Communicable Disease Surveillance Systems in Disasters: Application of the Input, Process, Product, and Outcome Framework for Performance Assessment

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ABSTRACT

Objective: One of the most important measures following disasters is setting up a communicable disease surveillance system (CDSS). This study aimed to develop indicators to assess the performance of CDSSs in disasters.

Method: In this 3-phase study, firstly a qualitative study was conducted through in-depth, semistructured interviews with experts on health in disasters and emergencies, health services managers, and communicable diseases center specialists. The interviews were analyzed, and CDSS performance assessment (PA) indicators were extracted. The appropriateness of these indicators was examined through a questionnaire administered to experts and heads of communicable diseases departments of medical sciences universities. Finally, the designed indicators were weighted using the analytic hierarchy process approach and Expert Choice software.

Results: In this study, 51 indicators were designed, of which 10 were related to the input (19.61%), 17 to the process (33.33%), 13 to the product (25.49%), and 11 to the outcome (21.57%). In weighting, the maximum score was that of input (49.1), and the scores of the process, product, and outcome were 31.4, 12.7, and 6.8, respectively.

Conclusion: Through 3 different phases, PA indicators for 4 phases of a chain of results were developed. The authors believe that these PA indicators can assess the system's performance and its achievements in response to disasters. (*Disaster Med Public Health Preparedness*. 2018;page 1 of 7)

Key Words: communicable diseases, disaster, performance assessment, surveillance system

When hazards occur in vulnerable communities, they destroy infrastructure,[1] which leads to the loss of healthcare facilities and structures[2] or disruption of their performance.[3] Disruption in the health system breaks down the health conditions in the disaster-affected areas. In addition to causing mortality and injuries, disasters also disrupt access to health services.[4] As a result, these events pave the way for epidemics and outbreaks of communicable diseases.[5-7] Many people and media believe that there is a high risk for an epidemic of communicable diseases after disasters,[8,9] although credible sources do not support this claim.[8] However, rumors and stories about outbreaks of communicable diseases in disasters horrify the disaster-affected people. The cholera epidemic after the 2010 Haiti earthquake, which affected more than 604 634 people and led to the hospitalization of 329 697 and the death of 7463, is evidence in this regard.[10]

Therefore, it is critical that health systems set up a communicable diseases surveillance system (CDSS) immediately after a disaster for an appropriate and effective response.[11-14] "A surveillance system is a systematic process for collecting, summarizing, analyzing and publishing data, and the results of its findings to stakeholders for the development of interventions."[15]

It is so important that the Centers for Disease Control and Prevention (CDC) in the United States formed a disaster surveillance work group for this purpose in 2006.[16] The Texas Department of State Health Services also developed a surveillance system (SS) for this purpose, named the Disaster-Related Mortality Surveillance, which was activated for the first time during Hurricane Ike.[17]

Like all programs, the performance of these systems should be assessed by experts. Their strengths and weaknesses should be extracted for the continuous development of the system. Performance assessment (PA) is a systematic process that monitors and assesses the achievement of goals of different parts of an organization or program and provides stakeholders with results.[18,19] However, despite numerous experiences in setting up a SS for communicable diseases after disasters,[20,21] there are not any PA indicators.

There is just a PA framework in which the indicators are not covered and only the features of a PA have been discussed. Although the CDC guideline is designed for health care systems in general and not specifically for communicable diseases and disasters, it is mainly used in the similar studies.[15]

Therefore, considering the importance of PA for all programs, the problems caused by lack of PAs, and the knowledge gap in this field, this study was conducted to design PA indicators in four areas—input, process, product, and outcome—for CDSSs in disasters.

METHODS

A 3-phase mixed-method (quantitative/qualitative) design was used for the development of PA indicators of SSs in response to disasters. Of course, before starting this study, the researchers conducted a systematic literature review to identify the existing PA indicators of SSs.[22] Then a qualitative approach was used for selecting indicators and developing potentially related indicators. A semistructured questionnaire was used to conduct focus group discussions and interviews. A purposeful sampling method was used to select individuals to participate in the group discussions and interviews. Selection criteria for interviews were the experience of individuals in the Communicable Diseases Management program in previous disasters and their desire to participate in the interviews. They were experts in the field of health in disasters and emergencies, health services managers, and officials of Communicable Diseases Management Departments of the Islamic Republic of Iran Ministry of Health. Oral consent was obtained from the participants. The focus group discussions and interviews started with the main question, "What indicators do you think can be used to assess the performance of a CDSS in a disaster?" Other questions based on the given answers were asked to obtain more detailed and richer data. The discussions of each session were immediately extracted and analyzed. Gaps in the data from the group discussion sessions and interviews were addressed in subsequent meetings. The meetings continued until data saturation was achieved.

