ORIGINAL RESEARCH

Inter-Agency Communication and Operations Capabilities during a Hospital Functional Exercise: Reliability and Validity of a Measurement Tool

Elena Savoia, MD, MPH;[1] Paul D. Biddinger, MD;[1,2] Jon Burstein, MD;[1,4] Michael A. Stoto, PhD[1,3]

1. Center for Public Health Preparedness, Harvard School of Public Health, Boston, Massachusetts USA
2. Department of Emergency Medicine, Massachusetts General Hospital, Boston, Massachusetts USA
3. School of Nursing and Health Studies, Georgetown University, Washington, DC USA
4. Department of Emergency Medicine, Beth Israel Deaconess Medical Center, Boston, Massachusetts USA

Correspondence:
Dr. Elena Savoia
Center for Public Health Preparedness
Division of Public Health Practice
Harvard School of Public Health
677 Huntington Avenue
Boston, Massachusetts USA
E-mail: esavoia@hsph.harvard.edu

This publication was supported by the Cooperative Agreement U90/CCU124242-03/04 from the Centers for Disease Control and Prevention. Its contents are solely responsibility of the authors and do not necessary represent the officials' views of the Centers for Disease Control and Prevention.

Keywords: communication; functional exercises; hospital preparedness; measurement; public health; validity

Abbreviations:
ICC = Intra-Class Correlation Coefficients

Received: 28 January 2009
Accepted: 27 February 2009
Revised: 17 March 2009

Web publication: 23 February 2010

Abstract

Introduction: As proxies for actual emergencies, drills and exercises can raise awareness, stimulate improvements in planning and training, and provide an opportunity to examine how different components of the public health system would combine to respond to a challenge. Despite these benefits, there remains a substantial need for widely accepted and prospectively validated tools to evaluate agencies' and hospitals' performance during such events. Unfortunately, to date, few studies have focused on addressing this need. The purpose of this study was to assess the validity and reliability of a qualitative performance assessment tool designed to measure hospitals' communication and operational capabilities during a functional exercise.

Methods: The study population included 154 hospital personnel representing nine hospitals that participated in a functional exercise in Massachusetts in June 2008. A 25-item questionnaire was developed to assess the following three hospital functional capabilities: (1) inter-agency communication; (2) communication with the public; and (3) disaster operations. Analyses were conducted to examine internal consistency, associations among scales, the empirical structure of the items, and inter-rater agreement.

Results: Twenty-two questions were retained in the final instrument, which demonstrated reliability with alpha coefficients of 0.83 or higher for all scales. A three-factor solution from the principal components analysis accounted for 57% of the total variance, and the factor structure was consistent with the original hypothesized domains. Inter-rater agreement between participants' self-reported scores and external evaluators' scores ranged from moderate to good.

Conclusions: The resulting 22-item performance measurement tool reliably measured hospital capabilities in a functional exercise setting, with preliminary evidence of concurrent and criterion-related validity.

Savoia E, Biddinger PD, Burstein J, Stoto MA: Inter-agency communication and operations capabilities during a hospital functional exercise: Reliability and validity of a measurement tool. ***Prehosp Disaster Med*** **2010;25(1):52–58.**

Introduction

One of the primary means for improving hospital disaster planning and preparedness has been the use of drills and exercises to train employees and test hospitals' disaster response capabilities.[1] Hospitals in the US that are accredited by the Joint Commission are required to conduct drills regularly and test their emergency management systems. In addition, many state regulations require hospitals to conduct drills and exercises; for example, the Commonwealth of Massachusetts requires hospitals to participate in exercises as a condition of receiving federal preparedness funding.

As proxies for actual emergencies, drills and exercises can raise awareness, stimulate improvements in planning and training, and provide an opportunity to examine how different public health system components would combine to respond to a challenge. Assessing the quality of the performance in the exercise requires data collection methods that are valid and reliable to allow

meaningful comparisons across jurisdictions for accountability and to assess progress and guide improvement efforts over time.

