ASSESSING INFORMATION QUALITY DEFICIENCIES IN EMERGENCY MEDICAL SERVICE PERFORMANCE

(Research-in-Progress)

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Abstract: There is an inevitable need for information sharing and coordinating among response departments during the occurrences of emergencies. Information quality in EMS performance has been the subject of very little research so far, especially on the influence of information deficiencies to EMS performance, despite the fact that the studied information quality in healthcare has been discussed. Due to the excessive amount of information and the dynamic change in the environment, the information decision process has become the backbone of EMS. Aim of this paper is to define dimensions for describing information quality deficiencies concerning the information flow across units from the communication center to dispatch center, to mobile rescue units, and to emergency department (ED). We present a literature review on information quality in emergency medical service (EMS) and indentify and define the dimensions for describing information quality., Three case studies are presented in order to describe the coordination in emergency service performance through information exchange and sharing. The contribution lies in the defined and exemplified dimensions for describing information quality deficiencies as a step towards our future work on information integration model for EMS performance improvement. A gross list of eight dimensions were defined from literature and used in describing information quality deficiencies in EMS performance of three cases.

Keywords: Quality, Information Quality dimension, Information Quality deficiency, performance, , Emergency Systems

INTRODUCTION

Performance of an Emergency Medical Service (EMS) system can be defined in many ways such as by the number of patients treated per month, by the average time it takes to receive care after a case has been logged in the EMS system, or by the outcomes of the patients treated. Regardless of the definition used, in today's information era, the performance of an EMS system can be significantly improved by using information effectively and efficiently [9]. An emergency is typically characterized as unpredictable in terms of unforeseen events, which evolve as a result of the nature of a crisis, exact actions and responsibilities of individuals, and exceptions to a planned response [4]. Information systems aid in the management of responses to an emergency by facilitating the information flow, decision making, and coordination management [14]. An effective emergency response information system should provide timely access to comprehensive, relevant, and reliable information in order to help emergency responders to collect, analyze, disseminate, and act on key information in order to better meet the needs of the patients [8, 33]. EMS system is information-critical referring to the fact that this service has become highly dependent upon information—from the nature and location of the incident, to the medical needs of

the patient that should be attended to at the awaiting hospital, and to the patient-health provider information exchange and treatment decision [1, 21, 23]. Effective response requires access to the right information on the right level of detail at the right time. Such requirements depend on Information Quality (IQ) dimensions . Consequently, EMS performance excellence is dependent on IQ.

Information problems are mainly analyzed and discussed by only focusing on a small number of dimensions of information quality, for example low or high accuracy [5, 19, 38], or adapted for other settings than that in EMS performance system. In healthcare performance literature, several authors use multi-dimensional approaches when discussing IQ, expressed as availability, accuracy, and timeliness [15], complete, correct, and timely information [18], accuracy, precision, and timeliness [31]. Information deficiencies can be identified by mapping between the information system state and the real world state break down. As a result of these deficiencies, the data in the information system can be incomplete, ambiguous, meaningless or incorrect [35]. Assessing IQ deficiencies by using one, or a few, dimensions of IQ in this manner might result in lack of nuances and too high aggregation level for applicable improvement suggestions.

More nuanced empirical research in the area is limited, although some studies have examed the area of IQ in relation to emergency and crisis response in details [20, 22]. Macdougall [20] concluded that relations exist between IQ and EMS decisions taken to manage the situation. Mattsson [22] indicated that improve IQ is associated with higher performance in emergency services. Further, existing IQ frameworks are identified as problematic by Kiel and Layton [16] regarding to collaboration under emergency condition. In the context of EMS systems, research is limited to understand information quality deficiencies, which could direct us to the root causes for low performance satisfaction.

There is a lack of studies identifying the dimensions needed to describe IQ deficiencies in healthcare performance specific setting like emergency medical service performance measurement. Describing IQ deficiencies can be useful in foremost descriptions, benchmarking or when analyzing IQ deficiencies and the corresponding causes for performance improvement plan. In order to address these limitations, the aim of this paper is to describe information quality deficiencies on EMS performance measurement based on case examples. Information flow among the related entities needs to be highly effective, and identifying the information quality while exchanging data is the key.

The paper is structured as follows: starts with a literature review of the IQ area, following by the theoretical identification of dimensions for describing and analyzing IQ deficiencies. The research framework is concluded by a framework of eight dimensions of IQ derived from relevant literature. Coordination process model and information flow chart is introduced. Subsequently, the methodology is discussed and case studies are presented, IQ deficiencies are exemplified in three different situations of EMS performance through the case examples.