The content of the discussions was analyzed manually using the Strauss and Corbin model (1998)[23] because this study was a part of another study that was conducted by using the grounded theory method. (First, the texts of the interviews were divided into meaning units. Then the codes were extracted from the meaning units. Similar codes were put together and subcategories were extracted. Finally, by putting the codes together, the main categories were ultimately extracted.) The outcome of this phase was the development of SS PA indicators.

After the indicators were developed, their appropriateness was investigated. A Likert scale questionnaire was designed and its validity and reliability were tested. Then, each of the indicators was measured on the Likert scale from 1 to 5 (ie, completely appropriate to completely inappropriate). The questionnaire was distributed among the heads of Communicable Disease Management Departments in medical universities throughout a country-level seminar. The completed questionnaires were collected, and the results were analyzed using Statistical Package for the Social Sciences 20 (SPSS20). The indicators that were considered appropriate by more than 70% of the participants were retained, and the other indicators were excluded from the study.

Next, a panel of experts from the Ministry of Health and health care administration experts screened and finalized the set of PA indicators. Nine interested individuals were invited to form the panel, of whom 6 were present at the meeting (participation rate, 66.66%).

The Communicable Diseases Management Center officers in the East Azerbaijan Province of Iran were randomly selected to determine the importance of the indicators and to weight them. They were asked to compare elements in the model to assess the performance of CDSSs in response to disasters using the analytical hierarchy process introduced by Professor Thomas L. Saaty. The analytical hierarchy process, one of the best-known and most widely used multivariate decision-making techniques, uses paired comparisons with several options and criteria.[24] Weighting was done in 2 phases. In the first phase, 5 criteria that had to have an indicator, such as clarity, relevance, economic impact, adequacy, and ability to monitor, were weighted.

In the second phase, participants used the criteria to compare all the indicators in pairs and weight them. A questionnaire was designed with the software and distributed among the participants. The participants were taught how to complete the questionnaires and were asked to complete them slowly and patiently. Finally, the questionnaires were completed and collected within 3 weeks, and the data were entered into the software.

Results were analyzed using the Expert Choice software 11, which was designed for fuzzy computing and multiple-criteria techniques. Its indicators were designed for the analytic hierarchy process.

RESULTS

A total of 21 people were interviewed for extracting PA indicators of CDSSs, of whom 10 (47.62%) were male and 11 (52.38%) were female. Five (23.8%) of the participants of interviews were specialists or subspecialists, 10 (47.62%) were general practitioners, and 6 (28.57%) were experts or top experts. Of these, 2 (9.52%) had less than 10 years of job experience, 4 (19.05%) had between 10 and 15 years, 9 (42.86%) had between 16 and 20 years, 3 (14.29%) had 21 to 25 years, and 3 (14.29%) had a history of over 25 years. The mean length of the interviews was 53 minutes.

Results of Interview Analysis

A total of 363 codes were extracted, of which 91 repeated codes were excluded. The remaining codes were classified into 40 subcategories and 4 main categories: input, process, product, and outcome. Of the 40 subcategories, 13 (32.5%) were inputs, 11 (27.5%) were processes, 8 (20%) were products, and 8 (20%) were outcomes.

Results of the Second Phase

This phase was carried out with the participation of 49 heads of communicable disease management departments at the medical universities and schools throughout the country.

A total of 67 questionnaires were distributed, of which 39 were completed and returned (response rate, 58.21%). In addition, 19 questionnaires were distributed among officers in CDM, of which 10 completed questionnaires were returned to the researchers after frequent follow-up (response rate 52.63%). Of the 49 people who participated in this phase of the study, 1 was less than 30 years old (2.04%), 12 were between 30 and 40 (24.49%), 20 were between 40 and 50 (40.82%), 13 were older than 50 (26.53%), and 3 (6.12%) did not fill out this section so their ages remained unknown. Thirty-four (69.39%) of the participants were male and the rest were female.