Reliability is an estimate of the degree to which an instrument measures a construct consistently when it is used under the same condition with the same or different subjects. Validity is the degree of confidence that the measure being used captures the intended phenomenon of interest. In 2005, Asch and colleagues published a review of preparedness instruments finding overlap in domains and little agreement about what constitutes preparedness or how it should be measured.[2] Since then, several instruments have been developed and used across the US, including the Homeland Security Exercise and Evaluation Guides that, among others, include measures to assess hospital functions. However, no study has proven the validity and reliability of such instruments. The issue of the properties of measurement in emergency preparedness has been addressed only by few.[3] A unique example is a recently published study calling into question the inter-rater reliability and validity of one of the most frequently used instruments, the Johns Hopkins/Agency for Healthcare Research and Quality (AHRQ) drill performance evaluation tool.[4] To fill the gap and increase awareness about the importance of evaluating exercises using evidence-based measures, the authors developed and tested the validity and reliability of a self-assessment performance tool designed to measure hospitals' communication and operations capabilities during a functional exercise.

Methods

Item Pool Generation

A 25-item questionnaire was created through a consensus process by a team of emergency preparedness experts with extensive background in the design, implementation, and evaluation of several tabletop and functional exercises reaching >3,000 first responders.[5] Items were designed to assess coordination, communications, and disaster operations capabilities during a hospital functional exercise. Fifteen items addressed the hospital's ability to establish and maintain inter-agency communication and coordination with federal, state, and local agencies, and other healthcare facilities. Fifteen items addressed the hospital's ability to establish and maintain inter-agency communication and coordination with federal, state, and local agencies, and other healthcare facilities, as well as their capability to the public, interact with the media. Ten items described the hospital's ability to operate in a disaster situation, including assignment of roles and responsibilities, gathering and management of resources, and maintenance of essential functions.

Study Participants and Setting

The study population was comprised of 154 hospital personnel from Massachusetts Emergency Preparedness Region 5 who participated in a functional exercise in June 2008. The exercise was designed to examine and validate the functions of incident coordination, command, and control between hospital emergency operation centers (EOCs) during a fictional severe weather event (hurricane). Specifically, the exercise objectives were to: (1) demonstrate the ability to establish and maintain effective communications among all appropriate agencies and emergency response personnel during response to a hurricane event; (2) demonstrate the ability to activate, staff, and utilize a hospital EOC to coordinate and support health and medical responses to a hurricane event; (3) demonstrate the ability to identify, mobilize, and manage the resources required to independently sustain hospital operations for 96 hours during a hurricane event; and (4) demonstrate the ability to activate existing regional memoranda of agreement and surge plans.

Participants represented nine different hospitals with average emergency department daily volumes of 162 ±31 patients, and ranging from 140–246 patients. The exercise scenario opened with a fictional Health and Homeland Alert Network (HHAN) announcement from the Massachusetts Department of Public Health (MDPH) alerting all hospitals that there was a category-three hurricane expected to approach the Massachusetts coast in the following 48 hours and urging them to review their provisions for emergency power, staffing, and supplies. Following the initial announcement, the exercise scenario progressed to span two days with the hurricane increasing in strength and making unexpected shifts in its track. Issues such as evacuation of residents, sheltering, traffic control, and establishment of alternate care sites all were tested during the exercise. Participants were expected to respond to the situation based on current knowledge of response procedures, communicating from their own hospitals, and using the plans and procedures developed by the department or agency they were representing. Local exercise debriefings occurred immediately after the exercise at each hospital. Subsequently, a central review was held and was attended, either in person or by conference call, by most participants.

At the end of the exercise and before the reviews occurred, participants were asked to rate their hospital's ability to perform each of the 25 functions listed in the questionnaire using a five-point Likert scale with responses ranging from 1 (very poor) to 5 (very good). External evaluators, one per hospital, also were assigned to independently judge the hospitals' performance using two questionnaires: one identical to the one completed by the participants (*first instrument*) and another developed for previous exercises focusing on hospital management and communication issues (*second instrument*). A copy of the two instruments is available in the Appendix. The external evaluators were selected based on their knowledge and experience in emergency preparedness, and their knowledge of the specific plans and organizational structure of the preparedness system tested during the exercise. Specific questions were asked to assess each evaluator's level of training, experience evaluating previous exercises, and years of experience in emergency preparedness. All evaluators selected for this analysis had received previous training from the Center for Public Health Preparedness at the Harvard School of Public Health in the evaluation of exercises, and had significant previous experience in judging exercises. Most evaluators had >10 years of professional experience in public health and/or healthcare emergency preparedness. Additional scoring guidance was not provided to participants; assessment was based on purely subjective judgments.