RELATED WORK

In order to identify IQ deficiencies, we are providing an overview of previous work on IQ, IQ dimensions and EMS process to support the correlation of them. We first review Information quality and then relate selected IQ dimension within the context of EMS, and thus define IQ deficiencies in EMS process.

Information Quality

Quality is often referred to two aspects: one is focusing on freedom from deficiencies and another on meeting expectations" [16, 37]. This can be reflected to IQ, describing freedom from deficiencies in relation to current EMS performance requirement, and the emergency situation IQ, describing if the

information meets the situational emergency service implied needs, both important pieces in high performance EMS system. We follow the definition of quality is based on the widely adopted view that quality data are "data that are fit for use". In this paper, we follow a definition based on Millller [23], "Data are of high quality if they are fit for the wide variety of users in an integrated emergency medical services system". Data are fit for use if they are free of defects and process desired features.
We selected this definition due to its intended usage and the consumer of the information in focus Chen, Wang and Zeng [3]. Low information quality can be expressed as information quality deficiencies. Information quality deficiencies, i.e. gaps in information quality from the information users' perspective and specific settings.
Following Miller's [23] literature review IQ is multidimensional construct consisting of several IQ dimensions. In this paper, an EMS specific set of dimensions are identified based on literature, considering of their relevance stated by previous research. In Table 1 we describe selected dimensions due to their relevance to the healthcare settings. However, the more dimensions are selected for IQ, the less comprehensible it is for users and the more difficult the assessments will become Pipino [29].

Area	Authors	IQ dimensions
Healthcare	Lammintakanen [18].	Accuracy, Relevancy, Representation, Accessibility
	Lambert et al. [17]	Accuracy, Timeliness, Privacy and Security
	Macdougall [20]	Accuracy, Timeliness, Comparability, Usability, Relevance
	Mattsson [22]	Completeness, Correctness, Timeliness
	Kerr and Norris [15]	Reliability, Timely, Integrity, Adequacy
Management of information systems	Raiford [30]	Accuracy, Completeness, Relevance, Timeliness
	Goodhue [7]	Accessibility, Accuracy, Assistance, Compatibility, Currency, Ease of use, Reliability, Presentation, Ease of use
	Miller [23]	Accessibility, Accuracy, Coherence
	English [6]	Accessibility, Accuracy, Completeness, Concurrency, of redundant or distributed data, Non-duplication, Precision, Rightness, Timeliness, Usability, Validity
	Lee et al. [19]	Accessibility, Appropriate amount, Believability, Completeness, Concise representation, Consistent representation, Ease of operation, Free of error, Interpretability, Objectivity, Relevance, Reputation, Security, Timeliness, Understandability, Credibility, Usefulness

Table 1. Literature review of IQ dimensions

Emergency Medical Service and IQ Dimensions

EMS Process

EMS performance is a continuum of care that can be measured and mainly assessed on three units [11]: Dispatch center, mobile rescue units, and emergency department (ED). The task of the EMS process is to manage the flow of the patients and ensure that the appropriate and timely care is provided. Information play a huge role for the continuum of care and thus the EMS performance.
In a typical scenario, the emergency unit has to receive suitable information in appointed time to take adequate action. To contribute to the needs of the units, every information flow has to have as less

obstruction in its way to the user of that information as possible. Regardless of the configuration, documentation of EMS service begins from the 9-1-1 caller, and the information starts to accumulate and possibly change as they flow. Emergency medical dispatch can assign a response priority to an EMS call based on a series of interactive questions between the caller and the dispatcher. The mobile unit crew then will be sent out according to the information received from the dispatcher. After arrived the emergency scene, the mobile unit crew will record or through radio to pass on the patient(s)' condition and general information to the ED staff in the hospital.

Conveying voice information on location and the nature of an emergency proved valuable to dispatching center to help prepare for the unique circumstances of each individual emergency incident [32]. During the process of rescuing on scene, information is considered to be one of the essential needs of ambulance team. Poor IQ can be disastrous for help providers to transport the patients the right place at right time. On arrival of the emergency department (ED), information exchange and sharing throughout the time-critical process is essential for the following care providing. In addition, many emergency incidents have to involve more organizations, such as fire department, policy stations etc. The nature of EMS leads to a complex system for the information quality assurance, and the EMS performance. The Information content becomes more complicated as the information exchange and sharing needs across units (see Figure 1.). The EMS system majorly has five components, but under crisis or some other occasions, there are more parties involved in [11]. Hence, it is necessary to ensure the information quality as it flows and changes, which ensures the EMS performance quality as the data plays huge role in a situation- critical time. This further put forward the requirements on multi-dimensional framework of IQ deficiencies dimensions to trace the causes of performance inefficiency. Because the EMS performance excellence largely depends on the information they have, there are needs to analyze the individual IQ dimensions under different emergency situations. To derive a comprehensive structure for describing and analyzing IQ in EMS performance, it is necessary to include both IQ dimensions in relation to the formalized system specifications and IQ dimensions in relation to situational needs. By identifying the IQ deficiencies, we can further study on IQ dimension significance and the causes, consequences, and information integration and maturity levels, and therefore to improve EMS performance by present the diagnoses and solutions.

