VRIO to guide the development of the hypotheses. The key variables included: situational complexity as an exogenous variable, RIS as exogenous interaction variable, and team member's engagement as a first-order endogenous variable, and team performance as the second-order endogenous variable.

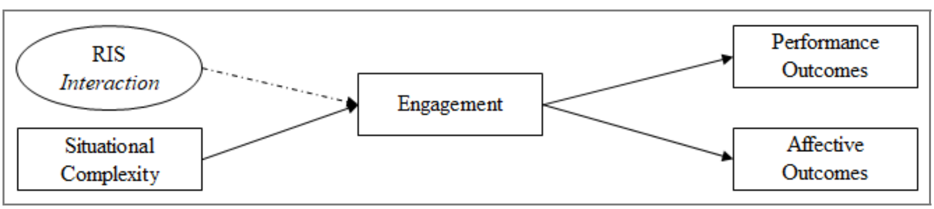
Table 1 Black-box test results of average loading time

System tool	*GSM Network*			*Broadband*		*Platform*		
	4G	*3G*	*2G*	*Wired*	*Wi-Fi*	*PC**	*Phone^*	*Tablet^*
IE8	3.6 s	4.0 s	10 s	3.6 s	3.6 s	3.6 s	–	–
Chrome	3.5 s	3.9 s	09 s	3.5 s	3.5 s	3.5 s	4.0 s	5.0 s
Firefox	3.5 s	3.9 s	10 s	3.5 s	3.5 s	3.5 s	5.0 s	6.0 s
Safari	3.6 s	3.9 s	10 s	3.6 s	3.6 s	3.6 s	–	–
Opera	3.5 s	3.9 s	10 s	3.5 s	3.5 s	3.5 s	4.5 s	6.0 s
UC	3.5 s	3.9 s	09 s	3.5 s	3.5 s	3.5 s	5.0 s	6.0 s

*Windows, ^Android.

In the way to reach the result of this study, each variable was measured with corresponding manifest variables (Figure 1). Prior research on system-enabled information generation suggests that IS contributes to emergency operations in several ways. First, IS contributes to knowledge generation processes used for problem diagnosis (Mukhopadhyay, 2015). Second, IS can enable the responders to scan both the avoidable and unavoidable difficulties in an emergency (Pathirage et al., 2015). Third, with IS support, the responding members can be able to identify the key opportunities to make response operations effectual (Alexander, 2015). Forth, IS has been appeared as an enabler of team coordination for emergency support and service departments (Reddy et al., 2009).

Figure 1 The proposed research model



With the emerging reality of an increasing number of emergency incidents, it has become a crucial necessity for the emergency departments to ensure high engagement of the emergency responders. While, such engagement could be tarnished by the inadequacy of necessary information, or for impaired information processing capacity of responding members because emergency often overwhelms with its complexity. Thus, it's been usual that the responding members underperform in such a situation. With such a problem at hand, usage of a RIS could be prolific in capitalising on the responding members' ability to employ their selves. Plus, might the eventual performance level: (a) performance outcomes and (b) affective outcomes of the responding members using RIS be higher, which were translated into the following research hypotheses:

> *$H1_a$: The effect of situational complexity on the engagement of emergency responders is different between the use and not the use of response information systems [$ENGA_{without} \neq ENGA_{with}$].*

$H1_b$: The effects of situational complexity on (a) performance outcomes and (b) affective outcomes mediated through the engagement of emergency responders are different between the use and not use of response information systems [$PERF_{without} \neq PERF_{with}$].

Besides, this study was aimed to examine the type of effects the use of RIS has on the level of engagement and the level of resulting performance outputs of the responding members in the situational negativity of emergency through an I-P-O framework. Therefore, we also hypothesised that,

$H2_a$: The use of a response information system dampens the negative effects of situational complexity on the engagement of emergency responders.

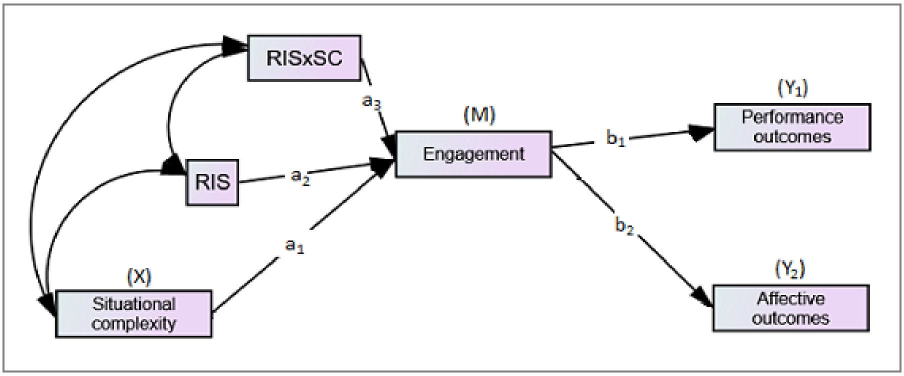
$H2_b$: The use of response information system dampens the negative effects of situational complexity on (a) performance outcomes and (b) affective outcomes mediated through the engagement of emergency responders.

