

9-5-2023

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Original Research

Cite this article: Ryan B, Kako M, Fink R, et al. Strategies for strengthening the resilience of public health systems for pandemics, disasters, and other emergencies. *Disaster Med Public Health Prep.* 17(e479), 1–13. doi: <https://doi.org/10.1017/dmp.2023.136>.






Keywords:

COVID-19 pandemic; health system; resilience; workshops; public policy

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Strategies for Strengthening the Resilience of Public Health Systems for Pandemics, Disasters, and Other Emergencies

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Abstract

Objective: The aim of this study was to identify and prioritize strategies for strengthening public health system resilience for pandemics, disasters, and other emergencies using a scorecard approach.

Methods: The United Nations Public Health System Resilience Scorecard (Scorecard) was applied across 5 workshops in Slovenia, Turkey, and the United States of America. The workshops focused on participants reviewing and discussing 23 questions/indicators. A Likert type scale was used for scoring with zero being the lowest and 5 the highest. The workshop scores were analyzed and discussed by participants to prioritize areas of need and develop resilience strategies. Data from all workshops were aggregated, analyzed, and interpreted to develop priorities representative of participating locations.

Results: Eight themes emerged representing the need for better integration of public health and disaster management systems. These include: assessing community disease burden; embedding long-term recovery groups in emergency systems; exploring mental health care needs; examining ecosystem risks; evaluating reserve funds; identifying what crisis communication strategies worked well; providing non-medical services; and reviewing resilience of existing facilities, alternate care sites, and institutions.

Conclusions: The Scorecard is an effective tool for establishing baseline resilience and prioritizing actions. The strategies identified reflect areas in most need for investment to improve public health system resilience.

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The Coronavirus Disease 2019 (COVID-19) is a reminder of how an emerging infectious disease can rapidly become a pandemic. Technological advances and societal changes of the last century exacerbated the impact of COVID-19. Rapid population growth, increased mobility, urbanization, societal interdependence, unreliable healthcare systems, and heightened inequalities created an unprecedented vulnerability to a fast-moving infectious disease outbreak. COVID-19 and the response had disproportionate health and socio-economic effects on low-income communities, the self-employed, elderly, and people with underlying health conditions with limited access to health care.¹ In addition, economically vulnerable populations were unable to endure long-term lockdowns and most countries lacked the ability to maintain a full nationwide relief operation.²

A resilient public health system can mitigate the impact of disease outbreaks, pandemics, and disasters. This includes the ability to respond, recover and absorb shocks while continuing to serve community needs and sustain vital functions.^{3,4} Resilience requires the agility to rapidly adapt to dynamic situations, which can mitigate vulnerability across and beyond the system.⁴ Success results in returning to a stable and recovered condition without compromising long-term development.⁵ However, border restrictions and lockdowns increased food insecurity worldwide by slowing agricultural production and dramatically raising food prices.⁶ School closures resulted in students losing one to two years of competencies, and despite favorable conditions, students made little or no progress while learning from home.⁷ Learning loss was most pronounced among students from disadvantaged homes.⁸

An estimated US\$10 trillion earning losses occurred during the pandemic and it will take approximately 500 years of preparedness spending to equal what was lost globally.⁶ Long-term total lockdowns negatively impacted mental health and access to essential healthcare, especially for people with chronic diseases.^{9–13} Managing the competing priorities of enabling communities to function while providing care for people with COVID-19, patients who need care every day, and maintaining safety efforts such as robust infection-control practices was both difficult and essential.¹⁴ The COVID-19 pandemic serves as a wake-up call for public health systems and facility leaders to become more adaptable and focused on meeting whole-of-society needs.¹⁵

A frame for achieving this is the World Health Organization (WHO) Health Emergency and Disaster Risk Management Framework (Health EDRM). It provides a useful series of tools and approaches for sharing country and community experiences, essential to informing an all-hazards risk management approach to public health.¹⁶ A key aspect of this is measuring the resilience of a community and then identifying priority areas for local action. Also, health equity and outcomes must be considered and are strongly dependent on robust collaboration across sectors including governance, financing, health workforce, public health, medical products and technologies.⁴ Complementary to this is the United Nations Office for Disaster Risk Reduction (UNDRR) Public Health System Resilience Scorecard (Scorecard).

The Scorecard is aligned with the Health EDRM and enables the establishment of a baseline and priorities for the resilience of a public health system using a multidisciplinary consensus-based approach. It was developed with input from a group of multisectoral experts, including UNDRR and WHO.¹⁷ It was created after application of the Disaster Resilience Scorecard for Cities revealed a need for a deeper dive into the health sector.¹⁸ The Scorecard Version 1.0 was launched in July 2018 and Version 2.0 in

April 2020, which included contributions from authors of this paper (B.R. and S.B.).¹⁹ It is freely downloadable, available in fifteen languages, and has been used by local, provincial, and national governments in many parts of the world.¹⁷

The aim of this study was to identify and prioritize strategies for strengthening public health system resilience for pandemics, disasters, and other emergencies using the Scorecard approach. This included applying the Scorecard in different scenarios, countries, and settings. Enabling complexity and sub-system interactions to be explored and help identify weaknesses affecting multiple social and physical factors. Local community members, public health representatives and others who experience the day-to-day impacts of emergencies were involved in this project. This group understands the areas requiring the most urgent improvement and are crucial when determining viable strategies for improving public health system resilience.