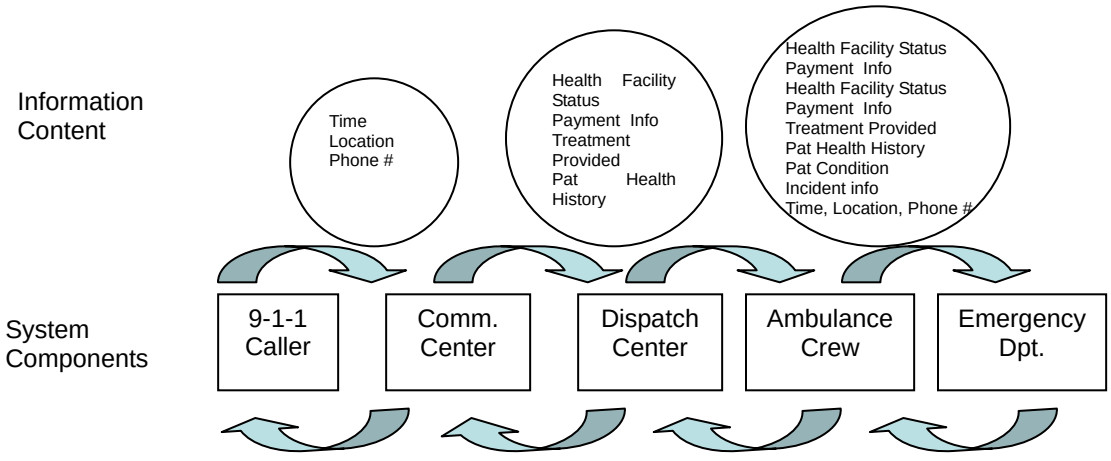


Figure 1. Information Sharing across EMS Service Process

Selected Information quality dimensions and deficiencies definitions

In the research for well-managed emergency events, there are a number of primary obstacles that have been identified. For example, one of which was fear of details [27]. Under the time and information critical circumstances, summary data are preferred, but some degree of backup detail is necessary to make

the right action and decision. This exemplified the complexity of individual requirements for IQ. Expectation and requirements can, for example, be reflections of knowledge level, EMS performance standards and requirements. The IQ dimensions defined below are supported by literature from IQ discipline as well as the healthcare and EMS logistic discipline. The related IQ deficiencies are derived from previous healthcare and crisis response literature.

The dimensions excluded from table 1 were either overlapping in terms of semantics or irrelevant. We strive to have a more detailed view on dimensions that are easy to focus and to use for explanations. This is particular important to identify causes for poor EMS performance. Lack of sharing information is closely related to effectiveness of communication, includes integration issues that can be described as a cause of IQ deficiencies, and is closely related to the chosen dimension accessibility [13]. From our theoretical discussion above, eight dimensions have been identified and defined (Table 2). They are considered relevant and important in analyzing and describing IQ deficiencies in EMS performance . The eight dimensions are not exclusive dimensions to use when identifying IQ deficiencies in EMS performance, adoptions to the specific situation are important to consider. However, in the following we use these eight dimensions as a starting point for describing IQ deficiencies.

IQ Dimension	**Definition**	**IQ Deficiency in EMS**
Timeliness	The extent to which the information is timely enough to be used for a specific task [19, 26].	From Dispatch center to mobile rescue units to the ED in hospital, the situation changes over time, information received in and/or delivered out may not sufficiently timely
Accuracy	The extent to which information in an automated system correctly and precisely represents states of the real world [2, 16, 36].	Information about the conditions is ambiguous and unreliable, which does not fit in the real time scene.
Conciseness	To the extent to which the information is expressed much in few words; clear and succinct that can be used directly, in terms of format, content and/or structure [26].	Overloaded information are transmitted, redundant content are presented.
Relevance	The extent to which is appropriate for the tasks and application [2, 16].	Certain information delivered is not related to the certain emergency task needs.
Completeness	The degree to which information is not missing and is comprehensive for the task on hand [36].	Complete information is not delivered in different complete levels of details.
Accessibility	The degree to which information is available, easily obtainable or quickly retrievable when needed [9].	Tools necessary to acquire it is not available under emergency situation.
Understandability	The extent to which the information is easy to use and comprehend, both orally and in written [25, 26].	Information is transferred in a complicated or unclear language or format.
Privacy and Security	Information that cannot be easily intercepted by any unpermitted agency/individuals and used in a harmful manner [29].	Patient Information is not standardized to the policies and processes, or, information is not protected potential misuse of

		information;