However, to test the hypotheses under study we used single group SEM analysis (Ryu and Cheong, 2017). In this type of analysis, the categorical variable representing the membership in the study group is usually used as a covariate in the model. Also, an interaction term of the exogenous variable (*X*) with the group affiliation is included to test the difference in the independent variable (*X*) to mediating variable (*M*) relationship between the study groups (i.e., Figure 2). The explanation of the constraints depends on the way the group membership is coded. In this study, the membership was dummy coded as 1 for RIS use and 0 for RIS do not use. As shown in Figure 2, a_1 = simple effect of situational complexity (*X*) on engagement (*M*) for members who did not use RIS; a_2 = group difference in conditional mean of engagement (*M*) for when the level of situational complexity (*X*) is at zero (i.e., conditional mean of engagement (*M*) in members who use RIS – conditional mean of engagement (*M*) in members who did not use RIS; a_3 = difference in simple effect of situational complexity (*X*) on engagement (*M*) between study groups (i.e., simple effect of situational complexity (*X*) on engagement (*M*) in members who use RIS – simple effect of situational complexity (*X*) on engagement (*M*) in members who did not use RIS). If $a_3 \neq 0$, it means that the relationship between situational complexity (*X*) and engagement (*M*) is not the same between groups. When the relationship between situational complexity (*X*) on engagement (*M*) differs between groups, the effect of situational complexity (*X*) on performance outcomes (Y_1) and affective outcomes (Y_2) via engagement (*M*) is conditional on the group membership, because the effect consists of *X* to *M* relationship and *M* to *Y* relationship.

In the model shown in Figure 2, an estimate of the effect of *X* on Y_1 via *M* is obtained by $\left[\left\{\widehat{a_1} + \widehat{a_3}\left(\text{RIS}\right)\right\}\widehat{b_1}\right]$ and effect of *X* on Y_2 via *M* is obtained by $\left[\left\{\widehat{a_1} + \widehat{a_3}\left(\text{RIS}\right)\right\}\widehat{b_2}\right]$ (Preacher et al., 2007). Therefore, the simple effect (i.e., the conditional indirect effect) estimate for the use of RIS (coded 1) is $\left[\left\{\widehat{a_1} + \widehat{a_3}\left(1\right)\right\}\widehat{b_i}\right] = \left(\widehat{a_1} + \widehat{a_3}\right)\widehat{b_i}$ and effect estimate for not the use of RIS (coded 0) is $\left[\left\{\widehat{a_1} + \widehat{a_3}\left(0\right)\right\}\widehat{b_i}\right] = \widehat{a_1}\widehat{b_i}$ in the path $X \rightarrow M \rightarrow Y_i$. Thus, the estimated difference in the effect is $\left[\left(\widehat{a_1} + \widehat{a_3}\right)\widehat{b_i}\right] - \widehat{a_1}\widehat{b_i} = \widehat{a_3}\widehat{b_i}$ (Hayes, 2015). Precisely, for the hypotheses under study the expressions are: $\widehat{a_3} \neq 0$ for $H1_a$; $\widehat{a_3}\widehat{b_1} \neq 0$

for H1$_{ba}$; $\widehat{a_3}\widehat{b_2} \neq 0$ for H1$_{bb}$; $\widehat{a_3} > \widehat{a_1}$ for H2$_a$; $\left[\left(\widehat{a_1}+\widehat{a_3}\right)\widehat{b_1}\right] > \widehat{a_1}\widehat{b_1}$ for H2$_{ba}$ and $\left[\left(\widehat{a_1}+\widehat{a_3}\right)\widehat{b_2}\right] > \widehat{a_1}\widehat{b_2}$ for H2$_{bb}$.

Figure 2 The hypothesised model (see online version for colours)



7 The research procedure

Primarily, the questionnaire in this study was designed based on hypotheses developed in the previous stage. The questions were natured with slight modifications to adjust to the research context and to ensure clarity in expression with reference to previous relevant researches. Each of the questions was considered as the source of data. A total of 19 items and four constructs were included in the questionnaire with a biographic section in the first part. Plus, the use and not use of the RIS was marked with a dichotomous variable to keep the track of participants between with and without the support of RIS. Validation of the questionnaire was confirmed through pre-testing and a pilot survey before going to the final study. Feedbacks of the participants to questionnaire pre-tests were incorporated cautiously to contextualise the instruments and to ensure the reliability of the questions. The final collection of data entailed the distribution of the structured questionnaires to seek the responses of the members of the emergency supports and services team of different FSCD stations in different divisional and district level cities and towns of Bangladesh. A total of 200 FSCD team members were targeted for data collection: they were selected through two-stage cluster random sampling from a list of FSCD units in Bangladesh. In three clusters (City, District, and Upazila) there are 287 FSCD stations in Bangladesh. A total of 125 responses were gathered from the city level, and 75 responses were gathered from the district level FSCD stations. The demography of the respondents is included in Table 2.

