Resilience Informatics for Public Health

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Abstract. Resilience research is attracting increasing attention as stressors such as pandemics and climate change impact normal life worldwide. Informatics tools can play an important role in enhancing resilience of people, communities, and organizations. We present Resilience Informatics as a sub-discipline of resilience research and propose a conceptual framework for Resilience Informatics to aid in the development and effective deployment of informatics systems for resilience.

Keywords. Resilience informatics (RI), pandemic response, public health emergencies

1. Introduction

While causing immense economic harm and loss of life the COVID-19 pandemic also highlighted the importance of Resilience at three levels: people, communities, and organizations. The US National Academies of Science defines resilience as "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to actual or potential adverse events [1]." Apart from public health emergencies the same definition applies to other stressors such as natural disasters (drought, floods, fires, earthquakes) and climate change. Recently there has been growing interest in Resilience Research [2], a discipline focusing on developing methodologies for enhancing multi-level resilience. In this paper we propose that Informatics can play an important role in resilience research and present a conceptual framework for the application of informatics concepts, technologies, and tools in Resilience. We define Resilience Informatics (RI) as the Application of informatics techniques to materially improve and promote the ability of people, communities, and organizations, to effectively cope with natural and man-made stressors.

Depending on the nature of the stressor(s) societies can be affected in multiple sectors including industry, agricultural production, economics, and others. Climate change, for example, can cause weather events such as droughts that harm agricultural production causing food insecurity. While RI can play an important role in these contexts, in this paper we focus on Resilience Informatics with respect to public health. Since public health is often seriously affected by disruptions in these other sectors, tools that enhance resilience in the health sector are often necessary to help people and communities return to normalcy even if the stressor is not initially threatening to health.

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1.1. Related work

Informatics tools to support resilience have been proposed in several context, sometimes without specifically referring to resilience. Purohit et al remark that emergency response officials could release information crisis response and outreach could occur via social media [3]. Effectively, a message of a resilience response is dispersed via social media so that the community as a whole can respond appropriately to the disaster and minimize its harm. Deserno et al encourages the use of alerting from emergency response officials in order to spread information about a crisis or disaster quickly and effectively [4,5]. Kamath et al point out benefits of Machine Learning to design informatics responses to emergencies [6]. Virapongse et al describe the importance of mobilizing knowledge to enhance community resilience [7]. Isa et al suggest using Agile methods to engineer informatics tools in rural areas [8].

Reviewing these, and other informatics efforts to aid recovery from disruptions to normal life, it appears that RI systems have certain special characteristics and also that a systematic framework could be useful to guide rapid development of informatics systems and tools to enhance resilience. In the following we propose such a framework.

2. Methods

Based on literature review and our experiences in developing Informatics tools including for the COVID-19 pandemic [7,9], we propose the following conceptual framework for developing RI systems.

We identify two categories of stressors affecting people, communities and organizations. The type of stressor could affect the nature of proposed RI solutions.

Acute Events result from natural and man-made disasters. Examples include Tsunamis, armed conflicts, infectious disease outbreaks. Here, a major role of informatics is to develop tools and systems that disseminate educational information on resources for resilience and recovery, and gather data for computing and measuring resilience metrics. **Long-term "chronic" and persistent events**, such as drought and pandemics, resulting from stressors such as climate-change, economic distress, poor healthcare systems, poor development, among others. Here, data science and machine learning can identify data patterns that contribute to the situation and generate efficacious responses.

RI systems can differ greatly from other informatics systems in several ways. In both Acute (Type 1) and Chronic (Type 2) stressors, there is a need to reach large numbers of people. In Acute stressors these people may need to reached rapidly. The system may have to cope with disruptions of infrastructure including cellular connectivity and electricity. Misinformation may be a particular concern. In the case of public health emergencies there may be a need for people to change behaviors such as the masking, social distancing, and frequent hand washing behaviors of the COVID-19 pandemic. These, and other needs, which may vary depending on the specific nature of the stressor, distinguish RI systems from other informatics systems.

To guide development of RI systems we developed the 6-component system in Table 1.