Table 2. IQ dimensions, definition and related deficiency

RESEARCH METHOD

Due to the character and nature of this paper as an explorative study, and the aim to identify EMS deficiencies and IQ dimensions, literature review is the most suitable research method. Literature review for this paper that involves two key phases: (1) define IQ dimension and EMS process; and (2) IQ dimension deficiencies on EMS performance. The first phase was aimed to select the most appropriate IQ dimensions for EMS performance. The objective of the second phase was to use case examples to demonstrate the IQ deficiencies in EMS information flow process and compare the IQ dimensions to further refine the important and sufficient IQ dimensions on EMS performance. This knowledge was mainly gathered from healthcare, EMS system, logistics, and management of information system literature, due to the similarities, relations of the importance to organizational performance.
The following diagram shows the information collecting details for this paper.

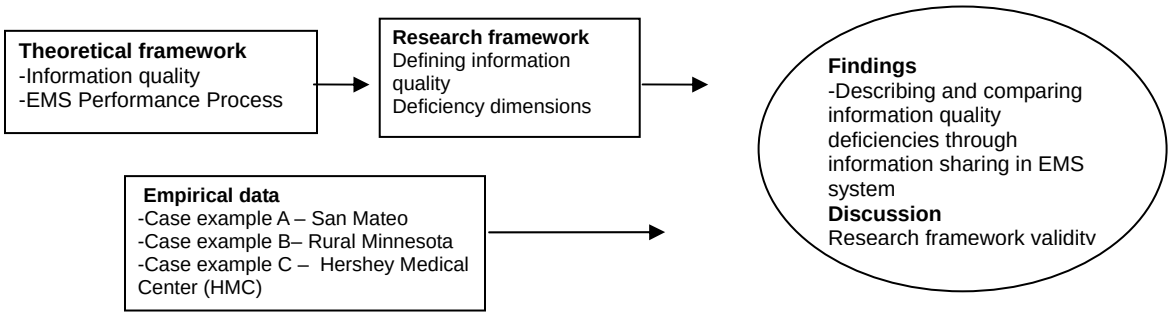


Figure2. Research procedure

CASE STUDIES

Case examples can be used to provide deeper understanding of complex phenomena as the IQ deficiencies in EMS performance.
The case studies were retrieved from the literature that can be well fit in to demonstrate the IQ dimensions usage in practice.
The empirical data were gathered mainly by reviewing the previous case studies, but also multiple data sources, such as EMS database, the observations were used. Totally, the cases combines with data from 73 relevant scenarios conducted from source of Medicare Patient Database, Healthcare Informa, INFOR Information systems and operational research, and Information Engineering and Computer Science (ICIECS). All the scenarios are focus on EMS information flow and coordination across organizations, including two major types of emergency incidents, from the incidents content perspective : normal day-to-day emergency (case A), and causality and crisis (case C) ; from the system perspective, case B illustrate the EMS system in rural areas in general. The case examples were documented by case protocols to ensure reliability [15]. Further, most of the previous works do not have direct connection between the IQ dimension and their deficiencies and EMS performance, therefore, the case study is

preferred to demonstrate the importance and necessary.
The IQ dimensions identified and defined in this study (Table 2) are expressing both the information users' needs and the situational requirements on IQ, and IQ level in relation to the EMS performance standards and policies. In EMS performance, IQ should be considered important as an individual rescuing process when the accident occurs, and also important for the overall EMS performance management. IQ deficiencies analyzed in these three cases lead to future refined and focused IQ dimensions specified in EMS. The critical dimensions are included to give the IQ assessment, not only a snapshot view of the present situation, but also a projection of future scenarios. The empirical data were structured and analyzed by using the framework of IQ in EMS performance from the literature study. The results were discussed in terms of identified important dimensions, differences and similarities between the cases and doubtfulness regarding the framework.

Case A— San Mateo County, CA

This case study described in [39] analyses the EMS agency's interorganizational information flow from the performance perspective that IQ deficiencies potentially inhibit or prohibit EMS performance information exchanges. As such, a first step in the analysis was to look at the existing system in terms of information flows and information systems across processes and units.