Table 2 The demography of the respondents

Age (In Yrs.)				*Experience (In Yrs.)*				*Designation*		
18–27	*28–37*	*38–47*	*48 and above*	*1–4*	*5–8*	*9–12*	*13 and above*	*Officer*	*Leader*	*Fire Fighter*
42	90	46	22	31	41	39	89	20	42	138
21.0%	45.0%	23.0%	11.0%	15.5%	20.5%	19.5%	44.5%	10.0%	21.0%	69.0%

7.1 Measuring instruments

Four self-reporting measuring instruments were identified and used in measuring the latent constructs under this study. In modifications brought to ensure the best fit and well capture of key characteristics of the measurement items, this study used relevant references and calculated coefficient alpha threshold. The details are included in the following section:

For assessing *situational complexity* researchers typically use a participant-based post-scenario questionnaire (MacMillan et al., 2013; Freund and Berzowska, 2010; Blum et al., 2005). For example, in research Entin and colleagues used a post-mission questionnaire to assess the effectiveness of the TACT program and found high reliability (Entin and Serfaty, 1999). To reach our aim to measure the effect of using the RIS as an interaction variable, we conducted scenario runs and used participant-based measures to obtain the ratings on the aspects of situational complexity. The measurement variables included: difficulty (SC1: the extent to which you understand the level of effort needed to address the incident) complexity (SC2: the extent to which the situation associates varying dimensions), uncertainty (SC3: the extent to which you think the situation could be different than how it is predicted), ambiguity (SC4: the extent of missing information associated with the situation) and pressure (SC5: the extent to which the situation makes you feel stressed). In this study, in item level, the factor loadings found to be ranged from 0.779 to 0.985 (Table 3) and the coefficient alpha found to be 0.948.

Table 3 Factor loadings of the measurement items

Variables	*Items*	*Factor loadings*	*Item-total statistics**	*Alpha coefficients*
Situational complexity	SC1	0.878	0.856	0.948
	SC2	0.985	0.939	
	SC3	0.779	0.783	
	SC4	0.953	0.904	
	SC5	0.825	0.828	
Engagement	EN1	0.931	0.899	0.961
	EN2	0.933	0.908	
	EN3	0.865	0.854	
	EN4	0.952	0.922	
	EN5	0.876	0.868	
Performance outcomes	PO1	0.914	0.864	0.932
	PO2	0.861	0.830	
	PO3	0.857	0.819	
	PO4	0.886	0.845	
Affective outcomes	AO1	0.604	0.542	0.915
	AO2	0.918	0.877	
	AO3	0.883	0.834	
	AO4	0.857	0.810	
	AO5	0.845	0.779	

*Corrected item-total correlations at item level.

The *engagement* of the participants was measured using a modified version of the Person-Organization (P-O) Fit Scale (Resick et al., 2007) and Psychological Climate Measures (Brown and Leigh, 1996). Virtually, the P-O fit scale includes several measures (Rodgers, 2000; Mikkelsen, 2015). Since, the subjects under study are specially trained, measures as role fit (EN1: the extent to which you understand your roles and responsibilities), team fit (EN2: the extent to which you believe you would be able to work with greater cooperation from others) and needs/supplies fit (EN3: the extent to which you found suitable the supplies you need to function well) among others were considered. In addition, regarding engagement, the psychological climate has been considered as the measures of organisation members' perception of psychological safety and personal significance (James et al., 1978). In definitions, these issues comprised of different measures including management support, clarity, self-expression, recognition, and challenge (Brown and Leigh, 1996; Biswas, 2011). To find a fit to the field under study we included two and rephrased those as- safety feeling (EN4: the extent to which you feel safe to infuse your abilities) and meaningfulness (EN5: the extent to which you can be able to scale the vitality of your work role) to measure the psychological climate. In the item level, the factor loadings found to be ranged from 0.865 to 0.952 (Table 3) and the rater version of the scale yielded the coefficient alpha was 0.961.

For measuring *team performance* especially in experimental conditions, a variety of measures including both the observer-based and participant-based measures can be applied (Entin and Entin, 2001). To obtain the measures of *performance outcomes*, this study mostly used participant-based measures, since this study included a scenario run of use and not-use of information systems (Janz et al., 1997; Choi et al., 2010). The key measures included: timeliness (PO1: critical information was obtained within the prescribed timeframe), efficiency (PO2: the extent to which you thought your attempts were quickest and used the best alternative), accuracy (PO3: place your rating on the level of accuracy of information that you'd obtained, shared and used) and communication quality (PO4: rate the quality of communication among the team members). In the item level, the factor loadings found to be ranged from 0.857 to 0.914 (Table 3) and the coefficient alpha the scale yielded was 0.932.