Methods

Setting and Participants

Purposeful sampling was used to select participants and workshop locations.²⁰ The selection of participants was determined by discussion with local representatives and invitations were sent by e-mail. Workshop participants included individuals who provided clinical care, public health, emergency management, and other community services during the COVID-19 pandemic. The workshop locations were selected based on access and convenience to ensure variety among rural and urban settings in several continents. In addition, we asked the invitees if there were any others who should be invited to participate, a recruitment approach consistent with snowball sampling.^{21,22}

Procedure

The study commenced with training of workshop facilitators on the Scorecard approach. This was followed by individual workshops where the Scorecard was applied to identify and define local priorities. After the individual workshops, the data were aggregated, analyzed, and interpreted to develop priority strategies reflective of participating locations. This study also incorporates the qualitative analysis of the Scorecard workshops in Turkey.²³ This expanded and more detailed study allowed the Scorecard method and findings to be evaluated across different settings. More details on the methods used are provided in [Figure 1](#) and the following.

Scorecard Workshop Format

The workshop format was based on the Disaster Resilience Scorecard for Cities, which was developed as a contribution to the Making Cities Resilient (MCR) Campaign.²⁴ The lead designers for this approach were AECOM (Architecture, Engineering, Construction, Operations, and Management) and IBM (International Business Machines) with support from the United States Agency for International Development (USAID) and the European Commission.²⁴ The Scorecard used in the study was chosen because of the frequent use by practitioners around the world and alignment with both the Health EDRM (Emergency and Disaster Risk Management Framework), Ten Essentials for MCR,²⁵ and MCR2030.^{17,26} It also overlaps with the coverage of

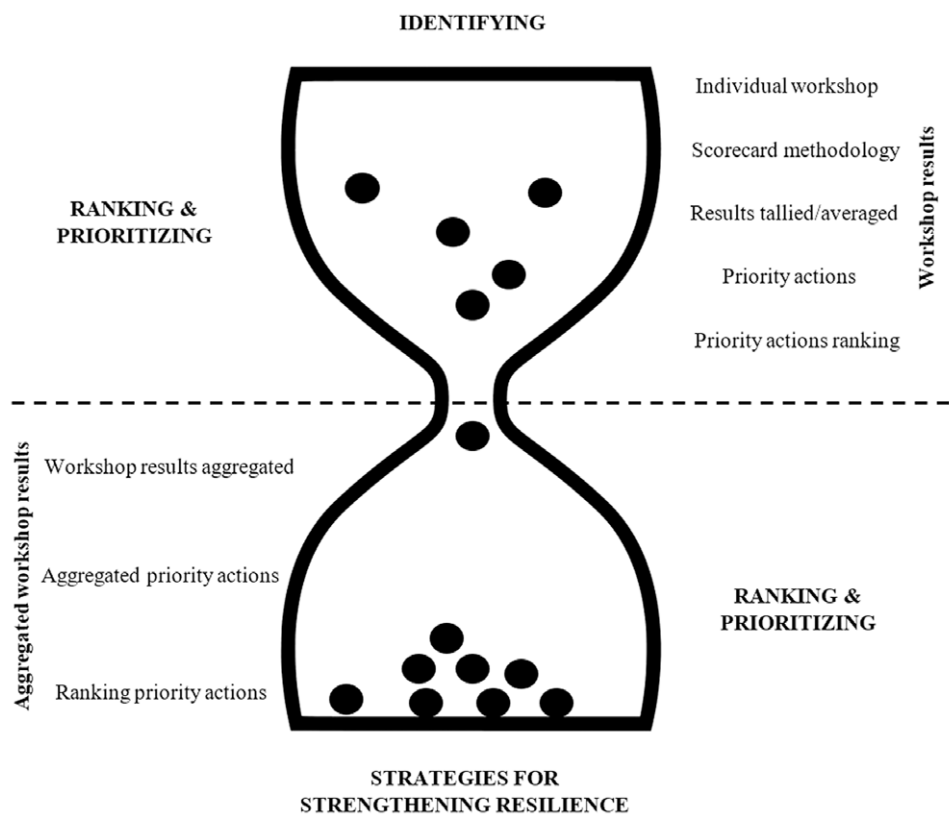


Figure 1. Strategies for strengthening resilience.

hospitals and food distribution in Essential 8 for the Ten Essentials for MCR but can be considered an amplification.¹⁸

The 23 questions/indicators for the Scorecard are spread thematically across a modified version of the Ten Essentials for MCR, which relate to public health systems and include:

- Integration of public health and governance (Essential 1);
- Integration of public health and disaster scenarios (Essential 2);
- Integration of public health and finances (Essential 3);
- Integration of public health and land use/building codes (Essential 4);
- Management of ecosystem services that affect public health (Essential 5);
- Integration of public health and institutional capacity (Essential 6);
- Integration of public health and societal capacity (Essential 7);
- Integration of public health and infrastructure resilience (Essential 8);
- Integration of public health and disaster response (Essential 9);
- Integration of public health and recovery/building back better (Essential 10).