Assessment
The San Mateo County EMS Agency formed an innovative public/private partnership to provide more efficient and effective emergency medical services to its citizens throughout the county. The EMS system consists of a consolidated dispatch center that performs all dispatch services for the 18 fire departments and ambulances within the County. Figure 2, adapted from [39], illustrates a sequential service process involving multiple public, private, and non-for-profit organizations collecting and sharing information related to the process, the incident, and service performance. It shows how EMS service process starts at the 9-1-1 phone call and continues through a series of organizations through to delivery at the ED. Information accumulates across the process as indicated in figure 1. The data and information may also change and increase in a dynamic circumstances and manner, and under that situation, information quality is the key, when the deficiencies appear, it affects the quality of the entire EMS performance.
The majority of the information flow in a sequential manner, there are some data exchange out of sequence, the disturbance in sequence was also found in other cases such as documented in [33]. For example, the hospital availability information is sent out from the hospitals to the communications center and then to the ambulance crew on scene. Also, it observed that data is been transmitted, collected, and facilitated through various tools, such as two-way radios, laptops, papers, computer aided dispatch (CAD), e-patient care record (PCR).

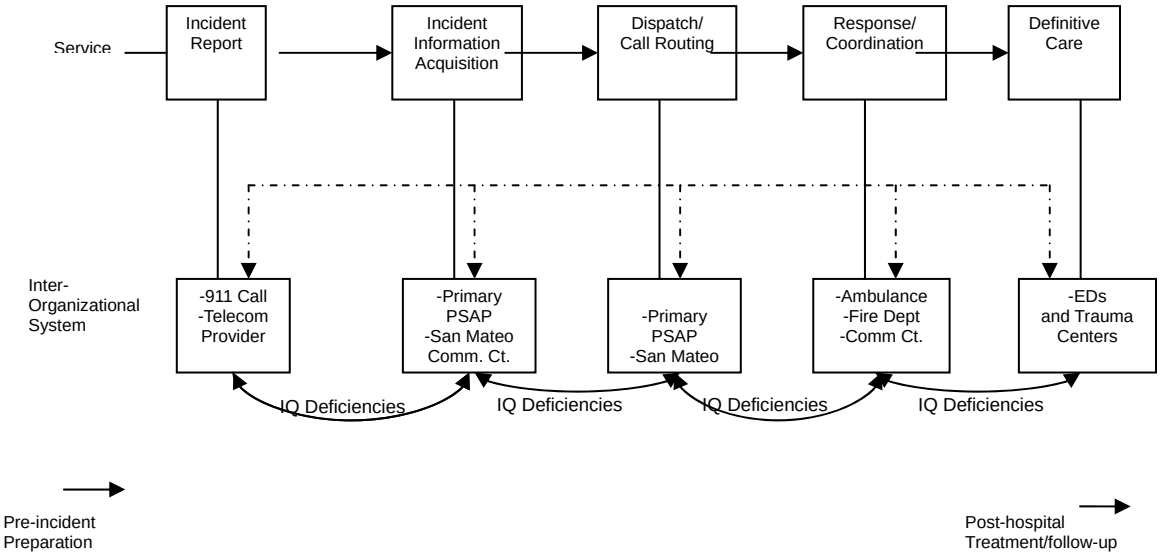


Figure 3. EMS information flow model in San Mateo

Analysis

According to the interviews and field observations carried out by Zchooley and Horan [39], several information quality deficiencies are indicated in San Mateo case.

The rescue crew explained many difficulties related to assembling "patient history" information from friends and family members at an incident site. Paramedics and physicians stated that when patient information is collected, their ability to deliver appropriate medical care is greatly enhanced [39]. Lacking of pre-hospital patient data for use in the field, which is the barrier to higher quality performance because of the information completeness and accuracy deficiency. It is noted that very little are aggregated and shared across all organizations including the hospitals [39]. The separate and disparate information system across different units causes performance analysis, as the accuracy and timeliness deficiencies exist. It was noted that sometimes it took a lot time more talking on their radios and driving to figure out which hospital had beds and doctors [39]. Hospital available data represents process change; Data set "out of sequence" cause timeliness deficiency. The agency provided PCR and CAD systems access to all the county hospitals and trauma centers. However, paramedics rarely enter patient information prior to patient arrival and physicians have no mobile means to look at the data. Many communications still via voice and paper, so that information accuracy, completeness, understandability, and conciseness deficiencies occurring. The EMS agency performs monthly quality improvement exercise by conducting in-depth analysis on few randomly chosen emergency incidences, so the personally identifiable information need to be careful, but the probability of violating HIPAA regulations would increase [39]. EMS agency role as contract holder mandates pre-hospital information sharing, which potentially cause privacy and security information deficiencies.