Component 1	Team	Multi-disciplinary teams that represent all aspects/factors of resilience (subject matter experts about the public health emergency, culture of target population, environment, informatics technologies, and the specific resilience context).
Component 2	Requirements	Rapid development is often a requirement especially for Type 1 stressors. The system may need to reach large numbers of people as soon as possible.
Component 3	Information	System must provide evidence-based information pertinent to the stressor, battle misinformation, match cultural, linguistic, educational, and economic status of the target users.
Component 4	Design	The system must match the technological capabilities available in the target context and the education levels, language, cultural characteristics of target users. Concepts from Persuasive Technology could aid in designing these systems [11,12] when there is a need to change behaviors to
Component 5	Implementation	Systems must be implemented efficiently and rapidly using an adaptive management approach, while incorporating a feedback loop using, e.g, the Agile development model [8].
Component 6	Evaluation	Systems must integrate an evaluation strategy to regularly assess the impact of the system and make changes as needed.

Table 1. 6-Component framework for Resilience Informatics (C6-RI).

3. Results

The advent of the COVID-19 pandemic in March 2020 resulted in enormous disruption to normal life, widespread economic losses, financial hardship and threats to public health with hundreds of cases and deaths being reported daily. Misinformation was also rampant. According to our classification, the COVID-19 pandemic was an Acute (Type 1) stressor. (The emergence of Long COVID means that it could transform into a Type 2 stressor.) To respond to this public health emergency University of Arizona (UA) faculty (including Iyengar, Ernst, Rains, Merchant) initiated development of a free bilingual (English and Spanish) bi-directional text messaging system called AZCOVIDTXT (www.azcovidtxt.org) to provide the people of Arizona with the most scientifically accurate knowledge about the disease and also information on the availability and location of daily necessities such as food, cleanliness, and personal hygiene supplies [10]. When vaccines became available the messages informed enrollees about the efficacy of the vaccines, locations, and eligibility. The system also queried the enrollees about how their needs for nutrition and healthcare were being satisfied. The goal of AZCOVIDTXT is to aid the people of Arizona cope successfully with the disease. In other words, to enhance their resilience to the pandemic.

AZCOVIDTXT is an application of the six component framework (6-C) in Table 1.

Component 1, Team: Identified the need for an epidemiologist specializing in Infectious disease (Ernst), a health promotions expert with a focus on persuasive messaging (Rains), and the informatics team consisting of informaticians (Iyengar, Merchant), systems architects, and programmers.

Component 2, Requirements: Simplicity and ease-of-use were primary requirements. Messaging in English and Spanish (at least 30% of the people of Arizona are Hispanic), rapid deployment, messages should be received on cell phones due to their very widespread use, minimal cognitive demand on user. These requirements precluded the use of apps because apps take time to develop, need maintenance and can require the user to download it on their phones. SMS messaging in English and Spanish was selected since it is available on all types of phones (not just smart phones)and everyone knows how to use it. The system was developed and deployed in four weeks, including a web site (www.azcovidtxt.org) and toll-free phone numbers for enrollment.

Component 3, Information: Messages and content are sourced from authoritative sources (Centers for Disease Control and Prevention, World Health Organization) and curated by an infectious disease epidemiologist and health promotions expert assisted by University of Arizona graduate students and staff [6]. Weekly messages reflect latest information and conditions (i.e., vaccine availability or SARS-COV-2 variant outbreaks.

Component 4, Design: The informatics team used the requirements of simplicity and ease of use to design the azcovidtxt.org web site.

Component 5: Implementation: The system was developed and deployed in four weeks using public-domain software and systems such as Django [13], PostGres [14] and REDCAP [15].

Component 6: Evaluation: The performance of the system was evaluated by the number of families enrolled, the reach of the system and also a user survey. To date, 3800 families have enrolled in 226 Arizona zip codes and 722,701 messages have been sent.

4. Discussion

As shown in Section 3, the framework presented in Section 2 can aid in the development of Resilience Informatics systems. The acute stressor, ie the pandemic, did not affect availability of infrastructure needed for development and deployment of the AZCOVIDTXT system. However, other stressors such floods, earthquakes, or human activity may destroy infrastructure such as electricity and cell phone service and decrease the scope of RI systems.

5. Conclusion

RI has great potential to enable and support strategies, informatics resources and technologies that enhance the ability of people, communities, and organizations to be resilient to stressors. The framework presented here could aid in systematic and effective development and deployment of RI solutions. More research is needed to develop and establish the discipline of Resilience Informatics in public health and other contexts.

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