Facilitators guided participants through the Scorecard during the workshop and ranking of strategies developed. This approach was selected because it provides an excellent platform to identify, explore, and understand the complex factors and processes of the public health system.²⁷ The participatory and interactive characteristics of workshops provide an ideal approach to leverage community-led knowledge that is needed to influence future processes and strategies.^{27–29} Also, this is ideal when engaging a diverse range of stakeholders involved in shaping strategic actions

within sub-systems and identifying factors that may not be clearly noticeable before the study.^{27,30}

Data Collection and Analysis

Five workshops were conducted from October 2021 to February 2022. Two workshops were held in the United States of America (USA) in Waco, Texas (October 13, 2021), Dallas, Texas (February 28, 2022); 2 in Turkey, Ortahisar (November 3, 2021) and Esenler (November 17, 2021); and 1 in Slovenia, Ljubljana (February 18, 2022). The Scorecard was completed based on the experiences, perspectives, roles, and respective expertise of participants. Facilitators encouraged group discussion about each question/indicator and the associated level of resilience observed while providing contextual information. Both in-person and online participation were used due to varying pandemic measures and constraints in-place. A mobile phone application ExPo Go © 2022 was developed to allow participants to document and submit scores on each Scorecard question/indicator. For those not able to use ExPo Go © 2022, a Google document was used.

The workshops were designed to be conducted in 2 parts over 1 day. Part 1 focused on participants reviewing the 23 questions/indicators using a Likert type scale with 0 the lowest score and 5 the highest. Scores from each participant were aggregated to develop a mean for each question/indicator. In part 2, aggregated scores were presented to the workshop participants for analysis with discussion focused on the lowest ranking questions/indicators highlighted for group discussion. The decision on removal, clarification and ranking of an indicator was determined by workshop participants through a consensus approach.^{18,31} Once consensus was reached, participants developed a strategy for each selected question/indicator. An impact versus difficulty process was then conducted to determine priority

Table 1. Characteristics of the workshop participants

Demographic	Workshop					
	Waco (USA) (n = 32)	Eseler (Turkey) (n = 28)	Ortahisar (Turkey) (n = 28)	Ljubljana (Slovenia) (n = 16)	Dallas (USA) (n = 21)	Total (n = 125)
Gender						
Male	17	23	19	6	13 (5)	78
Female	15	5	9	10	8 (4)	47
Participant location						
Local	15	12	16	9	15 (6)	67
Regional	5	16	12	7	5 (2)	45
External (outside region)	12	0	0	0	1 (1)	13
Sector/institution type						
Academia	12	2	3	2	15 (7)	34
Private sector	3	0	0	1	2	6
Government	9	26	25	13	1 (1)	74
Non-profit	3	0	0	0	2 (1)	5
United Nations	5	0	0	0	1	6
Role/discipline						
Academic	8	2	3	2	8 (4)	23
Communications	0	2	0	0	0	2
Doctor	4	3	2	2	7 (3)	18
Elected official	0	0	0	1	0	1
Emergency management	5	7	7	2	1	22
Environmental health	1	3	2	1	0	7
Epidemiologist	1	0	0	2	0	3
Local government	0	0	1	0	0	1
Logistics	0	3	2	1	0	6
Manager	4	0	1	1	1	6
Mental health	0	1	1	0	0	2
Nurse	1	2	2	2	0	7
Pharmacy	0	1	1	0	0	2
Primary health	1	1	1	1	1 (1)	5
Public health	1	2	2	1	1 (1)	7
Radiation safety officer	1	0	0	0	0	1
Responder	0	1	2	1	0	4
United Nations	5	0	0	0	1	6

Note: Numbers in parentheses represent participants at the Dallas follow-up workshop on June 28, 2022.

strategies.³² Due to time constraints, the Dallas Workshop was completed on 2 separate days, February 28, 2022 and June 28, 2022. The prioritization process was completed during a 1-hour virtual discussion with 9 participants (all except 1 attended the first workshop) on the second day.

Data from all workshops were then aggregated, analyzed, and interpreted to develop priorities representative of participating locations. This analysis was undertaken by several authors (A.F., A.S., B.R., C.N., I.T., P.S., R.F., R.S., S.N., and T.H.). One-way analysis of variance (ANOVA) and the Duncan test was conducted (author R.F.) and reviewed (author B.R.). This method was used to determine the significant differences among workshops at a significance level of $P < 0.05$.

Results

Sample Characteristics

One hundred twenty-five people participated in the 5 workshops (Table 1). There were 62% male and 38% female participants.

Within this group, 54% declared themselves local representatives, 36% regional, and 10% external (outside the region). The results from each workshop were aggregated, the mean for each indicator calculated and a statistical analysis conducted. The results are described below along with the individual workshop recommendations and aggregated priority strategies from all workshops.

Workshops Results

The workshop scores and data analysis are provided in Table 2. Strong statistical differences were found in support of questions relating to accessibility of individual health records after a disaster (A6.2.2), community willingness to act on public health information (A7.1.2), considering the needs of existing medical conditions (A9.3), and supplies/equipment (A9.4) ($P < 0.0001$). Similar scores were provided for questions relating to inclusion of public health in disaster risk management governance (A1.1), considering disaster outbreaks in disaster planning (A2.1), funding (A3.1), location of health facilities (A4.1), and ecosystems and the