Case B—Rural Minnesota Town, MN [34]

Assessment

The inter-organizational information exchange and sharing in rural area presents broader complex system that causes difficulty to provide an effective EMS service and EMS performance. This case study

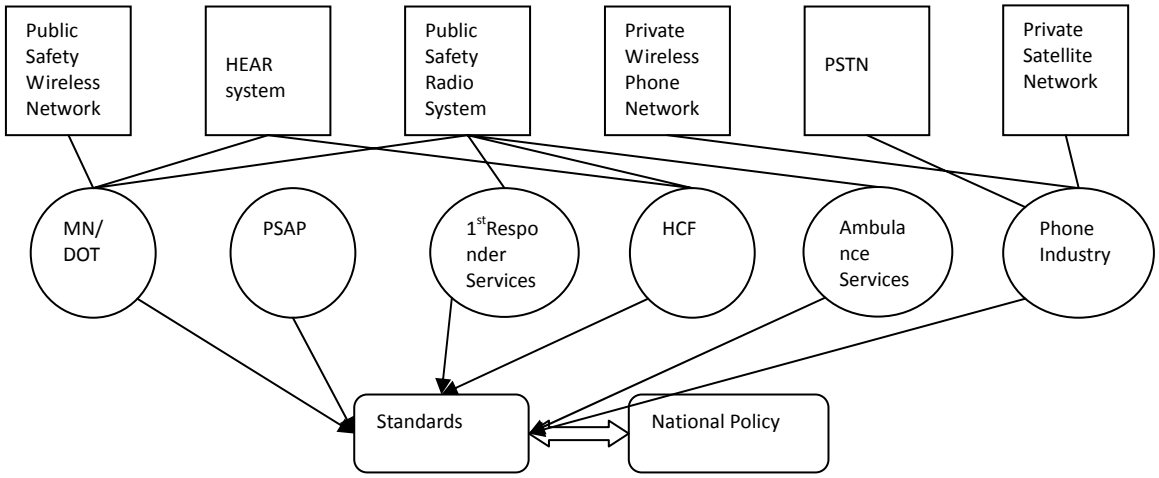
embedded subunits are the multiple EMS organizations within the rural Minnesota towns. From the identified technology, organizational, and policy issues [34], we can assess the information quality and deficiencies across the involved units.

EMS is comprised of many organizations and services that greatly rely upon technology to perform the vital liaison function for information sharing and coordinating actions [34].Two specific prohibitive technological issues identified by interviewees were in relation to wireless coverage and updating systems for better performance. These two factors strongly affect the information quality on EMS.

Interviewees described synergies and barriers between organizations by sharing technological resources [34]. As to the dynamic public-private partnership, the unbalanced nature of partnerships and uneven distribution opportunities bring issues to creating effective EMS.

The EMS technology-related policies including policies and standards put significant influence on EMS data and information sharing and coordinating actions among multiple units.

[34] implicates several technological, organizational and policy issues for EMS in rural Minnesota as well as rural areas more generally. The model highlights several critical areas that importantly affect the information flow and exchange (see Figure 4.)



HEAR- Hospital Emergency Area Radio
PSTN-Landline Telephone Network
DOT-Department of Transportation
PSAP- Public Safety Answering Point
HCF-Health Care Facility

Figure 4. EMS Model in Minnesota Town.

Analysis

Because of the complex relationships among all the parties, IQ deficiencies appear more frequently if the EMS performance is not operated effectively. From technological aspect, [34] showed that in recent years the Minnesota EMS has had to respond to a significant increase in mobile-based emergency calls, while there are inadequacies in developing wireless infrastructure in rural areas, including a limited coverage area and improper call routing to correct Public Safety Answering Point (PSAP) [34]. This creates delays and other difficulties related to immediate response to emergency calls and the accident location, which is the appearance of information timeliness, and accurate deficiencies.

Because of the complicated partnership involved in EMS, the cross-agency resource sharing created barriers regarding to resource sharing. These organizations had varying levels of information interconnectivities, ranging from integrated CAD systems [34] to elementary phone-transfer operations [34]. This leads to information breakdowns, and therefore, creates information completeness and accuracy

deficiencies.
[34] suggests that federal, state and local policy had critical role in determining terms for EMS functionality. Lack of standards is a major factor that affects the choosing location identification. The lack of uniform method for describing incident locations has long been a major impediment to rapid and effective emergency response in diverse metropolitan and rural areas [34]. This reveals information accuracy, understandability, and timeliness deficiencies. The national policy for the EMS access and information sharing is not well defined that causes the information privacy and security deficiencies.