Operations	Factor Loading
Fully activate the hospital's emergency operation plan	0.57
Identify strategies to minimize staff shortage (i.e., family emergency planning, specific incentives)	0.71
Effectively assign roles and responsibilities to medical, nursing, and administrative staff	0.74
Ensure the provision of emergency power and supplies	0.71
Have plans and resources to assure operational sufficiency for 96 hours	0.61
Gather resources such as medical supplies and medical equipment needed to support implementation steps	0.72
Provide consumable resource needs (e.g., masks, supplies, hand hygiene, products)	0.65
Increase bed availability within the facility	0.66
Ensure rapid return of patient access standard health services in the hospital system	0.67
Identify, prioritize, and maintain essential functions	0.61
Communication with Federal and State Agencies	
Identify key public health points of contact (e.g., local health authority, state Department of Public Health (DPH))	0.80
Establish contact with the Massachusetts Emergency Management Agency (MEMA) regional office	0.81
Activate mutual-aid agreements	0.57
Coordinate risk-communication messages with regional and state healthcare providers and public health responders	0.59
Communicate efficiently with DPH, MEMA, EMS and regional hospitals about asset requests and supply needs	0.72
Provide bed counts to appropriate emergency response agencies	0.52
Communication with Local Agencies and the Public	
Provide and gather information from other hospitals/healthcare facilities	0.45
Ensure consistent communication with the media	0.71
Communicate with the local health department or board of health	0.53
Communicate with local community health centers and long-term care facilities	0.54
Communicate with the population about where to seek medical care	0.74
Communicate with the public to minimize fear	0.84

Table 1—Questionnaire factor loading (EMS = emergency medical services)

Comparatively, some scoring guidance was given to the external evaluators; during the training phase, they were provided with information regarding hospital volumes and available resources and on the capabilities that were to be challenged during the event.

Statistical Methods

Standard psychometric methods were used to assess internal consistency and inter-rater agreement and employed as measures of reliability.[6–8] After matching the data by hospital, participants' responses were correlated with those given by the external evaluators using Intra-Class Correlation Coefficients (ICC). Furthermore, the concurrent validity of the instrument was tested by comparing the results of the two instruments completed by the external evaluators (first and second instrument). The statistical analysis was performed using the statistical package SPSS version 16.00 (SPPS, Inc., Chicago, IL).[9]

Results

Characteristics of Respondents/Communities and Analysis of Missing Values

Of the 210 subjects that participated in the functional exercise; 154 completed the questionnaires. Participants in this sample represented nine hospitals and had leadership positions in >20 different types of services including engineering, finance and administration, registration, home care, hospitality, security, plan operations, spiritual care, volunteers' activities, quality assurance, ambulance and emergency medical services, food supplies, infection control, information and communication, logistics, patient advocacy, and law enforcement. There were missing values for an average of 0.9% on each item; ranging from 0–2.9%. Twenty-four of 25 items had <15% of "not applicable" responses, only these 24 were included in the final analysis. Missing values were replaced with the average value of a given scale when more than 50% of the items of the scale were not missing.

Empirical Scale Development
Data derived from all 154 subjects who completed the instrument were determined suitable for principal components factor analysis by inspection of the anti-image covariance matrix, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, and Bartlett's Test of Sphericity. The KMO value was 0.88 (satisfactory value). The Bartlett Test of Sphericity, which tests for the presence of correlations among the variables, was significant (p <0.001), indicating that the correlation matrix was consistent with the hypothesis that the measures were not independent. A three–factor solution (which accounted for 57% of the total variance) was parsimonious, had a simple structure, and could be meaningfully interpreted. Factors were defined by items with factor loadings >0.40. Of the original 25 items, 22 met the criteria. (Full item wording and corresponding factors loadings are in Table 1). One item was dropped because of a high percentage of "not applicable" responses (>15%) and two items were not included in the final instrument because of similar factor loadings in multiple factors. The first factor consisted of 10 items and accounted for 40% of the total variance. All 10 items were related to disaster operations capabilities. The second factor consisted of six items and accounted for 11% of the variance. All six items addressed hospitals communication capabilities with federal and state agencies. The third factor accounted for 6% of the variance and was comprised of six items describing the hospital's ability to maintain adequate communication with local healthcare facilities (hospitals, long-term care facilities, community healthcare centers) and the public.