Table 2. Workshop essential results and data analysis

Essential	Ref	Question/assessment area	W	E	O	L	D	Avg	F value	P-Value
Integration of public health and governance (Essential 1)	A1.1	To what extent does/do the governance mechanism(s) for disaster risk management integrate the full breadth of public health considerations?	3.26 ^{ab}	3.11 ^b	3.65 ^a	3.06 ^b	3.18 ^{ab}	3.25	2.354	0.0599 [#]
Integration of public health and disaster scenarios (Essential 2)	A2.1	To what extent are emergencies and disasters including disease outbreaks are included in disaster risk planning?	3.33 ^{ab}	3.67 ^{ab}	3.78 ^a	3.06 ^b	3.67 ^a	3.50	2.137	0.0832 [#]
	A2.2	To what extent are public health impacts included in the city's scenario planning for other disaster risks?	3.16 ^a	3.72 ^a	3.27 ^a	2.43 ^b	3.09 ^{ab}	3.13	3.818	0.0069 [*]
	A2.3	To what extent are pre-existing chronic health issues included in scenarios where disasters are likely to exacerbate these, or where they are likely to impede recovery?	2.00 ^b	2.56 ^{ab}	2.96 ^a	2.56 ^{ab}	2.92 ^a	2.60	3.514	0.0105 [*]
Integration of public health and finances (Essential 3)	A3.1	To what extent is funding identified and available to address public health risks and impacts of disasters?	2.33 ^b	2.56 ^{ab}	2.83 ^{ab}	2.43 ^b	3.00 ^a	2.63	1.972	0.1060 [#]
Integration of public health and land use/building codes (Essential 4)	A4.1	To what extent are key health facilities located and built in a manner that will allow them to continue to be operational after a disaster?	2.78 ^{ab}	2.22 ^b	2.91 ^a	2.75 ^{ab}	2.83 ^a	2.70	1.899	0.1180 [#]
Management of ecosystem services that affect public health (Essential 5)	A5.1	To what extent are ecosystem services that provide public health benefits identified and protected?	2.58 ^a	2.39 ^a	2.13 ^a	2.56 ^a	2.33 ^a	2.40	0.526	0.7170 [#]
Integration of public health and institutional capacity (Essential 6)	A6.1	To what extent are the workforce, competencies, and skills required to plan and maintain public health systems and services for disaster resilience available to the city?	3.39 ^{ab}	3.67 ^a	3.17 ^{ab}	2.75 ^b	3.33 ^a	3.26	2.525	0.0466 [*]
	A6.2	To what extent are public health data on health vulnerabilities and capacities, as well as risks and early warning of outbreaks shared with other stakeholders who need it?	3.26 ^b	4.17 ^a	3.48 ^b	3.00 ^b	3.33 ^b	3.45	3.359	0.0133 [*]
	A6.2.1	To what extent are data from other critical systems shared with public health system stakeholders who need it?	2.85 ^b	3.78 ^a	3.65 ^a	2.87 ^b	2.92 ^b	3.21	3.727	0.0075 [*]
	A6.2.2	To what extent are individuals' health and prescription records protected from a disaster, and accessible in the aftermath of a disaster?	2.84 ^b	4.28 ^a	4.09 ^a	3.06 ^b	2.92 ^b	3.44	11.21	<0.0000 [*]
Integration of public health and societal capacity (Essential 7)	A7.1	To what extent do communities understand and are able to fulfil their roles in maintaining public health and well-being levels before, during, and after a disaster?	2.00 ^b	2.94 ^a	2.96 ^a	2.31 ^b	1.92 ^b	2.43	6.451	0.0001 [*]
	A7.1.2	To what extent do communities receive, respect, and are willing to act upon public health information?	2.21 ^c	3.39 ^a	3.8 ^{ab}	2.87 ^b	2.08 ^c	2.87	13.28	<0.0000 [*]
	A7.2	To what extent are communities' mental health needs addressed?	1.48 ^{bc}	2.17 ^{ab}	2.27 ^a	1.93 ^{abc}	1.17 ^c	1.80	3.359	0.0132 [*]

(Continued)

Table 2. (Continued)

Essential	Ref	Question/assessment area	W	E	O	L	D	Avg	F value	P-Value
Integration of public health and infrastructure resilience (Essential 8)	A8.1	To what extent is public health infrastructure (besides hospitals) resilient?	2.48 ^b	2.22 ^b	3.39 ^a	2.43 ^b	2.67 ^b	2.64	4.95	0.0012*
	A8.2	To what extent are hospitals and emergency care centers able to manage a sudden influx of patients?	3.3 ^{ab}	3.89 ^a	3.68 ^{ab}	2.62 ^c	3.00 ^{bc}	3.30	5.361	0.0006*
	A8.3	To what extent can care be maintained for those who are already sick or dependent?	2.85 ^{bc}	3.11 ^{ab}	3.39 ^a	2.56 ^c	3.00 ^{ab}	2.98	3.402	0.0124*
Integration of public health and disaster response (Essential 9)	A9.1	To what extent do early warning systems exist for impending emergencies that have potential health effects?	3.05 ^{bc}	2.78 ^c	4.00 ^a	3.18 ^{bc}	3.64 ^{ab}	3.33	4.956	0.0012*
	A9.2	To what extent are public health sector and professionals integrated with the emergency management team?	4.20 ^a	3.17 ^b	4.17 ^a	3.00 ^b	4.33 ^a	3.77	5.975	0.0002*
	A9.3	To what extent are the needs of higher risk populations considered, such as citizens with pre-existing medical conditions, disabilities or loss of function that may mean that they require additional support?	2.00 ^{cd}	3.11 ^{ab}	3.73 ^a	1.80 ^d	2.58 ^{bc}	2.64	9.069	<0.0000*
	A9.4	To what extent can the city supply item and equipment required to maintain public health during and after a disaster.	2.68 ^c	4.61 ^a	3.57 ^b	2.68 ^c	3.00 ^{bc}	3.31	14.32	<0.0000*
Integration of public health and recovery/building back better (Essential 10)	A10.1	To what extent do comprehensive post event public health plans exist?	2.13 ^c	3.78 ^a	3.09 ^{ab}	2.50 ^{bc}	2.91 ^{ab}	2.88	6.332	0.0001*
	A10.2	To what extent do formalized mechanism to learn from performance of public health system before, during, and after disasters exist?	3.41 ^a	3.83 ^a	3.43 ^a	2.37 ^b	3.27 ^a	3.26	4.662	0.0019*