Case C—Hershey Medical Center, PA [32]

Assessment
The Hershey Medical Centre described in [32] is characterized by a decentralized approach and in contract to the previous two cases shows. The Pennsylvania state EMS systems typically operate as follows:
(i) An individual experiencing an emergency calls a local "emergency" number, either 911 or a designated seven-digit number.
(ii) The call is answered by a call-taker, who evaluates the caller's emergency and gathers necessary information (including the location and severity of the incident).
(iii) The call-taker communicates with service agencies for dispatch of emergency personnel.
(iv) Call-takers may provide additional instructions to the caller in some systems.
No 911 systems are typically decentralized. Individual municipalities may have their own seven-digit telephone number, and police and fire departments often forgo the use of specialized call-taking personnel [32].
Hershey Medical Center (HMC) is a major state hospital in Pennsylvania. During a crisis, HCM's ED would be a major recipient of casualties in the Central Pennsylvania region. HMC's ED is serviced by an EMS team consisted of [32]:

- LifeLion service: two medically equipped helicopters and a pediatric mobile intensive care ground ambulance. A communication Center (CC) supports the LifeLion service. The CC is staffed by specially trained air medical communications and ground dispatch specialists.
- University EMS (UEMS) service: nine Advanced Life Support-equipped ground ambulance.

Madhu, Sharoda etc. [32] conducted a series of focus groups involving both ED and EMS team members using crisis scenario of a train derailment involving leakage of hazardous materials as the basis of the focus group discussion, and collected the workflow information/data.

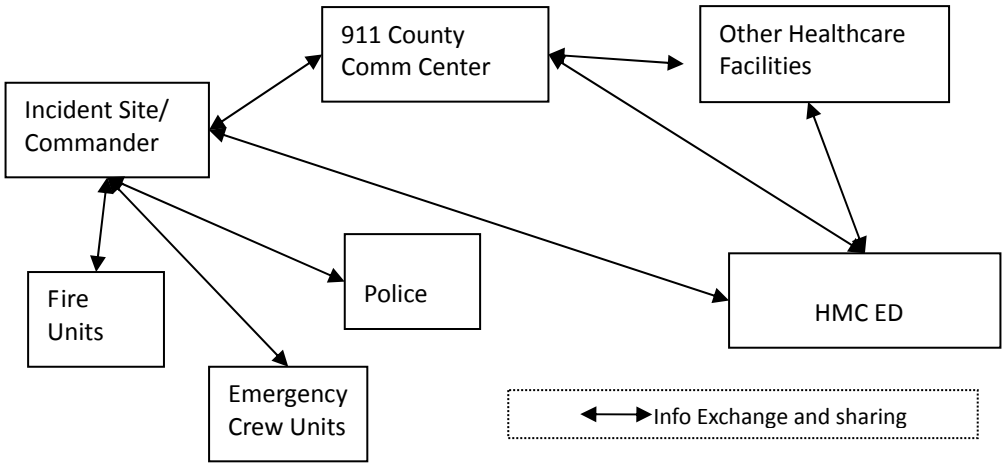


Figure 3. Web of Information Flow

A unique characteristic of information sharing and coordination among units is the presence of multiple

parties who need to communicate in order to coordinate patient care. Figure 3.depicts this "web of communication" that aids coordination in a mass casualty incident (MCI). The incident site call the communication center of the hospital while at the same time the on site commander contacting various first responder units (such as fire, police, EMS) about the information to transport the patients.
Give the importance of information sharing for inter-team coordination, a rang of ICTs are used, such as pagers, computer systems, radio, cell phones, and walkie-talkies etc.

Analysis
Major Information quality deficiencies can be identified through the information flowing procedure, based on the qualitative research method carried out by Madhu and Sharoda.
One of the key mechanisms for information sharing among different organizations are communication technologies such as cell phone, and two-way radios. However, these devices often have limitations. The communication breakdown when any tem members were in "dead spot". Additionally, EMS team participants highlighted other problems that significantly affected their coordination and information exchange. For instance, the 2-way radios do not work effectively in many areas as the mismatch between certain frequencies. The lack of interoperability among communication technologies during emergency response causes information accuracy, timeliness, and completeness deficiencies. In response to the scenario, many of focus group participants preferred paper over computing systems for coordination [32].The handwriting paper forms for coordinating activities cause information understandability and accuracy deficiencies.
One of the identified challenges is the "mutual knowledge" among geographically dispersed staff in different units [32]. Mutual knowledge is the knowledge that all team members share and know that they share [36], which is referred as "common ground" (paper). Experience and interaction [38](paper) are two important mechanisms by which the common ground established. The fire crew, rescue crew, policemen, and ED teams have little direct knowledge of each other's activities (including roles and responsibilities) because of constant changes to teams [32]. Therefore, lacking of common ground among team members from different units leads to information completeness, and accuracy deficiencies.
Breakdowns in information flow are prominent challenges that affect interorganizational coordination [32]. The communication center (CC) personnel transmit information to ED team break down the information from the rescue crew to the ED team. The CC personnel are concerned that information exchanges between them often do not occur through them, as required by protocol [32]. Information transmitted through different channels than anticipate leads to breakdowns, and therefore leads to information accuracy.

