

# Health Informatics for Pediatric Disaster Preparedness Planning

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## Keywords

Children, disaster, preparedness, informatics, technology, planning

## Summary

**Objective:** 1. To conduct a review of the role of informatics in pediatric disaster preparedness using all medical databases. 2. To provide recommendations to improve pediatric disaster preparedness by the application of informatics.

**Methods:** A literature search was conducted using MEDLINE, CINHL and the Cochrane Library using the key words "children" AND "disaster preparedness and disaster" AND "informatics".

**Results:** A total of 314 papers were initially produced by the search and eight that met the selection criteria were included in the review. Four themes emerged: tools for disaster preparedness, education, reunification and planning and response.

**Conclusion:** The literature pertaining to informatics and pediatric disaster preparedness is sparse and many gaps still persist. Current disaster preparedness tools focus on the general population and do not specifically address children. The most progress has been achieved in family reunification; however, the recommendations delineated are yet to be completed.

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## 1. Background

The potential contribution of informatics to public health and disaster preparedness was first demonstrated during the anthrax attacks in 2001 [1]. At that time, the contribution of informatics was primarily considered to be supportive and focused mostly on ancillary technology, such as electronic mail communication. Since the anthrax attacks, a series of public health events have helped to define the role of informatics in disaster preparedness [1]. The ensuing events exposed the fragmented public health information system, which complicated rapid information sharing and response, and demonstrated the need for consistency and interconnectedness of information systems in public health and disaster preparedness. Since then, many leaders and emergency planners have recognized the importance of informatics for response to natural and man-made disasters [1-6].

During and after a disaster, children are particularly vulnerable due to physiological, developmental, and psychological differences [7-9] and special considerations are necessary in order to provide proper care for them. Pediatric response can be improved in a number of ways, including enhanced pediatric disaster expertise and limited family separation [10]. However, planners tend to overlook pediatric needs because the significance of their differences from the adult population is not generally recognized [11]. Moreover, some believe that during emergencies and disasters children can receive the same care as adults. However, this notion is wrong. With regards to physiological makeup, their organs are proportionately larger, closer together, and not as well-protected as adult organs. Their small size increases their chances of sustaining serious head and multisystem organ injuries from blunt trauma. The fact that children breathe faster and have more rapid heart rates increases their susceptibility to airborne chemical and biological agents. Children also metabolize drugs differently than adults, thereby requiring varying dosages of drugs, antidotes, and specialized equipment for medication administration. Children also have a greater surface area relative to body mass than adults and have more permeable skin, thereby receiving proportionally higher doses of agents that either affect the skin or are absorbed through the skin. Children become dehydrated easily and possess minimal reserve, placing them at greater risk to agents that cause diarrhea and/or vomiting.

Children also have developmental and psychological limitations and may not have the motor or cognitive skills necessary to understand the presence of risk and seek an escape. Developmentally, children lack the self-preservation and cognitive skills that enable them to know how to react [11]. The coping skills of children are less developed than are those of adults. Their mental health suffers not only from direct exposure to traumatic events but indirect exposure as well. Psychological stress hinders their growth and development patterns. The chaos associated with disaster events may induce a crippling sense of fear or anxiety in children, such as post-traumatic stress disorder [11].

Disaster planning that thoroughly incorporates the specific vulnerabilities of the pediatric population serves to increase a healthcare facility's success in treating children involved in a disaster. Since many children are seen and cared for emergently in adult hospitals, it is reasonable to postulate that most children will receive emergency care at these same facilities after a disaster. Therefore, online disaster-related pediatric information and decision-support software may assist healthcare workers at these adult centers in preparation for, during and after a disaster crisis. Consistent with the gap in pediatric preparedness, we found that despite the increasing role of informatics in public health and disaster preparedness, there is sparse discussion in relation to the pediatric specific informatics tools [12].

## 2. Objectives

1. To conduct a systematic review of the medical literature, from 1990-2010, investigating the role of informatics in pediatric disaster preparedness.
2. To provide recommendations to improve pediatric disaster preparedness by the application of informatics.