Note: Waco (W), Esenler (E), Ortahisar (O), Ljubljana (L), Dallas (D); Values in a row followed by a different letter are significantly different in the Duncan ($P < 0.05$) test. * $P < 0.05$. [#] $P > 0.05$.

effect on public health (A5.1) with no statistical differences observed ($P > 0.05$). For all other questions, statistical significance among groups was observed ($p < 0.05$).

Individual Workshop Recommendations

After completing the scoring, the workshop participants discussed the results and identified priority recommendations (Table 3). Based on the scoring, addressing community mental health needs (A9.2) was the priority identified in the Waco, Dallas, (USA) and Esenler (Turkey) workshops. This was scored as the second priority in Ortahisar (Turkey) and Ljubljana (Slovenia). Protecting ecosystem services (A5.1) was the area needing most attention in Ortahisar (Turkey) while this was deemed a priority 4 in Dallas (USA). The workshop in Ljubljana identified the needs of higher risk populations (A9.3) as a priority and this was number 4 in Dallas and Waco. While discussing the results at the Dallas workshop, the community's willingness to act upon public information (A7.1.2) moved from priority 2 to 1 after an action for this item was developed. At the Waco workshop, the indicator relating to pre-existing chronic health issues moved from priority 3

to 2 after developing an action for addressing this challenge. Also, a similar outcome occurred in Ljubljana where the indicator relating to addressing mental health needs (A7.2) moved from priority 2 to 1 once an action item was developed.

The highest scoring indicators for all the workshops related to the integration of public health and disaster response. This demonstrated workshop participants considered this the most developed aspect in-terms of public health system resilience. More specifically, integration of the public health sector and professionals with the emergency management team (A9.2) scored highest in Dallas, Ortahisar, and Waco. The highest scoring indicator in Ljubljana related to early warning systems for impending emergencies with health effects (A9.1). In Esenler, the ability for the city to supply items and equipment to maintain public health (A9.4) received the highest score.

Aggregated Priority Strategies

The workshops identified 21 priorities across 4 of the public health system Ten Essentials for MCR (Table 4). This included inclusion of public health in disaster scenarios (Essential 2), management of

Table 3. Individual workshop scores and recommended strategies

Workshop	Lowest scores by indicator (average)	Highest scores by indicator (average)	Priority recommendations
Waco, Texas, USA	To what extent are communities' mental health needs addressed – A7.2 (1.48)	To what extent are public health sector and professionals integrated with the emergency management team – A9.2 (4.20)	<ol style="list-style-type: none"> 1. Evaluate access to mental health care for communities in need (A7.2). 2. Identify and assess community disease burden (mapping), and system needs depending on the duration of the disaster/incident (A2.3). 3. Identify and assess non-medical needs before, during, and after a disaster (A9.3). 4. Establish long-term recovery community groups and coalitions (A10.1). 5. Identify strategies for achieving reciprocal trust among the different communities (A7.1).
	To what extent do communities understand and are able to fulfil their roles in maintaining public health and well-being levels before, during, and after a disaster – A7.1 (2.00)	To what extent do formalized mechanism to learn from performance of public health system before, during, and after disasters exist – A10.2 (3.41)	
	To what extent are pre-existing chronic health issues included in scenarios where disasters are likely to exacerbate these, or where they are likely to impede recovery – A2.3 (2.00)	To what extent are the workforce, competencies, and skills required to plan and maintain public health systems and services for disaster resilience available to the city – A6.1 (3.39)	
	To what extent are the needs of higher risk populations considered, such as citizens with pre-existing medical conditions, disabilities, or loss of function that may mean that they require additional support – A9.3 (2.00)	To what extent are emergencies and disasters including disease outbreaks are included in disaster risk planning – A2.1 (3.33)	
	To what extent do comprehensive post event public health plans exist – A10.1 (2.13)	Not applicable	
Dallas, Texas, USA	To what extent are communities' mental health needs addressed – A7.2 (1.17)	To what extent are public health sector and professionals integrated with the emergency management team – A9.2 (4.33)	<ol style="list-style-type: none"> 1. Assessment of what has worked well in community engagement during disasters to inform future responses/resilience (A7.1.2). 2. SWOT analysis of ecosystem needs and their impact on resilience such as water, air quality, and green space (A5.1). 3. Identify and implement community mental health training programs for communities and health care workers (A7.1). 4. Develop a dynamic process for assessing risk parameters and threats for target populations (A9.3).
	To what extent do communities understand and are able to fulfil their roles in maintaining public health and well-being levels before, during, and after a disaster – A7.1 (1.92)	To what extent are emergencies and disasters including disease outbreaks are included in disaster risk planning – A2.1 (3.67)	
	To what extent do communities receive, respect, and are willing to act upon public health information – A7.1.2 (2.08)	To what extent do early warning systems exist for impending emergencies that have potential health effects – A9.1 (3.64)	
	To what extent are ecosystem services that provide public health benefits identified and protected – A5.1 (2.33)	To what extent are public health data on health vulnerabilities and capacities, as well as risks and early warning of outbreaks shared with other stakeholders who need it – A6.1 (3.33)	
	To what extent are the needs of higher risk populations considered, such as citizens with pre-existing medical conditions, disabilities, or loss of function that may mean that they require additional support – A9.3 (2.58)	To what extent are public health data on health vulnerabilities and capacities, as well as risks and early warning of outbreaks shared with other stakeholders who need it – A6.2 (3.33)	
Esenler, Turkey	To what extent are communities' mental health needs addressed – A7.2 (2.17)	To what extent can the city supply item and equipment required to maintain public health during and after a disaster – A9.4 (4.61)	<ol style="list-style-type: none"> 1. Assemble a study group to evaluate the adequacy of the mental health service capacity (A7.2). 2. Ensure adequate number and capacity of prefabricated facilities (A4.1). 3. Establish control mechanisms to assess and monitor the resilience of public health facilities (A8.1). 4. Establish a study group for the identification, control, and development of ecosystem services (A5.1).
	To what extent are key health facilities located and built in a manner that will allow them to continue to be operational after a disaster – A4.1 (2.22)	To what extent are individuals' health and prescription records protected from a disaster, and accessible in the aftermath of a disaster – A6.2.2 (4.28)	
	To what extent is public health infrastructure (besides hospitals) resilient – A8.1 (2.22)	To what extent are public health data on health vulnerabilities and capacities, as well as risks and early warning of outbreaks shared with other stakeholders who need it – A6.2 (4.17)	
	To what extent are ecosystem services that provide public health benefits identified and protected – A5.1 (2.39)	To what extent are hospitals and emergency care centers able to manage a sudden influx of patients – A8.2 (3.89)	