In measuring *affective outcomes*, scholars in the field of team research used several variables such as- satisfaction and commitment (Marks et al., 2001; Van Der Vegt et al., 2000; Laney and Conte, 2009). Early research by Brustad demonstrated that team affective outcome includes the affective experiences of the members in the achievement contexts (Brustad, 1988). In 2009 in a meta-analysis, Klein and colleagues demonstrated 'trust' as a significant indicator of team affective outcome (Klein et al., 2009). In research, Salas and colleagues included trust and confidence as the measures of team affective outcome (Salas et al., 2008b). A recent academic effort by Krzeminska and colleagues evidenced that, with occupational stresses, team members may lose their endeavour to do their part (Krzeminska et al., 2018). Therefore, team members' motivational orientations can be also considered as the measures of team affective outcomes. However, in this study we used- satisfaction (AO1: rate your level of satisfaction that you feel with your work and responsibilities with the current system), commitment (AO2: rate your level of commitment that you have with your work and responsibilities with the current system), confidence (AO3: rate your level of confidence on yourself and on others in the team at your work and responsibilities with the current system), trust (AO4: rate your level of trust on your teammates that they well understood the situation and are able to assist you perfectly) and encouragement (AO5: rate your level of energetic involvement to conduct your responsibilities in this perspective) to obtain the measures on team affective outcomes. In the item level, the factor loadings found to be ranged from 0.604 to 0.918 (Table 3) and the coefficient alpha the scale yielded was 0.915.

7.2 Statistical analysis

Missing values: It has been common to have missing values in assessment through self-report instruments (Jo et al., 2010). To confirm the accuracy of the parameter estimates and to obtain a valid result of the study, the problem of missing value must be properly addressed (Fox-Wasylyshyn and El-Masri, 2005). In researches, different methods can be applied to appropriately impute the missing values (Schmitt et al., 2015). In this study, imputation by mean was used to address the problem.

Item analysis: The item analysis in this study was performed to calculate the alpha coefficients and to test the item-total correlation which is used to check if there any item that is inconsistent with the averaged behaviour of other items of a test. Maintaining through the cut-off criteria of it (>0.30) crops to the purification of the measures by eliminating the items that do not actually represent the construct (Churchill, 1979). We also performed factor analysis and crosschecked with AMOSTM graphical user interface (GUI) run to find factors loadings of the measurement items (Table 3).

Unidimensionality: All the factors measuring a latent construct should have positive and acceptable factor loadings, which is said that unidimensionality achieved (Anderson and Gerbing, 1988). In doing so, the items with lower factor loading less than 0.50 should be omitted from the model. However, in this study, the factor loadings corresponding to each of the latent variables as presented in Table 3 met the unidimensionality criteria.

Validity: Validity concern is the central point for research to prevent it from the garbage in and out. In this research, for the construct validity concern of the instruments, the required level of fitness indexes was achieved using confirmatory factor analysis (CFA). The other important validity concerns- convergent and divergent validity were also ensured as per the established cut-off criteria (Table 4).

Table 4 Model validity and reliability measures

Variables	*CR*	*AVE*	*MSV*	*MaxR*(H)
SC	0.948	0.788	0.724	0.981
EN	0.961	0.832	0.724	0.967
PO	0.932	0.774	0.528	0.935
AO	0.915	0.687	0.560	0.937

SC: Situational complexity; EN: Engagement; PO: Performance outcomes; AO: Affective outcomes; CR: Composite reliability; AVE: Average variance extracted; MSV: Maximum shared variance; MaxR(H): McDonald construct reliability.

Reliability: The reliability of each of the instruments used in this study was ensured using the scale reliability analysis procedure. As discussed in the result section, the reliability concerns including- internal, composite and AVE for the respective constructs were achieved with the required cut-off level (Table 4).

Ethical consideration: In terms of ethics, the purpose of the research was shared with the participants. Plus, informed consent was sought from the participants before the completion of the questionnaire and confidentiality of the data was maintained. Participants were not obliged to become the part of the study and there was no envisaged harm.

Structural equation modelling: Structural equation modelling (SEM) has become one of the leading choices of researchers (Hooper et al., 2008). It helps to describe the extent to which each manifest variable can measure the latent constructs, termed as measurement models. Plus, it aids in explaining the hypothesised relationship among the constructs in a causal model, termed as the structural model. As mentioned earlier, item analysis is usually performed to ensure the sound estimation of the measurement model. To do so, SPSS 15.0 was used in this study to identify any poor items (i.e., corrected-item-total correlations < 0.30). After confirming that no poor item is present, IBM AMOSTM 24 was used to perform CFA. To obtain satisfactory fit, one indicator variable (i.e., AO1) was deleted, since it contained a lower factor loading < 0.60 and R2 < 0.40 (Awang et al., 2015). For further model refinement, the modification indices after every run were checked carefully to obtain the value of fit indexes within the cut-off range (Hu and Bentler, 1999). However, to reach the finest fit, the measurement model in AMOS GUI took a second time run in this study; the detail of which is included in the result section. Once a satisfactory fit was achieved, regression lines between the exogenous and endogenous latent variables were constructed. To obtain the structural model in accordance with the hypotheses, the use and not use of the RIS was added as an interaction variable (i.e., Figure 2) in a single-group SEM (Ryu and Cheong, 2017). It is to be noted that, since RIS in the model was an exogenous dichotomous variable and measured through dummy coded 0 and 1, a parameter constraint was used (Arbuckle, 2016). However, like it was during the measurement model stage the modification indices were checked with care after the model run in AMOS GUI. In the first run, the model showed the hypothesised paths significant and a good fit for fitness indexes except for a terrible fit with PClose (Hu and Bentler, 1999). To achieve a more acceptable model fit, error variance of two indicator variables (i.e., e2 and e4) was freed up during the second run and one indicator variable (i.e., SC3) was dropped during the third run as per the modification indices. More detail on the structural model under study is included in the result section.