Reliability and Validity
Internal Consistency—Cronbach's α coefficient was calculated for the three summary scales based on the factor analysis, as well as for the total summary score based on all 22 items. The overall measure of internal consistency for the summary score was 0.92. All scale α coefficients were 0.83 or higher: operations (α = 0.88), communication with federal and state agencies (α = 0.83), communication with local agencies and the public (α = 0.83). These results indicate that for each of the three domains, questions within each domain were correlated with one another and had robust internal consistency.

Inter-Rater Agreement—In the field of emergency preparedness, the use of external evaluators has been proposed as an evaluation method to assess organizational and system capabilities; a sort of "gold standard" compared to self-assessments. For this reason, group-level correlations between self and evaluator ratings were performed to test inter-rater agreement, and high agreement was considered as evidence of measurement reliability and criterion-validity. Analysis of the external evaluators' judgments indicates substantial variability in the distribution of scores, with values ranging from 1–5 (on a five-point Likert scale) and standard deviations ranging from 0.4–1.3 depending on the item. After matching the data by hospital, the level of agreement between participants self-reported scores and the external evaluators' scores ranged from moderate to good depending on the scale: operations (ICC = 0.43; moderate), communication with federal and state agencies (ICC = 0.49; moderate), communication with local agencies and the public (ICC = 0.65; good).

Domain Structure and Construct Validity—All three domains/scales were positively and significantly correlated with one another; correlations ranged from moderate to large (r >0.40; p <0.001). The correlation between the two comparable domains related to communication capabilities ("with federal and state agencies" and "with local agencies and the public") was stronger (r = 0.68; p <0.001) than between less comparable ones such as "operations" and "communication with federal and state agencies" (r = 0.47; p <0.001) or "operations" and "communication with local agencies and the public" (r = 0.61; p <0.001). To evaluate construct validity, the correlation of the measure being evaluated with other variables that are known to be related to the construct purportedly measured was examined, namely indicators of hospital structure that are considered related to operational capabilities: average daily emergency department volumes and hospital level-2 surge beds. The average daily emergency department volume was used as proxy for the demand that would occur during a large-scale event (assuming the hurricane would affect the geographic areas served by the hospitals with similar intensity) and an indicator of surge capacity was created by calculating the ratio of hospital level-2 surge beds to the average daily emergency department volumes for each hospital. This ratio was categorized as "low" or "high" based on whether it was ≤ or >20%.

Hospital Surge Capacity—A crucial part of community disaster preparedness planning is a healthcare system's ability to expand quickly beyond normal services to meet an increased demand for medical care in the event of a large-scale emergency. Such ability depends on the availability of qualified personnel and their ability to perform tasks assigned to them.[10] It was hypothesized that hospital operations capabilities were related to a hospital's ability to increase surge capacity. Hospitals in the higher category of surge capacity performed better in terms of operations capabilities (mean value) compared to those in the lower categories (Figure 1).

Concurrent Validity—In order to test concurrent validity, the external evaluators' results, collected using two different questionnaires (first instrument and second instrument), were compared. Scales belonging to different instruments but used to assess similar constructs were compared. The agreement was moderate between "communication with federal and state agencies" (first instrument) and "inter-agency communication" (second instrument) (ICC = 0.54) and good between "operations" (first instrument) and "hospital management" (second instrument) (ICC = 0.74). These results support the concurrent validity of the newly developed instrument.