(Continued)

Table 3. (Continued)

Workshop	Lowest scores by indicator (average)	Highest scores by indicator (average)	Priority recommendations
Ortahisar, Turkey	To what extent are ecosystem services that provide public health benefits identified and protected – A5.1 (2.13)	To what extent are public health sector and professionals integrated with the emergency management team – A9.2 (4.17)	<ol style="list-style-type: none"> 1. Define elements that threaten the ecosystem for the rural and central parts of the county separately (A5.1). 2. Identify and train experts and counsellors who will provide mental health services (A7.2). 3. Evaluate the adequacy of the reserve funds of institutions and organizations that are responsible for disaster response (A3.1). 4. Identify alternative institutions that will undertake the services of those health facilities (A4.1).
	To what extent are communities' mental health needs addressed – A7.2 (2.27)	To what extent are individuals' health and prescription records protected from a disaster, and accessible in the aftermath of a disaster – A6.2.2 (4.09)	
	To what extent is funding identified and available to address public health risks and impacts of disasters – A3.1 (2.83)	To what extent do early warning systems exist for impending emergencies that have potential health effects – A9.1 (4.0)	
	To what extent are key health facilities located and built in a manner that will allow them to continue to be operational after a disaster – A4.1 (2.91)	To what extent do communities receive, respect and are willing to act upon public health information – A7.1.2 (3.8)	
Ljubljana, Slovenia	To what extent are the needs of higher risk populations considered, such as citizens with pre-existing medical conditions, disabilities or loss of function that may mean that they require additional support – A9.3 (1.80)	To what extent do early warning systems exist for impending emergencies that have potential health effects – A9.1 (3.18)	<ol style="list-style-type: none"> 1. Information to the public should be verified before made public (A7.1). 2. Establish community health consulting immediately when the emergency appears (A7.2). 3. Continuous provision of assistance to risk population during and after an emergency (A9.3). 4. Establish “lifelong” learning on pandemic and emergency preparedness (A10.2).
	To what extent are communities' mental health needs addressed – A7.2 (1.93)	To what extent does/do the governance mechanism(s) for disaster risk management integrate the full breadth of public health considerations – A1.1 (3.06)	
	To what extent do communities understand and are able to fulfil their roles in maintaining public health and well-being levels before, during, and after a disaster – A7.1 (2.31)	To what extent are emergencies and disasters including disease outbreaks are included in disaster risk planning – A2.1 (3.06)	
	To what extent do formalized mechanism to learn from performance of public health system before, during, and after disasters exist – A10.2 (2.37)	To what extent are individuals' health and prescription records protected from a disaster, and accessible in the aftermath of a disaster – A6.2.2 (3.06)	