8 Results

Given that this paper dealt with latent factors (i.e., situational complexity, engagement and performance, and affective outcomes) and an observed variable (i.e., RIS), a hybrid SEM approach was used (Markus, 2012). To obtain an indication for acceptable strength of the measures and test of hypotheses, this study included required statistical analyses and model runs, which products to the following key results:

8.1 The measuring items

The first result to include here is that the size of the factor loadings of the measuring items for corresponding constructs in this study ranged between 0.542–0.939 (Table 3) and therefore met the unidimensionality criteria (factor loading > 0.50) to become initially fit for measurement model. Also, the corrected item-total correlation estimate (Table 3) showed that none of the value violated the cut-off criteria (>0.30) to represent the averaged behaviour of other items in the test. On validity concerns, the estimated value for the average variance extracted (AVE) for the constructs found to be ranged between 0.687–0.832 (Table 4), which met the basic criteria for convergent validity (AVE ≥ 0.50). Also, the items in the measurement model were found statistically significant at $p < 0.001$. Thus, all required criteria for convergent validity was passed. Besides, the fit measures for the constructs from model run was found as *x2/df* = 2.530, CFI = 0.94, NFI = 0.91, TLI = 0.94 and RMSEA = 0.08 from a pooled measure, which met the cut-off criteria for the construct validity. To be confirmed that, the constructs in the model are free from redundant items, the maximum shared variance (MSV) for each of the constructs was obtained. The estimate showed that for every construct the AVE is higher than the corresponding MSV (Table 4); therefore, the divergent validity concern was also conceded.

In addition, to find the solution of how reliable the measurement model is for measuring the latent constructs under study, the corresponding Cronbach's alpha (α) and Composite Reliability (CR) were calculated. The result showed that for every construct the Cronbach's alpha exceeds 0.70 (Table 3). Therefore, the internal reliability criteria (i.e., the strength of the measuring items to hold together in measuring the corresponding construct) was satisfied. As shown in Table 4, the result also met the criteria for composite reliability (CR ≥ 0.60), and thus the internal consistency of the constructs was proved.

To become confirmed a more on the reliability concern of the measures, the average percentage of variation explained by the measuring items for a latent construct required to be greater than 0.50 (i.e., AVE > 0.50). For the constructs under study, the lowest AVE estimate is 0.687 (Table 4), which is greater than 0.50. Therefore, all the criteria for reliability concern were satisfied.

8.2 Goodness-of-fit: the measurement model

After the first run of the measurement model understudy, the χ^2 value showed an estimate of 369.312 with df = 146 significant at the level of $p < 0.001$. Hence, the χ^2 to df ratio was 2.530 (Table 4) and to this estimate, the model fit (MM1) to the data was satisfactory. Likewise, the other comparative family indexes showed a good fit to the data (NFI = 0.918, RFI = 0.904, IFI = 0.949, TLI = 0.940, CFI = 0.949, SRMR = 0.078). While, the RMSEA estimates indicated slightly poor fit (RMSEA = 0.088, LO = 0.077, HI = 0.099, PClose = 0.000). Through a careful look into the modification indices, it was identified that tuning up of one item with the latent construct affective outcomes could improve the model fit. That same item (i.e., AO1) was also found to embrace the lowest factor loading in the model. Therefore, the case was dropped, and the new-tuned model was run. For the new measurement model (MM2) the χ^2 value showed an estimate of 208.840 with df = 129 significant at the level of $p < 0.001$. Hence, the χ^2 to df ratio was 1.619 (Table 5), which is within the cut-off criteria for model fit (i.e., between 1 and 3). Besides, the other fit indexes were changed to a better level of model fit (NFI = 0.951, RFI = 0.942, IFI = 0.981, TLI = 0.977, CFI = 0.981, SRMR = 0.034). The RMSEA estimates also showed better fit compared to MM1 (RMSEA = 0.056, LO = 0.042, HI = 0.069, PClose = 0.239). Although the fitness indexes showed better model fit and the modification indices had no critical indication for adjusting discrepancy after the second run, we decided to omit one indicator variable of situational complexity (i.e.SC3), since it embraced the lowest squared multiple correlations (R2) in the model (i.e., 0.61) and ran the newly tuned measurement model (MM3). In the new run, the χ^2 estimate showed a value of 173.969 with df = 113 at $p < 0.000$ level of significance; resulting in an estimate of 1.540 for χ^2 to df ratio. Therefore, χ^2/df cut-off criteria were satisfied. Besides, the other fit indexes were changed to an improved level of model fit (NFI = 0.957, RFI = 0.949, IFI = 0.985, TLI = 0.981, CFI = 0.984, SRMR = 0.033). Compared to the second measurement model (MM2), a finest fit in the RMSEA estimate was also observed in this refined model (RMSEA = 0.052, LO = 0.036, HI = 0.067, PClose = 0.397). Hence, the refined measurement model (MM3) was finalised to be used for the structural model.