## 3. Methods

### 3.1 Search Strategies

A search of all research articles was conducted on MEDLINE, CINHL and the Cochrane Library. The search was restricted to peer-reviewed articles published. In accordance with the Medical Subject Heading (MeSH-Thesaurus) system, the following search terms were entered in PubMed: “children” AND “disaster preparedness” (164 hits) and “disaster” AND “informatics” (130 additional hits). The same search terms were entered in CINHL and the Cochrane Library. The CINHL search produced an additional 20 hits while the Cochrane Library search failed to produce any additional hits. No language restriction was included. The first screening took place on November 11, 2009.

We imported the search results into EndNote [13], a bibliographic management software program and removed duplicates. One reviewer screened all titles and abstracts to identify scientific papers reporting relevant research findings. In cases where the abstract did not provide enough information, the full article was retrieved and examined by the reviewer. The final set of articles was confirmed by the entire investigative team. We proceeded in accordance with the QUOROM Statement, which indicates how to perform meta-analyses of randomized controlled trials [14]. The QUOROM Group explicitly recommends the use of the QUOROM checklist and QUOROM flow-charts for systematic reviews like this one. The structured presentation of methods and results is also in line with the Statement.

### 3.2 Selection Criteria

Titles and abstracts ( $n = 314$ ) were screened to identify scientific papers reporting research findings. Manuscripts identified as correspondence were excluded. Inclusion criteria were: original papers published in 1990-2010, containing the aforementioned search terms in the title and/or in the abstract. Because of the sparse literature pertaining to informatics and pediatric disaster preparedness, we expanded the search to include manuscripts that although may not mention children specifically, discussed disaster preparedness themes that may be applied to the pediatric population. The selection process is delineated in ►Figure 1.

### 3.3 Collection/Analysis

In total, eight articles reported findings or discussed topics that met the selection criteria and were included in this review. Four key themes were identified from the content of the articles reviewed.

### 3.4 Human Subjects

No human subjects were involved in the preparation of this manuscript.

## 4. Main Results

Of the 314 articles culled, four themes emerged: disaster preparedness tools, education, reunification, and planning and response. Our key findings are reported below. A summary of the basic details of these research-based papers is presented in ►Table 1.

### 4.1 Disaster Preparedness Tools

We examined other papers that focused on disaster preparedness tools and informatics. One study found that most U.S. hospitals have wireless local area networks (WLANs) with disaster medical response capabilities, which consists of mass casualty response, incident control, decontamination, comprehensive medical treatment, and public health initiatives. Their data indicated that combined with the wireless LAN, many hospitals have also acquired personal digital assistants, tablets, and

handheld personal computers. These devices are important for rapid disaster medical response [2], which include being able to locate, mobilize, and move available resources swiftly as well as to coordinate their use effectively upon arrival at a disaster scene. New technologies in communications, the Internet, computer miniaturization, and advanced “smart devices” have the potential to vastly improve the emergency medical response to disasters [15]. Particularly, wireless Internet and ge-positioning technologies may have the greatest impact on improving communications, information management, and overall disaster response and emergency medical care by enhancing mass casualty field care, provider safety, field incident command, resource management, informatics support, and regional emergency department care of disaster victims [15].

In another report, we found that an informatics tool was developed for integrating handheld devices, wireless networks, global positioning system, digital cameras, and bar code scanners with customized triage software. The architecture infrastructure for the portable device, called Triage and Casualty Informatics Technology (TACIT), can expedite triage, transport, and treatment procedures within a mass casualty incident [16]. Initial field trials demonstrated robustness of operation, reduced triage collection time and improved collection accuracy, suggesting that the system could increase response efficiency during a disaster [16].

## 4.2 Education

We found a total of three articles that discussed online education and disaster preparedness. None of the articles specifically addressed education in pediatric disaster preparedness; however, the conclusions of the articles can be extended to pediatric disaster preparedness as well since the mechanism described can be used for both adult and pediatric disaster preparedness education.