In terms of job experience, 8 (16.33%) of the participants had between 5 and 10 years, 6 (12.24%) had between 10 and 15 years, 5 (10.2%) had between 15 and 20 years, 18 (36.73%) had between 20 and 25 years, and 9 (18.37%) had over 25 years. The job experience of 3 participants was unknown.

Of the 111 proposed indicators in this phase, 33 indicators (29.73%) did not meet the desired criteria, from the participants' viewpoints, and were excluded from the study. Finally, 77 of the indicators won the approval of at least 70% of the participants. Because of the high number of indicators and the difficulty of assessing them, the proposed indicators were revised again by an expert panel of researchers and specialists. Finally, 26 indicators (33.77%) were excluded and the remaining 51 entered the next phase (weighting). Of the final 51 indicators, 10 were related to input (19.61%), 17 to process (33.33%), 13 to product (25.49%), and 11 to outcome (21.57%).

Determining the Criteria for Weighting

The criteria were compared two by two to determine the weight. For example, the "economic" criterion was compared to the "clear" criterion to determine which was more important.

The calculation results are shown in Table 1.

It should be noted that, in cases where the inconsistency was higher than the standard (0.1), the participants were asked to revise their scoring. This continued until the acceptable inconsistency was achieved.

TABLE 1

Importance of the Criteria

Order of Importance	Criterion	Importance Coefficient
1	Economic	0.419
2	Clear	0.245
3	Relevancy	0.186
4	Monitorable	0.091
5	Adequate	0.059

Inconsistency: 0.03

TABLE 2

Weights of Indicators

Indicator	Weight
Health team ratio to population	0.099
Equipping of health teams	0.084
Authorities and legal supports	0.07
Health relief posts ratio to population	0.074
Setting up incident command system	0.065
Availability of databases	0.06
Emergency funding	0.065
Coordination	0.041
Recording, reporting, and confirming of cases	0.047
Data analyzing	0.042
Providing feedback and documentation	0.042
Simplicity	0.023
Flexibility	0.023
Data quality	0.029
Data protection and security	0.025
Setting surveillance system	0.018
Representativeness	0.017
Timeliness	0.017
Stability	0.016
Acceptability	0.015
Reliability	0.014
Providing required data	0.018
Estimating the process and severity of outbreaks	0.015
Outbreak recognition and issuing early warning	0.015
Usefulness	0.013
Designing interventions	0.011
Satisfaction	0.01
Outbreak control	0.012
Prevention and prophylaxis	0.012
Monitoring accountability	0.011

Weighting of the Indicators

At this phase, the priority of each indicator was judged with the criteria. The judgment was based on Saaty's 9-point scale. The results of this calculation were registered after the paired comparison matrix with the criteria. Inconsistency of items was calculated through normalization of row and column averages. The question answered in this section was, "Among the criteria of clarity, relevance, economic impact, adequacy, and ability to monitor, which one is preferred and to what extent?"

TABLE 3

Final List of Performance Assessment Indicators for Communicable Disease Surveillance Systems Designed for Use in Natural Disasters