DISCUSSION
The 3 cases indicate the importance of IQ deficiencies, which are summarized in Table 3 that indicates IQ deficiencies in the studied cases. In each scenario, there are IQ deficiencies indications, from the aspects of emergency types and EMS system in size. The San Mateo case shows the sequential service process and information sharing in a well developed EMS system. However, because of the one way information flow caused several IQ deficiencies that negatively affect the performance quality. The rural Minnesota case shows a more complicated EMS system in rural area, multiple parties and mixed network are involved in. Because of its remote and complicate system, the information quality is difficult to manage. IQ deficiencies are created as analyzed earlier in this paper. The Hershey Medical Center showed the emergency crisis within a team coordination circumstances. Because of the communication efficiency, IQ deficiencies are appeared through the information flow process.
As we see, regardless of the size and content of the emergency incidents, they all showed the similarities: information is processed while it exchanged and shared across organizations. There are multiple parties involved in the complicated EMS system. IQ deficiencies still exist although improvement has been made, and therefore, future recommendations are necessary for EMS performance quality.

The same time, differences are appeared through the case examples: traditional sequential service cause more difficulties to provide timely service; in rural areas, due to distance and costs concerns a higher level of integrated systems are required with complex layers; to ensure the information accuracy and completeness in a crisis should be more carefully handled as the chaos.
Deficiencies in the dimension relevance and accessibility were not identified in the studied information types. However, due to the chosen definition this result may not be general and should be analyzes further in future research. Further, relevance can be closely connected to accuracy why this should be considered in operationalizing the dimensions. The lack of deficiencies in theses dimensions can also indicate that they are rare in the specific situation of the case examples or that they are dimensions of low importance in general.

	Case A: San Mateo	Case B: MN Town	Case C: HMC
Timeliness	x	x	x
Accuracy	x	x	x
Conciseness	x		
Relevance			
Completeness	x	x	x
Accessibility			
Understandability	x	x	x
Security and Privacy	x	x	

Note: x indicated some deficiencies in the information identified in the respective case studies

Table 3 IQ deficiencies described in the EMS performance

CONCLUSIONS

The purpose of this paper is to define dimensions for describing information quality deficiencies and to describe the important but neglected information quality deficiencies on three major EMS units. First, a gross list of eight dimensions were defined from literature and used in describing information quality deficiencies that are important. Our analysis shows that many of these dimension have been overlooked of three different cases, for example, case 1 showed that timeliness, accuracy, and completeness, and conciseness deficiencies are hugely affect the EMS performance. Similarly, case 2 and 3 illustrated that timeliness, understandability, and security and privacy deficiencies. The eight dimensions and deficiencies were timeliness, accuracy, conciseness, relevance, completeness, accessibility, understandability, and security and privacy and are defined in Table 2.
Our results in form of a framework of information quality dimensions in EMS system could be the first step for an information quality assessment model for EMS performance improvement for the future research.
The set of eight IQ dimensions can be used by researchers, consultants and managers. Firstly, researchers can benefit from structuring IQ when investigating the impact on EMS performance, both qualitatively interviews and quantitatively in surveys. The benefit lies in the possibility of operationalizing the dimensions into metrics. For managerial use such as performance measurement/or improvement, the structure can be used for:

- Assessing IQ deficiencies;
- Identify and communicate information needs and requirements in a structured way;
- Managing IQ by structures evaluation, for example, quarterly auditing or process-specific evaluation; and
- Identifying causes and consequences of IQ deficiencies to design the solutions for EMS performance level improvement.

When establishing definitions for suggested dimensions, the measurement is implicitly incorporated through the definition.

Although our research provided first indication of information quality dimensions in EMS and the deficiencies related to its performance quality. The study is also limited by the depth and width of the cases. These limitations are subject of future research which aims to developing measures with defined scales, i.e. making them fully operational, and including them in an applicable measurement system. Therefore, through the measurement, the maturity level of the EMS performance can be defined, and further, framework can be development to help improving EMS performance. The set of eight dimensions needs to be further validated on more healthcare industries before the IQ framework can be considered valid.

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