Table 5 Results of SEM fit indices for measurement models

Models	X^2	*df*	X^2/df	*CFI*	*NFI*	*IFI*	*SRMR*	*RMSEA*	*PClose*
MM1	369.312	146.000	2.530	0.949	0.918	0.949	0.078	0.088	0.000
MM2	208.840	129.000	1.619	0.981	0.951	0.981	0.034	0.056	0.239
MM3	173.969	113.000	1.540	0.984	0.957	0.985	0.033	0.052	0.397

*Significant at $p < 0.001$, MM: Measurement model.

8.3 Goodness-of-fit: the structural model

Given the inclusion of interaction effect and one mediating variable, the model was initially tested with no direct path between exogenous and outcome constructs. After the run of the initial model (SM1), the χ^2 value showed an estimate of 306.428 with df = 147 at $p < 0.001$ level of significance (Table 6). Hence, the χ^2 to df ratio was 2.085, which met the cut-off criteria. Also, the other fit indexes showed a good fit to the data (NFI = 0.943, RFI = 0.934, IFI = 0.970, TLI = 0.965, CFI = 0.970, SRMR = 0.033). Whereas, the RMSEA estimates showed slightly poor fit (RMSEA = 0.074, LO = 0.062, HI = 0.085, PClose = 0.001). By looking into the modification indices, it was identified that, drawing a double-headed arrow (i.e., covariance) between the residuals of two measurement variable (SC2 and SC4) of the situation complexity would improve the model fit. Given the commonness of a linear relationship between complexity and ambiguity, the suggested line made theoretical sense. The modified model with an added covariance line (SM2) indicated good fit to the data in χ^2/df estimate. (i.e., χ^2 = 222.755, df = 146, $p < 0.000$; χ^2 to df ratio = 1.526). Besides, the other fit indexes were changed to a finest level of model fit (NFI = 0.959, RFI = 0.952, IFI = 0.985, TLI = 0.983, CFI = 0.985, SRMR = 0.033). Plus, compared to initial structural model (SM1), the RMSEA estimates showed better fit for the refined model (RMSEA = 0.051, LO = 0.037, HI = 0.065, PClose = 0.419).

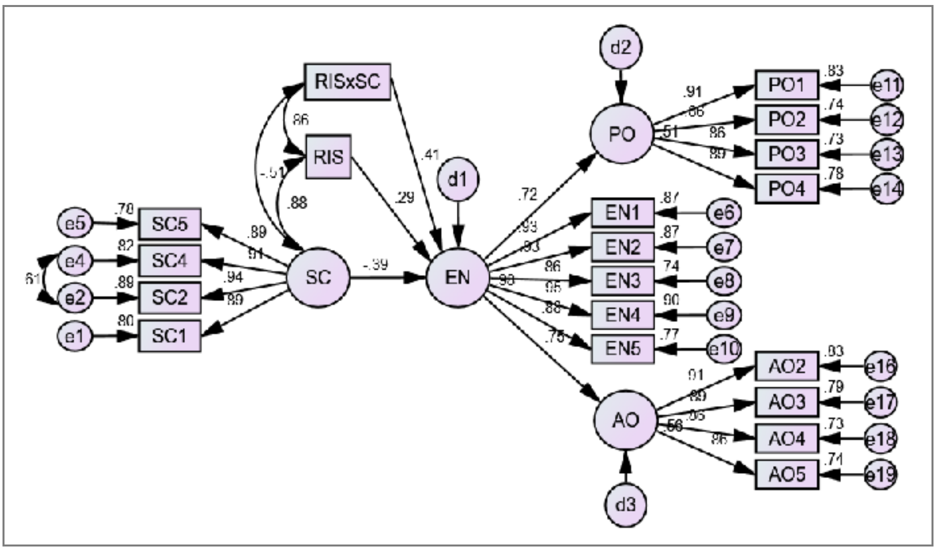
Also, in the modification indices, no critical indication was found to adjust any discrepancy in the refined model. Therefore, the second revised model (SM2) was chosen as the final model (Figure 3).

Table 6 Result of SEM fit indices for structural models

Models	X^2	*df*	X^2/df	*CFI*	*NFI*	*IFI*	*SRMR*	*RMSEA*	*PClose*
SM1	306.428	147.000	2.085	0.970	0.943	0.970	0.033	0.074	0.001
SM2	222.755	146.000	1.526	0.985	0.959	0.985	0.033	0.051	0.419

*Significant at $p < 0.001$, SM: Structural model.

Figure 3 The final research model (see online version for colours)



8.4 The relationship between constructs

The analysis of SEM based on the final model confirmed the proposed hypotheses. As stated in H1$_a$, in respect of the effect of situational complexity on the engagement of the responders was found to be different between the use and not use of RIS (i.e., $\widehat{a_3} \neq 0$). Also, as per the statement in hypothesis H2$_a$, the effect (direct and indirect) of situational complexity on performance and affective outcomes of the responders were found to be different between the use and not use of RIS with mediation through engagement (i.e., H1$_{ba}$: $\widehat{a_3}\widehat{b_1} \neq 0$ and H1$_{bb}$: $\widehat{a_3}\widehat{b_2} \neq 0$).