All of the articles discussed the potential of an online course for disaster and emergency preparedness. Canada developed the Disaster Medicine Online (DMO) course to fill the need for a formal training program in disaster medicine for health care professionals. DMO is an Internet-based, interactive, facilitator-guided distance-learning course on the fundamentals of disaster medicine. Evaluation of the learning materials and educational methodology demonstrated a high degree of satisfaction among users and 91% successfully passed the course, indicating that the online course is a viable option for healthcare professionals [17].

A similar online course was also developed for paramedic students. Student performance in the classroom and online was compared and the authors found that distance learning technology appears to be an effective mechanism for extending didactic paramedic education off-campus, and may be beneficial particularly to areas that lack paramedic training programs or adequate number of qualified instructors [18].

A group from Japan designed a satellite-based Internet system for use in medical applications. They combined digital satellite communication with an ordinary telephone network to create an economical countrywide network for emergency medicine and continuous medical education. The system appears to be useful not only in the event of a disaster but also during daily clinical activities [19].

## 4.3 Reunification

Mass casualty incidents, such as Hurricane Katrina, demonstrate that children are extremely vulnerable and can be easily separated from their families. Such events highlight the need for strategies that minimize parent-child separation and improve methods for reuniting separated children with their families. Reunification is further complicated by the developmental limitations of children, as some children may be unable to offer their name or may be too frightened to give any information [20].

After the Tsunami in 2004 separated a large number of children from their parents and families, the World Health Organization listed Guiding Principles for tracking and reunification of families [21]. Since then, several other disasters have separated families and demonstrated the complicated process of family reunification. Reunification is further complicated by the lack of development of an interoperable tracking system or a central data bank [22]. There is no current system in the United States that effectively expedites the reunification of children with their families when chil-

dren are separated during a disaster. Chung and Shannon proposed the creation of a system that employs advanced imaging and feature-extraction technology [20]. The system would digitally capture images of individual children as they enter a facility, with these images then being automatically downloaded and posted onto a secure website. Features of each child, such as hair and eye color, would be indexed and cataloged. If a family is separated, parents could enter their child's features into the system and receive a limited set of images for identification, allowing for rapid reunification of the family [20].

## 4.4 Planning and Response

Our literature search discovered only one informatics disaster tool specifically designed for the pediatric population, PEDSS (Pediatric Emergency Decision Support System). PEDSS was designed and implemented to support the tasks of a hospital or health care center emergency planner. PEDSS guides users at a facility that expects to receive pediatric victims through the collection and utilization of the critical information needed for a just-in-time disaster plan, which is launched immediately prior to its use. PEDSS software is designed to embody best disaster preparation practice knowledge, gather information about the specifics of a medical facility's situation, and apply that knowledge to produce advice about viable preparations. Currently PEDSS only addresses earthquakes [23] but the inclusion of other disaster types, such as fires and floods is feasible.

Kondaveti and Ganz introduced and demonstrated a decision support system for emergency managers [24]. The proposed tool can help emergency response organizations not only to perform emergency response activities efficiently but also to perform emergency resources planning (amount and location of resources). The decision support system integrated with real-time emergency response information can be a comprehensive solution for resource management in disaster response.

## 5. Discussion

### 5.1 Current state of informatics and pediatric disaster preparedness

Research focusing on pediatric disaster preparedness has increased in recent years. All of the articles meeting the inclusion criteria for this review were written in the last decade. However, there is scant research addressing pediatric disaster preparedness [8], particularly in the context of informatics. This review has identified specific gaps in the scientific literature.

The potential role of informatics in disaster preparedness was realized with the introduction of the Public Health Information Network (PHIN) by the Centers for Disease Control and Prevention, in collaboration with the Department of Homeland Security. The goal is to implement a consistent national network of information systems that will support public health in being prepared for public health disasters [1]. In addition, the American Medical Informatics Association (AMIA) issued recommendations and urged the creation of a national health information infrastructure (NHII). The creation of an NHII would provide access to local health providers and health officials to national data systems necessary to detect and track threats to public health through high-speed networks. AMIA recommended the accelerated development and wide-scale deployment of electronic public health surveillance systems, computer-based patient records, and disaster-response information technologies, which would provide the greatest potential of protecting public health and national safety [5].