Indicator	Rank	Description
Health teams with a doctor and CDM officers ratio to affected population	1	Health teams with a doctor and communicable diseases management Department officers' ratio to affected population
Health centers/health teams with the required equipment rate	2	Equipped teams' ratio to all teams The equipped health teams' ratio to all health teams
Availability of medical tests	3	The mobile laboratories and existing laboratory tests ratio to expected ones
Drugs and essential biologic materials depot for diseases under surveillance	4	The teams with an essential drugs depot in proportion to all teams
Existing guidelines and definitions of syndromes/diseases under surveillance	5	The teams with guidelines regarding syndromes/diseases under surveillance in proportion to all teams The teams with job action sheets and familiarity with them
Legislation and authority	6	How to provide legal support (qualitative)
Setting up health relief posts in disaster-affected areas	7	Established health posts ratio to the affected population
Establishing incident command system	8	The teams with a disaster command center in proportion to all teams
Existence of health-related databases	9	Existing databases' ratio to the expected ones
Emergency funding	10	The teams with revolving funds in proportion to all teams
Coordination	11	The ratio of coordination meetings held to the expected ones
	12	Ratio of health committee meetings held with the presence of the head of a Communicable Diseases Department to all committee meetings held
Existence of patients' registration book in the teams and completing of it by health teams	13	The ratio of teams with patients' registration book completed to all teams
Case reporting rate	14	The ratio of reported cases of disease to all recorded cases
Timelines of case confirmation	15	The ratio of diseases studied in less than 24–48 hours to all reported cases
Daily trend analyzing	16	The ratio of diseases studied in less than 24–48 hours to all cases
Preparing and publishing outbreak/epidemic reports and filing them	17	The ratio of filed and published reports to all outbreaks/epidemics
Providing weekly/monthly/quarterly feedback	18	The weekly/monthly ratio of published reports and feedback provided to all reports
Required teaching/learning resources for teams	19	The required training resources for teams
Similarity	20	The degree of similarity between setup of surveillance system with routine SS
Flexibility	21	Changes in the report forms Changes ratio in the syndromes/diseases under surveillance to expected changes
	22	Applicability of the surveillance system to other hazards
Data quality	23	The ratio of completed items in the daily examining and reporting forms to all items
Sensitivity and positive predictive value	24	Sensitivity and positive predictive value
Examining all syndromes with outbreak, epidemic, and endemic disease potential (respiratory infection, bloody diarrhea, acute watery diarrhea, rash, malaria, and meningitis)	25	The endemic diseases under surveillance in proportion to all endemic diseases Syndromes with outbreaks or epidemic potential in proportion to all expected cases
Data security	26	The degree of protecting records and data against misuse
Identifying diseases under surveillance by active referrals to hospitals/laboratories/homes and …	27	Actively identified diseases ratio to all identified cases
Implementation of SS in the disaster-affected areas	28	The population /area covered by the surveillance system in proportion to entire population in disaster-affected area
The length of setting up of SS	29	The onset of surveillance system activity in the area (the time of the disaster occurrence)
Timely reporting of diseases	30	Weekly reports received within 24 hours from the appointed time in proportion to all reported cases Immediate reporting of diseases reported within 24 hours from the onset in proportion to all reported cases
Regular daily reporting	31	The days with regular reports of cases in proportion to all days that there were reports
Participation rate of different sectors in the SS	32	The participation rate of different sectors in the surveillance system
Reporting of expected mortality rate	33	The expected mortality rate reported
Reporting of expected mortality rate	34	The reported mortality rate caused by syndromes under surveillance
Prevalence/incidence rates of diseases/syndromes under surveillance	35	Prevalence/incidence rate of diseases/syndromes under surveillance

TABLE 3

(Continued)

Indicator	Rank	Description
Using surveillance system data in planning, decision-making, and policy making	36	The degree of surveillance system data use in planning, decision-making, and policy making (qualitative)
Providing estimation of future trends (predicting the size, speed, and intensity of outbreaks)	37	The ratio of t outbreaks whose sizes, speeds, and intensity are predicted to all outbreaks
Outbreak identification	38	The identified outbreaks' (timely) ratio to the expected ones The ratio of outbreaks identified by the surveillance system to all of the identified outbreaks
Setting early warning system based on trends	39	The issued warning rate based on the trend to the expected cases
Providing demographic data and indicators	40	The ratio of areas and teams with demographics data to all areas and teams The cities with population indicators in proportion to all of the disaster-affected cities
Achievement of SS set up goals	41	Achievement of surveillance system set up goals (Qualitative)
Incidence rate of diseases/syndromes under SS	42	Incidence rate of diseases/syndromes under surveillance
Hospitalization and disability rate	43	Hospitalization rate due to diseases/syndromes under surveillance The disability rate caused by diseases/syndromes under surveillance
Crude mortality rate	44	Daily/weekly crude mortality rate
Infant and children mortality rate		Daily/weekly mortality rate of infants under one year or under five years
Mortality rate caused by diseases/syndromes under SS		Mortality rate caused by diseases/syndromes under surveillance
Daily costs in comparison with the previous process	45	Decrease/increase rate in daily expenses
Designing/assessment of interventions in relation to disease process	46	The designed/ assessed interventions ratio in relation to disease process to the expected cases
Satisfaction of staff and the public with SS	47	Satisfaction rate of staff and the public with surveillance system (qualitative)
Outbreak control	48	The outbreaks controlled within… in proportion to the all reported outbreaks
Chemical Prophylaxis	49	The number of people receiving prophylaxis in proportion to the expected numbers
Providing feedback to the authorities	50	Amount of feedback provided to the authorities in proportion to the expected amount
System response to suggestions and recommendations	51	The number of suggestions and recommendation fulfilled by the system in proportion to the all suggestions and recommendations

Determining the Final Weights of the Indicators

At the final stage of the weighting process, the results of the 2 previous phases were integrated and the final weights of items were calculated. The detailed results were presented in Table 2. The highest weight score, which was 49.1 out of 100, belonged to the indicators in input, and the scores of processes, products, and outcomes were 31.4, 12.7, and 6.8, respectively.