From the result it was also observed that, the regression estimate of situational complexity on engagement was negative without the effect of interaction variable ($\widehat{a_1} = -0.388$, $p < 0.001$). While, with the interaction, the negative effect changed significantly ($a_3 = 0.414$, $p < 0.001$). Therefore, hypothesis H2$_a$ was supported. The test of indirect effect revealed that, engagement significantly mediated the relationship between situational complexity and performance and affective outcomes, which were negative without the interaction effect

$$[(a)\ \widehat{a_1}\widehat{b_1} = -0.278, p < 0.001; (b)\ \widehat{a_1}\widehat{b_2} = -0.289, p < 0.001].$$

While, with interaction, the negative effect not only dampened to a significant level, rather improved to positive [(a) $\left(\widehat{a_1} + \widehat{a_3}\right)\widehat{b_1} = 0.018$, $p < 0.001$; (b) $\left(\widehat{a_1} + \widehat{a_3}\right)\widehat{b_2} = 0.019$,

$p < 0.001$]. Thus, the data supported hypothesis $H2_{ba}$ and $H2_{bb}$. The results from the samples are summarised in Tables 7 and 8.

Table 7 Result of the test of hypotheses (Difference ≠ 0)

Paths	*Hypotheses*	*Estimate**	*Value*	*Result*
$X \rightarrow M$	$\widehat{a_3} \neq 0$	0.414	>0	Supported
$X \rightarrow M \rightarrow Y_1$	$\widehat{a_3}\widehat{b_1} \neq 0$	0.296	>0	Supported
$X \rightarrow M \rightarrow Y_2$	$\widehat{a_3}\widehat{b_2} \neq 0$	0.309	>0	Supported

*Standardised estimate at $p < 0.001$.

Table 8 Result of the test of hypotheses (Interaction effect)

Paths	*Hypotheses (L > R)*	*Estimate (L)**	*Estimate (R)**	*Result*
$X \rightarrow M$	$\widehat{a_3} > \widehat{a_1}$	0.414	–0.388	Supported
$X \rightarrow M \rightarrow Y_1$	$\left[\left(\widehat{a_1} + \widehat{a_3}\right)\widehat{b_1}\right] > \widehat{a_1}\widehat{b_1}$	0.018	–0.278	Supported
$X \rightarrow M \rightarrow Y_2$	$\left[\left(\widehat{a_1} + \widehat{a_3}\right)\widehat{b_2}\right] > \widehat{a_1}\widehat{b_2}$	0.019	–0.289	Supported

*Based on standardised estimate at $p < 0.001$.

However, the unstandardised regression estimates between situational complexity and engagement were –0.399 with no interaction effect, which was significant with CR = –14.469 at $p < 0.001$ level of significance. While, it was 0.435 with interaction effect, which was significant with CR = –16.849 at $p < 0.001$ level of significance.

9 Discussion

The study explored the relationships between situational complexity and team performance and affective outcomes mediated through the level of engagement of responders from the study of the use or not use of RIS. The result was obtained through the testing of a structural model that construes the hypothesised structural relationships amongst the constructs. It also included the test that, the model fits the data well. The practical value of the results lies in the view that, the timely supply and use of response information are critical to responders' level of engagement and performance and affective outcomes in the part of response activities in operationally complex situations. With the goodness-of-fit indices, both the refined measurement and structural models exhibited reasonable fit.

In the model under study, each of the latent variables was confirmed through CFA. Hence, it can be settled that, the measurement items measured well the latent variables. The indirect effect measures between situational complexity and two endogenous outcome variables suggest that, responding members who embrace the RIS are likely to score more in performance outcome and affective outcome indicators. Generally, it becomes hard for emergency responders to process the data once it is generated from a variety of points in an emergency. Responders often have poor situational awareness and poor coordination when they lack usable response information (Netten et al., 2006; Toner, 2009; Nunavath and Prinz, 2017).

This study specifically showed a significant negative effect of situational complexity on performance outcomes mediated through a poor level of engagement when information availability was limited. The same result was demonstrated for affective outcomes. While, with high information availability, the negative effect demolishes, and the actors showed improved performance and positive affective outcomes through an enhanced level of engagement (Table 8). This finding supported the seminal work of Simon in which it is stated that informed actors are always able to set well the target and act reasonably (Simon, 1991). The result also concurs with the finding in the previous study that, the more the situational stress the less is the possibility of better performance outcomes (Motowidlo et al., 1986).

However, according to the concept of achievement orientation, the engagement of actors depends upon how s/he interprets and reacts to the job (Dweck and Leggett, 1988). Also, an actor's approach to work accomplishment is highly sensitive to the achievement situation (Janssen and Van Yperen, 2004). As per the result in this study, the informed members demonstrated better scores in psychological safety and personal significance measures in engagement towards their job (Table 9). While such measures were found lower for respondents who lack necessary processed information. Also, in activities like emergency support, added discretionary behaviour of the actors is very crucial (Saji, 2014), which is basically a property of contextual performance to support task performance and organisational effectiveness (Duyar and Normore, 2012).