Table 4. Aggregated priority strategies and Scorecard references

Theme	Scorecard reference	Workshop ^a	Identified action (priority ranking from workshop)	Integrated priority action
Governance	A3.1	Ortahisar	Evaluate the adequacy of the reserve funds of institutions and organizations that are responsible for disaster response (3).	Action not integrated, remained the same.
Planning and Preparation	A2.3	Waco	Identify and assess community disease burden (mapping), and system needs depending on the duration of the disaster/incident (2).	N/A Action not integrated, remained the same.
	A4.1	Esenler	Ensure adequate number and capacity of prefabricated facilities (2).	Explore the resilience of existing facilities, alternate care sites and institutions involved in delivering public health services.
		Ortahisar	Identify alternative institutions that will undertake the services of those health facilities (4).	
	A8.1	Esenler	Establish control mechanisms to assess and monitor the resilience of public health facilities (3).	Identify and examine ecosystem risks and needs to protect and sustain public health at the local level.
	A5.1	Esenler	Establish a study group for the identification, control, and development of ecosystem services (4).	
		Ortahisar	Define elements that threaten the ecosystem for the rural and central parts of the county separately (1).	
		Dallas	SWOT analysis of ecosystem needs and their impact on resilience such as water, air quality, and green space (2).	
	A7.1	Waco	Identify strategies for achieving reciprocal trust among the different communities (5).	
		Ljubljana	Information to the public should be verified before made public (1).	
		Dallas	Assessment of what has worked well in community engagement during disasters to inform future responses/resilience (1).	
	A7.2	Waco	Evaluate access to mental health care for communities in need (1).	Evaluate mental health-care needs in communities and address gaps through broad training of community members.
		Esenler	Assemble a study group to evaluate the adequacy of the mental health service capacity (1).	
		Ortahisar	Identify and train experts and counsellors who will provide mental health services (2).	
Ljubljana		Establish community health consulting immediately when the emergency appears (2).		
Dallas		Identify and implement community mental health training programs for communities and health-care workers (3).		
Response and recovery	A9.3	Waco	Identify and assess non-medical needs before, during, and after a disaster (3).	Explore options for providing non-medical needs for high-risk populations before, during, and after a pandemic, disaster, or other crisis.
		Ljubljana	Continuous provision of assistance to risk population during and after an emergency (3).	
		Dallas	Develop a dynamic process for assessing risk parameters and threats for target populations (4).	
	A10.1	Waco	Establish long-term recovery community groups and coalitions (4).	Embed long-term recovery and evaluations into disaster management systems at the community level.
	A10.2	Ljubljana	Establish “lifelong” learning on pandemic and emergency preparedness (4).	

^aThe priority strategies for the Esenler and Ortahisar workshops are included in a qualitative analysis of the Scorecard application in Turkey²⁴

ecosystem services that affect public health (Essential 5), public health and societal capacity (Essential 7), and integration of public health and disaster response (Essential 9). After considering participant discussion, the priority strategies were grouped by the authors (B.R., M.K., R.F., and P.S.) into the themes of governance, planning and preparation, and response and recovery. Following this process, integrated priority strategies from all 5 workshops

were developed with 8 provided. The theme with the most identified strategies was planning and preparation with 10 priorities and 5 after integration.

The 8 integrated priorities reflect the areas in most need for public investment to improve the resilience of public health systems. The strategies are prioritized in the following based on the number of workshop recommendations integrated into each

action. Where there was a tie, the ranking from each workshop was totaled with the lowest overall score used to determine priority (see parenthesis for each workshop action in [Table 4](#)). If this did not resolve the tie, alphabetical order was used.

1. Evaluate mental health care needs in communities and address gaps through broad training of community members.
2. Explore what communication strategies worked well and built trust during the COVID-19 pandemic and other disasters.
3. Identify and examine ecosystem risks and needs to protect and sustain public health at the local level.
4. Explore the resilience of existing facilities, alternate care sites and institutions involved in delivering public health services.
5. Explore options for providing non-medical needs for high-risk populations before, during, and after a pandemic, disaster, or other crisis.
6. Embed long-term recovery and evaluations into disaster management systems at the community level.
7. Identify and assess community disease burden (mapping), and system needs depending on the duration of the disaster/incident.
8. Evaluate the adequacy of the reserve funds in institutions and organizations responsible for disaster response.

Limitations

Our study has several limitations. First, self-selection bias is a potential limitation. Participants were interested in this study area and wanted to contribute during the COVID-19 pandemic. However, the aim was to maximize participation and identify locations with the willingness and ability to apply the Scorecard using a workshop methodology. A vital aspect of this research leveraged existing experience and knowledge of local public health systems, emergency management, and other aspects of societal responses to a disaster situation. Existing networks and contacts were used to identify participants from a range of sectors, which was followed by asking if there was anyone else who may be interested in participating. This approach was consistent with purposeful and snowball sampling techniques. Second, the direction of this study was influenced by the work of the authors and researchers in this field. To minimize this impact, an interdisciplinary, multinational team completed this study. The experience of the team encompassed medicine, nursing, environmental health science, public health, risk management, health promotion, emergency management, and information technology. Third, the application of the findings should be applied cautiously as priority needs and areas may not be generalized to other countries with their distinct health delivery systems, comprising unique legislative and organizational characteristics, and within different clinical and political settings. Fourth, the research was undertaken during the COVID-19 pandemic with most strategies identified based on participant experience. However, this limitation was mitigated due to the uniqueness of this situation that provided the opportunity to better understand the impacts of a simultaneous event or hazard.

Discussion

Our findings demonstrate the actions needed to strengthen public health systems for the next pandemic, disaster, or other emergency. We found alignment of the Scorecard with the Health EDRM

demonstrates their useful potential in rapidly sharing country and community experiences and areas for system improvement. This includes the enablers and barriers affecting the implementation and design of risk management strategies relating to public health system resilience. For example, all workshop participants identified the need to enhance mental health care, services, and capacities. The participants in Dallas, Esenler, Ortahisar, and Waco discussed the importance of ensuring adequate facilities and staff when there is a surge of patients. Participants at the Dallas, Ljubljana, and Waco workshops also highlighted the needs of people at risk, such as those with chronic diseases, should be included in response and recovery activities along with the delivery of non-medical services and supplies.