Our review identified additional roles of informatics in pediatric disaster preparedness. Though online disaster preparedness courses were demonstrated to be effective, none focused on pediatric preparedness. Current training methods may be ineffectual in building a prepared and willing pool of first receivers [25], healthcare workers and others who have a role in receiving and treating victims [26]. The convenience and accessibility of online courses may be a practical alternative for pediatric disaster preparedness and warrants further exploration.

The only topic that we came across in our review that had a specific pediatric focus is reunification. The recommendations presented in the paper should be acted upon, as a national tracking

system would greatly expedite reunification of families after a disaster. Existing infrastructure, such as school systems, electronic medical records, or the National Center for Missing and Exploited Children, can be employed to create such a system. Because children are dependent on others for their basic needs and care, planning for large numbers of homeless and even orphaned children is essential to disaster preparedness and management. Keeping children together or reuniting them with their parents is critical to the management of children in mass casualty incidents, as swift reunification of the child with the primary caregiver reduces the acute effects of community panic and upheaval and minimizes post-traumatic stress [27]. A large-scale drill, involving pediatric victims moving across county or state lines, is recommended in order to educate first receivers about the reunification process and to test and refine current reunification systems [22].

The only pediatric-centered disaster preparedness tool that we were able to find in the literature was PEDSS. This finding is perplexing since hospitals must have different supply sizes and medication dosages for children in the event of a disaster. PEDSS provides planning information in the event of an earthquake; efforts are underway to expand the types of disasters for which the application can offer recommendations.

## 5.2 Recommendations

Based on our findings, we have developed the following key recommendations for the incorporation of informatics into pediatric disaster preparedness:

1. Current and future national disaster preparedness informatics initiatives should be expanded to include experts and advocates capable of addressing pediatric needs.
2. Disaster preparedness informatics tools should be adjusted to accommodate pediatric specifications.
3. A national tracking system that employs existing infrastructure, such as the National Center for Missing and Exploited Children, should be developed to facilitate family reunification after a disaster.

## 6. Conclusion

The literature pertaining to informatics and pediatric disaster preparedness is sparse and many gaps still persist. Current disaster preparedness tools focus on the general population and do not specifically address children, for whom special considerations must be made in the event of a disaster. The most progress has been achieved in family reunification. A significant amount of work remains to be completed in the other areas discussed.

### Clinical Relevance Statement

Children are one of the most vulnerable populations in the aftermath of a disaster. Recently, informatics tools have been applied to disaster preparedness efforts; however, the pediatric population has largely been ignored. This paper introduces the practitioner to the current role of informatics in pediatric disaster preparedness and provides recommendations in areas in which informatics can be incorporated.

### Conflict of Interest

The authors declare no conflicts of interest.