Discussion

Drills and exercises can provide a useful opportunity to assess components of a health system's preparedness,[5] but their utility in this regard depends on having valid and reliable measures. Several scales for assessing preparedness

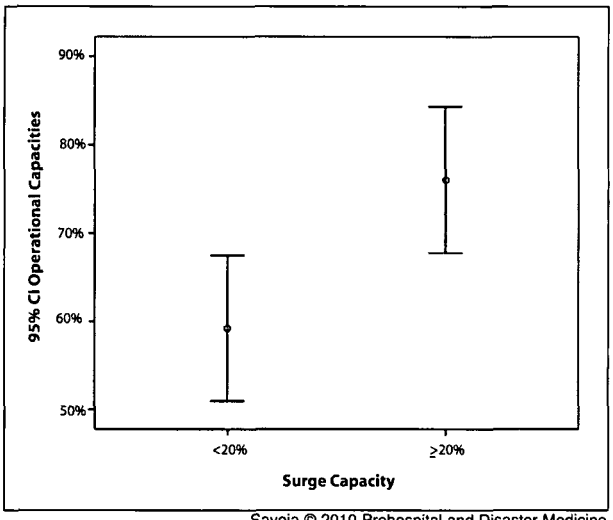

Figure 1—Relationship between hospitals' operational capabilities and surge capacity

have been published, but most have not been validated extensively. One exception is the AHRQ scale,[3] which has been shown to have significant discordance in certain settings, and is too long, limiting its use in unfunded institutions and settings. In this context, the scale used in this study offers a simple, but valid and reliable way to assess disaster functional exercises. These results indicate that this scale may be helpful in broadly assessing hospital performance, especially in the face of limitations of time, staff, and financing.

Limitations

The limitations of this study are similar to those encountered during any evaluation study that uses exercises to assess emergency preparedness. Exercise outcomes are influenced by several factors, including: (1) exercise design; (2) ability of the controller and facilitators to conduct the exercise; and (3) professional role, level of participation, training, and experience of the participants. The preliminary results demonstrate the reliability of the measurement tool. However, the reliability of a measure is linked to the population in which it is applied. Moreover, validity is strongly related to the context in which the instrument is implemented, which in this particular case, refers to the way the exercise was designed and conducted. Therefore, the reliability and validity of the instrument are context-specific and should be retested if the instrument is used in a setting with characteristics of responders and hospitals that are different from the sample used in this study, or if the context is not a functional exercise. Furthermore, as shown in similar studies,[4] the challenge remains in identifying external parameters to test construct validity. As an experiment, in this study, testing construct validity using a numerical indicator of surge capacity, which is not intended to cover the all construct of surge capacity, but rather, stimulate further research in this direction, was proposed.

Conclusions

A measurement tool consisting of a 22-item questionnaire was developed and found to be a reliable qualitative measure of hospitals' inter-agency communication and operational capabilities in a functional exercise setting with preliminary evidence of reliability, construct, and criterion-related validity. The items cluster in three scales representing the functions of: (1) inter-agency communication and coordination with federal and state agencies; (2) communication with local healthcare facilities; and (3) disaster operations capabilities. The tool can be completed by participants and external evaluators during hospital emergency preparedness functional exercises to identify hospital capabilities in need of further improvement.

References

1. Dausey DJ, Buehler JW, Lurie N: Designing and conducting tabletop exercises to assess public health preparedness for manmade and naturally occurring biological threats. *BMC Public Health* 2007;7:92.
2. Asch SM, Stoto MA, Mendes M, Valdez M, Gallagher ME, Halverson P, Lurie N: A review of instruments assessing public health preparedness. *Public Health Rep* 2005;120(5):532–542.
3. Kaji AH, Lewis RJ: Assessment of the reliability of the Johns Hopkins/Agency for Healthcare Research and Quality hospital disaster drill evaluation tool. *Ann Emerg Med* 2008;52(3):204–210.
4. Savoia E, Testa MA, Biddinger PD, *et al*: Assessing public health capabilities during emergency preparedness tabletop exercises: Reliability and validity of a measurement tool. *Public Health Rep* 2009;124(1):138–148
5. Biddinger PD, Cadigan R, Auerbacj B, *et al*: Using tabletop exercises to identify systems-level changes for improving preparedness. *Public Health Rep* 2008;123(1):96–101.
6. Cronbach LJ: Coefficient alpha and the internal structure of tests. *Psykometrika* 1951;16:297–333.
7. Hair JF, Anderson RE, Tatham RL, *et al*: *Multivariate Analysis: With Readings*. 4th ed. Englewood Cliffs, New Jersey: Prentice-Hall, 1995.
8. Duteman GH: *Principal Components Analysis*. Newbury Park, California: Sage Publications, 1989.
9. SPSS for Windows, Release 16.0.1 2007. Chicago: SPSS Inc.
10. Agency for Healthcare Research and Quality: Optimizing Surge Capacity: Hospital Assessment and Planning. Bioterrorism and Health System Preparedness, Issue Brief No. 3. AHRQ Publication No. 04-P008. Available at http://www.ahrq.gov/news/ulp/btbriefs/btbrief3.htm.