Finally, the developed indicators for PA of CDSSs in disasters and their definitions were shown in Table 3.

DISCUSSION

The present study was designed and conducted to develop PA indicators based on the input, processes, products, and outcomes framework for CDSSs in response to natural disasters. The researchers interviewed 21 experts in related fields in 2 phases and extracted 51 indicators in the 4 areas of input, processes, products, and outcomes. The indicators were weighted using the analytical hierarchy process approach.

The absence of such indicators was noted in previous years by many experts.[25-27] The frameworks and indicators proposed and applied in previously published work had been designed for usual conditions (not disasters). It is obvious that the conditions following a disaster are different from the normal ones. So, the designed CDSS and associated processes will be different from those designed for normal conditions.[28] Thus, PA indicators of such systems should also be different from those that are appropriate under usual conditions. Although some of the indicators in previous studies and developed frameworks have been used in this study, these are the first indicators that have been developed specifically for the PA of CDSSs in disasters.

For example, all 9 attributes of the CDC guidelines,[15] 31 of the World Health Organization (WHO)-proposed indicators in *Communicable Diseases Surveillance and Response: A Guide to Monitoring and Evaluating*,[28] and 7 of the proposed indicators in the "Surveillance System" chapter in *Communicable Diseases Control in Emergencies: A Field Manual*[29] were included in the PA indicators list.

In this study, the performance indicators for each of the 4 areas—input, processes, products, and outcomes—are presented. In *Control of Infectious Diseases in Emergencies*, CDSS includes 6 processes: diagnosis, reporting, examining, verification, analysis, and feedback. Although some indicators have been formulated for each of the 6 processes, these indicators are not used without supporting activities, such as input, education, communication, and supervision.

Essentially, any shortcomings in this area will affect the performance. Thus, these indicators are included in the present PA.

However, these areas has been considered in previous studies of PA (in fields other than disaster). In various studies, some indicators have been developed for the PA of these areas and have been used practically.[30-32] The 4 indicators provided by WHO for assessment have been noted.[29]

Other important points in this study are the weights of indicators and their importance in the PA. These indicators can be used not only to assess the performance of designed SSs in response to disasters, but also to rank them through the obtained indicator scores. In this study, the highest weight (49.1 out of 100) is devoted to the input indicators. Although they are not among the highest indicators proposed by the WHO, 41 out of the 95 indicators are in the input areas.[29] The results are similar in the outcomes. Outcome indicators in this study have the lowest role in PA (8.6 out of 100). Among the indicators proposed by the WHO, only one indicator is devoted to outcome as well. The indicators help identify the strengths and weaknesses of CDSSs in disasters. Obviously, the extraction of these cases is the responsibility of every manager and could possibly improve and enhance CDSSs in the future.

CONCLUSION

Natural hazards and the disasters that they create in communities have always been an inevitable part of human life. They will also continue to occur in the future. The common effects of these disasters are the destruction of infrastructure including health facilities. This paves the way for the occurrence and prevalence of communicable diseases that may intensify the side effects of the disasters as they themselves become the secondary disasters. To manage these conditions, the first and the most important step is to design and set up a CDSS. The performance of a SS, like that of any other program, should be assessed for efficiency and effectiveness. In the existing literature, attention is paid to the lack of such indicators, but few practical actions have been taken. To overcome this deficiency, this study recommends 51 indicators for PA of CDSS. The researchers believe that these indicators will be effective and useful in the PA of SSs. Although there may be shortcomings and problems with these indicators, it is hoped that researchers around the world will overcome these weaknesses by testing the indicators in the field.

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Acknowledgements

This study was part of a PhD thesis/dissertation supported by Tehran University of Medical Sciences.

Funding

This study has been funded and supported by I.R. Iran's National Institute of Health Research (NIHR), Tehran University of Medical Sciences.

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