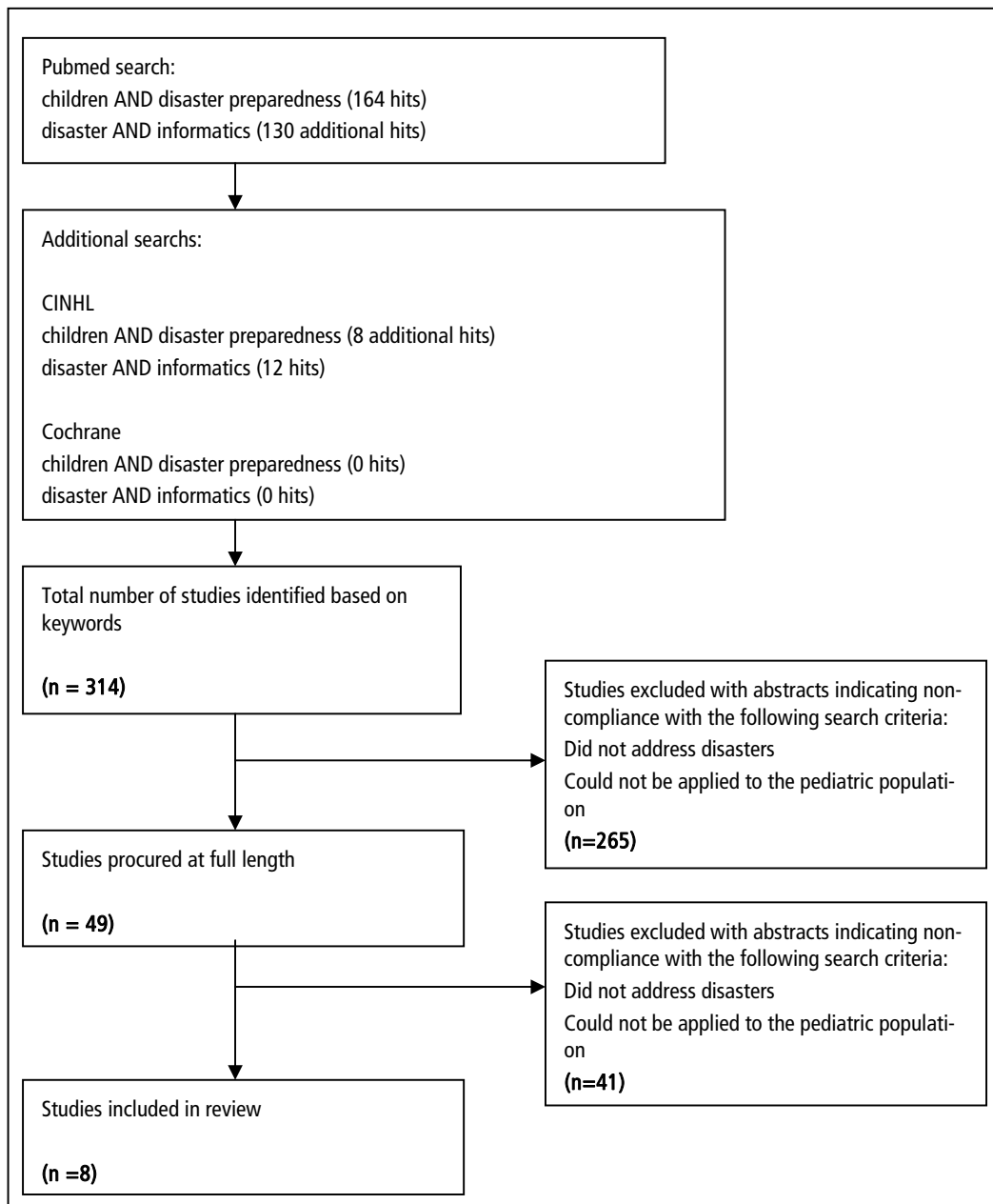


Fig. 1 Flow chart of systematic review of the literature concerning informatics and pediatric disaster.

**Table 1** Peer-reviewed papers on health informatics and pediatric disaster preparedness.

Author	Year	Country	Specific-pediatric focus	Theme	Reference Number
Chung and Shannon	2007	USA	Yes	Reunification	20
Harrison et al	2008	USA	No, but pediatric focus can be included	Tools	2
Hubble et al	2006	USA	No, but pediatric focus can be included	Education	18
Kondaveti and Ganz	2009	USA	No, but pediatric focus can be included	Planning and reponse	24
Lund et al	2002	USA	No, but pediatric focus can be included	Education	17
Neches et al	2009	USA	Yes	Planning and response	23
Okada et al	2000	Japan	No, but pediatric focus can be included	Education	19
Zhao et al	2006	USA	No, but pediatric focus can be included	Tools	16