The workshops identified mental health services as a priority area for strengthening resilience. This is consistent with other studies, which have reported mental health care represents 1 of the most predominant concerns post pandemic.^{33–35} Any ongoing traumatic event such as a pandemic or disaster clean-up can result in depression, anxiety, stress, and even posttraumatic stress disorder.³⁶ Health-care workers are also at high risk of developing mental health issues during an ongoing crisis as they are often faced with living in the area impacted along with physical and mental exhaustion.³⁷ To address this risk, mental health services at the local government and organizational level must be evaluated and become more accessible during a crisis.

Many participants expressed deep concerns about the ability of existing emergency management structures to better support hospitals during patient surges, a finding that requires further investigation.³⁸ This could include enabling telehealth and primary health to manage patients at home using telehealth and remote patient monitoring and directly supporting hospital staff during a crisis.³⁹ The repurposing and redeployment of the existing health workforce, students, and volunteers during the COVID-19 pandemic and other disasters is another option that requires exploration.⁴⁰ The resilience of existing facilities, alternate sites, and institutions involved in delivering health services should also be evaluated. A starting point could be the formation of local community working groups to evaluate data, motivate citizens to create an effective learning system, and help sustain local health services during a crisis.⁴¹

A better understanding is required of nonmedical needs before, during, and after a disaster. This includes access to shelter, water, food, clothing, employment, and social connections. These needs contribute to the drivers of risk and were identified in the 2009 Global Assessment Report, more than 10 y before the COVID-19 pandemic. Examples include poorly planned and managed urban developments, vulnerable rural livelihoods, environmental degradation, poverty, and inequality, all of which generate and accumulate disaster risk, especially in low-income communities and households.⁴² Many of the solutions to nonmedical needs are within services already provided by community organizations or the private sector. Highlighting the need for emergency management and public health systems to include those who provide community wellbeing and support services daily in preparedness and response planning. Non-medical needs are also the foundation of a functioning society and are vitally important because individuals, communities, businesses, and local organizations are key to helping the public health system overcome and meet future challenges.⁴³

The COVID-19 pandemic has revealed current resources and supply chains lack the flexibility and diversity required to support

community resilience in a crisis.⁴⁴ Frameworks to address this risk could include Maslow's hierarchy of needs and the social determinants of health.^{2,45–47} By aligning supply chains, decisions, and actions with societal priorities and needs, all segments of society will be catered to and met while managing the crisis.² Key considerations include what is needed to maintain access to health-care services, water and sanitation, lifestyle, education, and productive and safe working and living conditions.⁴⁸ Input must be sought from beyond the emergency management and public health system to allow community and private organizations, such as transport companies, universities, and schools to help solve this challenge.^{2,49} This could be achieved by building local community decision-making competencies in community coalitions to better interpret data, inform and tailor preparedness actions to local needs, and support long-term recovery groups and coalitions.⁵⁰

There is a need to identify and assess public health ecosystem risks. The ecosystem is a biological community consisting of living organisms (including humans) in a particular area and nonliving components, such as air, water, and mineral soil, with which the organisms interact.⁵¹ The significance of ecosystem health is increasingly being recognized as a key to human health risk assessment.^{52–54} For example, increasing animal interactions are driving factors in pathogen transfer due to the close relationships between humans, animals, and environmental health.⁵⁴ This is a challenge for low, middle, and high income countries. For example, an estimated 57 million people across Europe and North America lack piped water at home, which compromises the ability to address and mitigate human health risks from the environment.^{54,55} Degradation of ecosystems and their services also increases risks of human-to-human transmission and effective care of the infected.⁵⁴ Better understanding of this relationship can provide a sustainable approach to mitigating the impact of future disease outbreaks, pandemics, and disasters.

The COVID-19 pandemic overwhelmed many health systems and societal functions, highlighting the need to better understand elements of the response and what needs strengthening.⁴ Planners need to understand how systems are linked to each other, and how a weakness in the health system can lead to impacts in other systems and sectors. Locations that weathered the pandemic the best had public health systems ready to respond, populations that sought early care, and a priority to implement actions and measures to balance the tensions between protecting lives and community viability.⁵⁶ The recommendations from this study provide a path for public health systems and their leaders to become more flexible, agile, and resilient.

Conclusions

Communities that weathered the COVID-19 pandemic most effectively were ready to respond, had populations that sought early care, and balanced the tensions between protecting lives and community viability. Application of the Scorecard and its alignment with the Health EDRM was effective in identifying and prioritizing strategies across different communities and countries. These recommendations include assessing community disease burden; embedding long-term recovery groups in emergency systems; exploring mental health care needs; examining ecosystem risks; evaluating reserve funds; identifying what crisis communication strategies worked well; providing non-medical services; and reviewing resilience of existing facilities, alternate care sites, and institutions. We recommend implementing

interventions addressing these strategies to help ensure investment in societal priorities, which are vital to strengthen the resilience of public health systems for future pandemics, disasters, and other emergencies.

Acknowledgements. The authors thank the workshop participants for their willingness to provide input and advice on how to strengthen the resilience of public health systems.

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Funding. This research was supported by the World Health Organization Centre for Health Development (WHO Kobe Centre – WKC: K21002). In-kind support and guidance were provided by the United Nations Office for Disaster Risk Reduction's Global Education and Training Institute and the regional office for the Americas and Caribbean.

Ethical statement. This study was approved and determined by Baylor University Institutional Review Board (IRB Reference #1792629) to meet the

exclusion criteria for institutional review board approval. Participants were invited to attend the workshops and provided oral consent to participate and have the workshop recorded.

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