The results of this study showed that respondents with RIS interaction exhibited better scores in team fit indicators of engagement (Table 9). Thus, it was conceded that with RIS interaction the responders can ensure greater assistance and cooperation with coworkers to ensure better contextual performance (Borman and Motowidlo, 1997). The novelty of this research in this concern is that, the structural model has demonstrated the complex structure of human-computer interactions (HCI) from a system context (i.e., Prasanna et al., 2013; Streefkerk et al., 2014). It also helps in recognising what sorts of response information in an emergency contribute to the true interaction of response personnel and information systems (i.e., Van de Walle and Turoff, 2008).

According to previous research, engagement can be defined as burnout antithesis (Bakker et al., 2004; Wollard and Shuck, 2011). This means that the more the people are high on engagement the less they are on burnout and vice versa (Schaufeli et al., 2002). In this research, the respondents with RIS interaction demonstrated better scores in engagement measures. Thus, it can be argued that they were on low burnout than the respondents under control. Plus, performance, in theory, is viewed as both a mental and behavioural approach (Campbell, 2013). The standardised estimates of the effects of situational complexity on the outcome indicators in the structural model under study were found better in respondents with RIS interaction as compared to without interaction. Therefore, from a broader sense, it can be also argued that with necessary information support the actors can be able to process the mental function well and perform better in a skeptical situation like emergencies. Hence, this research has evidenced the way to obtain a true interaction when emergency responders have the least amount of information processing due to lighter working memory (Carver and Turoff, 2007).

Table 9 Estimates of standardised total effect (SM2)

Constructs	*Indicator level*			*Overall*	
	Items	*Without^*	*With^*	*Without^*	*With^*
Engagement	EN1	–0.362	0.386	–0.388	0.414
	EN2	–0.362	0.386		
	EN3	–0.334	0.356		
	EN4	–0.369	0.393		
	EN5	–0.341	0.364		
Performance Outcomes	PO1	–0.253	0.270	–0.278	0.296
	PO2	–0.240	0.256		
	PO3	–0.238	0.254		
	PO4	–0.246	0.262		
Affective Outcomes	AO2	–0.263	0.281	–0.289	0.309
	AO3	–0.258	0.275		
	AO4	–0.248	0.264		
	AO5	–0.249	0.266		

*Independent: Situational Complexity; ^Interaction: Response Information Systems.

Overall, the findings concur with the recent findings that, in situationally atypical events, actors with system support yield well predictions and enhanced performance (Parsa and Hassal, 2018). Thus, as mentioned in the theoretical framework, the result of this study concurs with the framework that, resource capability helps to exploit the situational negativity. The risks of working memory impairment of emergency responders can be minimised through the true interaction of people and technology.

10 Conclusion and further research

The urban living in developing countries is becoming immensely pressurised with increasing population and densely established structures. Therefore, threats to lives and properties are becoming heightened day by day. In providing the local emergency response services in developing countries, the FSCD authority is a special purpose department. They play the central role to minimise the harms of hazardous incidents like fires, collapses, accidents and other natural and man-made disasters to lives and properties. However, because of associated situational complexity, three things are critical for emergency service renderers: perception, attention, and memory (Smith et al., 2004). With limited information at hand, impairment of effective perception, improper attention and weaken working memory are usual for the responding members. With the results of this study, it is expected that the concerned policymakers in developing countries would be better able to recognise the illusory threats to ensure the infuse of fullest personal selves of emergency responders if they used a system enabled response information support. Typically, the successful response needs intense information support which goes beyond usual job duties and provides response performance that is beyond expectations. In order to reach this ideal, emergency response teams need policymakers who place greater emphasis on capacity development and are more motivated toward acquiring, preserving and using the required information to advance their engagement. As a result of this research evidenced, the integration of RISs to the local emergency response departments in developing countries is expected to excel in the performance outcomes through true human-computer interaction. If members of the emergency response team simply provided with the opportunity of getting necessary information in time, they will be able to use their abilities, talents and cooperate their mates with the employment of their fullest selves.

However, as an important practical implication, policymakers must emphasise on the diagnosis of highly skeptical nature of the emergency and ensure that responders feel fully powered to engage in jobs at hand. Otherwise, capacity underuse may incite a further loss of human resource strength that continually might drain the energy and willingness of responding members. Policymakers in developing countries must install additional resources to effectively cope with emerging challenges in emergency response scenarios (Botzen et al., 2018; Manoj and Baker, 2007). Plus, they must create scopes in environments which motivate the actors to establish and acquire a true human-computer interaction infrastructure.

One of the limitations of the study relates to the comparability of a scenario-run setting to a real setting. The study was conducted in the FSCD workstations. Although, relevant pressures and uncertain ground realities were infused to the scenario run, a real emergency incident definitely would provide more robust results. Thus, future studies should examine whether the result of the scenario run and study on the real setting is different. Plus, cross-sectional research data from a wide range of demographics including other emergency service agencies could be helpful to attain a better generalisation of the findings. Moreover, the final structural model can be used for future research on other existing and future emergency response systems including response to a pandemic such as Covid-19. Furthermore, future research can be conducted to expand the theoretical model by incorporating other latent variables, such as personal level factors, team-level factors, team situation awareness, and cognitive outcomes, to explain team effectiveness.

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