Appendix 1—Instrument 1

In light of your experiences during today's tabletop exercise, using a scale ranging from 1 (Very Poor) to 5 (Very Good) please rate the ability of the hospital you are representing to:

Disaster Operations						
1. Fully activate the hospital's emergency operation plan	1	2	3	4	5	NA
2. Identify strategies to minimize staff shortage (i.e., family emergency planning, specific incentives)	1	2	3	4	5	NA
3. Effectively assign roles and responsibilities to medical, nursing and administrative staff	1	2	3	4	5	NA
4. Ensure the provision of emergency power and supplies	1	2	3	4	5	NA
5. Have plans and resources to assure operational sufficiency for 96 hours	1	2	3	4	5	NA
6. Gather resources such as medical supplies and medical equipment needed to support implementation steps	1	2	3	4	5	NA
7. Provide consumable resource needs (e.g., masks, supplies, hand hygiene, products)	1	2	3	4	5	NA
8. Increase bed availability within the facility	1	2	3	4	5	NA
9. Ensure rapid return of patient access standard health services in the hospital system	1	2	3	4	5	NA
10. Identify, prioritize, and maintain essential functions	1	2	3	4	5	NA
Communication with Federal and State Agencies						
11. Identify key public health points of contact (e.g., local health authority, state Department of Public Health (DPH))	1	2	3	4	5	NA
12. Establish contact with the Massachusetts Emergency Management Agency (MEMA) regional office	1	2	3	4	5	NA
13. Activate mutual-aid agreements	1	2	3	4	5	NA
14. Coordinate risk-communication messages with regional and state healthcare providers and public health responders	1	2	3	4	5	NA
15. Communicate efficiently with DPH, MEMA, EMS and regional hospitals about asset requests and supply needs	1	2	3	4	5	NA
16. Provide bed counts to appropriate emergency response agencies	1	2	3	4	5	NA
Communication with Local Agencies and the Public						
17. Provide and gather information from other hospitals/healthcare facilities	1	2	3	4	5	NA
18. Ensure consistent communication with the media	1	2	3	4	5	NA
19. Communicate with the local health department or board of health	1	2	3	4	5	NA
20. Communicate with local community health centers and long term care facilities	1	2	3	4	5	NA
21. Communicate with the population about where to seek medical care	1	2	3	4	5	NA
22. Communicate with the public to minimize fear	1	2	3	4	5	NA

https://doi.org/10.1017/S1049023X00007664 Published online by Cambridge University Press

Appendix 2—Instrument 2

In light of your experiences during today's tabletop exercise, using a scale ranging from 1 (Very Poor) to 5 (Very Good) please rate the ability of the hospital you are representing to:

Inter-Agency Communication						
1. The hospital has established plans and protocols for sharing incident-specific intelligence with other hospitals in Massachusetts Region 5 during an emergency.	1	2	3	4	5	NA
2. The hospital has established plans and protocols for communicating with other local, regional, and state entities during an emergency.	1	2	3	4	5	NA
3. The hospital has interoperable systems and technologies for rapidly communicating with partner agencies during an emergency.	1	2	3	4	5	NA
4. During the exercise, relevant incident-specific intelligence was promptly shared with the appropriate departments and personnel with other hospitals in Massachusetts Region 5.	1	2	3	4	5	NA
Hospital Management						
5. During the exercise, players activated their Emergency Operations Center (EOC) and observed the Incident Command System (ICS).	1	2	3	4	5	NA
6. The hospital has established staffing plans and protocols to ensure that essential functions are maintained during an emergency.	1	2	3	4	5	NA
7. The hospital has plans and protocols in place to ensure shelter, feeding, and related services for personnel working during an emergency.	1	2	3	4	5	NA
8. The hospital has plans and protocols to independently sustain clinical aspects of patient care for at least 96 hours.	1	2	3	4	5	NA

https://doi.org/10.1017/S1049023X00007664 Published online by Cambridge University Press