## References

1. Loonsk JW, McGarvey SR, Conn LA, Johnson J. The Public Health Information Network (PHIN) Preparedness initiative. *J Am Med Inform Assoc* 2006; 13(1): 1-4.
2. Harrison JP, Harrison RA, Smith M. Role of information technology in disaster medical response. *Health Care Manag (Frederick)* 2008; 27(4): 307-313.
3. Brennan PF. AMIA recommendations for national health threat surveillance and response. *J Am Med Inform Assoc* 2002; 9(2): 204-206.
4. Brennan PF, Yasnoff WA. Medical informatics and preparedness. *J Am Med Inform Assoc* 2002; 9(2): 202-203.
5. Tang PC. AMIA advocates national health information system in fight against national health threats. *J Am Med Inform Assoc* 2002; 9(2): 123-124.
6. Teich JM, Wagner MM, Mackenzie CF, Schafer KO. The informatics response in disaster, terrorism, and war. *J Am Med Inform Assoc* 2002; 9(2): 97-104.
7. Fox L, Timm N. Pediatric issues in disaster preparedness: meeting the educational needs of nurses-are we there yet? *J Pediatr Nurs* 2008; 23(2): 145-152.
8. Markenson D, Redlener I. Pediatric terrorism preparedness national guidelines and recommendations: findings of an evidenced-based consensus process. *Biosecur Bioterror* 2004; 2(4): 301-319.
9. Seideman RY, Hutchison B, Buckner SK, Myers ST, Miller-Boyle D, MacRobert M, Heath S. The response of children to disaster. *MCN Am J Matern Child Nurs* 1998; 23(1): 37-44.
10. Pediatric Preparedness for Disasters and Terrorism. A National Consensus Conference [<http://www.bt.cdc.gov/children/pdf/working/execsumm03.pdf>]
11. Allen GM, Parrillo SJ, Will J, Mohr JA. Principles of disaster planning for the pediatric population. *Prehosp Disaster Med* 2007; 22(6): 537-540.
12. Markenson D, Reynolds S. The pediatrician and disaster preparedness. *Pediatrics* 2006; 117(2): e340-e362.
13. Thomson Reuters. Endnote X2. Carlsbad: Author; 2009.
14. Moher D, Cook DJ, Eastwood S, Olkin I, Rennie D, Stroup DF. Improving the Quality of Reports of Meta-Analyses of Randomised Controlled Trials: The QUOROM Statement. *Onkologie* 2000; 23(6): 597-602.
15. Chan TC, Killeen J, Griswold W, Lenert L. Information technology and emergency medical care during disasters. *Acad Emerg Med* 2004; 11(11): 1229-1236.
16. Zhao X, Rafiq A, Hummel R, Fei DY, Merrell RC. Integration of information technology, wireless networks, and personal digital assistants for triage and casualty. *Telemed J E Health* 2006; 12(4): 466-474.
17. Lund A, Lam K, Parks P. Disaster Medicine Online: evaluation of an online, modular, interactive, asynchronous curriculum. *CJEM* 2002; 4(6): 408-413.
18. Hubble MW, Richards ME. Paramedic student performance: comparison of online with on-campus lecture delivery methods. *Prehosp Disaster Med* 2006; 21(4): 261-267.
19. Okada Y, Haruki Y, Ogushi Y. Disaster drills and continuous medical education using satellite-based Internet. *Methods Inf Med* 2000; 39(4-5): 343-347.
20. Chung S, Shannon M. Reuniting children with their families during disasters: a proposed plan for greater success. *Am J Disaster Med* 2007; 2(3): 113-117.
21. Unaccompanied and Separated Children in the Tsunami-Affected Countries <http://www.icva.ch/doc00001315.html>
22. Blake N, Stevenson K. Reunification: keeping families together in crisis. *J Trauma* 2009; 67(2 Suppl.): S147-S151.
23. Neches R, Ryutov T, Kichkaylo T, Burke RV, Claudius IA, Upperman JS. Design and evaluation of a disaster preparedness logistics tool. *Am J Disaster Med* 2010, in press.
24. Kondaveti R, Ganz A. Decision support system for resource allocation in disaster management. *Conf Proc IEEE Eng Med Biol Soc* 2009; 2009: 3425-3428.
25. Chokshi NK, Behar S, Nager AL, Dorey F, Upperman JS. Disaster management among pediatric surgeons: preparedness, training and involvement. *Am J Disaster Med* 2008; 3(1): 5-14.
26. Koenig KL. Strip and shower: the duck and cover for the 21st century. *Ann Emerg Med* 2003; 42(3): 391-394.
27. Brandenburg MA, Watkins SM, Brandenburg KL, Schieche C. Operation Child-ID: reunifying children with their legal guardians after Hurricane Katrina. *Disasters* 2007; 31(3): 277-287.