

Disaster Medicine in Low-Resource Settings: Recent Challenges and Innovations

Wayan Dhea Agastya¹

¹Faculty of Medicine Universitas Pembangunan Nasional Veteran Jawa Timur

Corresponding Author

Wayan Dhea Agastya

Faculty of Medicine Universitas Pembangunan Nasional Veteran Jawa Timur

Rungkut Madya Street Number 191, Rungkut Kidul, Rungkut District, Surabaya, Jawa Timur 60293

Tel/Fax: +628113111846

E-mail: wayan.dhea.agastya.fk@upnjatim.ac.id

Abstract

Background. Disaster medicine in low-resource settings faces many challenges. Most are aggravated by limited infrastructure, scarce medical supplies, and insufficiently trained health professionals. This calls for complexity in responding to these events due to enhanced logistic challenges and sociopolitical instability, according to which may hamper effective and timely medical interventions.

Methods. Literature searching was conducted using databases such as PubMed, Google Scholar, and Web of Science using Search terms included "disaster medicine," "low-resource settings," "emergency response," and "innovations in disaster care.". Systematic reviews of peer-reviewed articles, reports, and case studies were chosen.

Discussion. Disaster medicine in low-resource settings faces critical challenges, including underdeveloped healthcare infrastructure, shortages of trained personnel, logistical issues, socio-political factors, and economic constraints. Innovative solutions such as mobile health clinics, telemedicine, portable medical devices, and renewable energy solutions have proven effective in mitigating these challenges. Case studies from Nepal, West Africa, Mozambique, India, and the Philippines highlight the importance of community-based approaches, international cooperation, and technology in improving disaster response and healthcare delivery in resource-constrained environments

Conclusion. Disaster medicine in low-resource settings faces significant challenges, but recent innovations provide promising solutions. By focusing on mobile health clinics,

telemedicine, community-based approaches, and low-cost technologies, it is possible to enhance disaster preparedness and response.

Keywords. disaster medicine, low resources, healthcare

Introduction

Disasters, whether natural or artificial, strike hardest to the low-resource area. Moreover, they increase their existing vulnerabilities to brew into a complexity of challenges for disaster responses and medical care. Mostly in these areas, not much is experienced in terms of health infrastructure, there is a deficiency of medical resources, and a shortage of trained health care workers—factors that contribute greatly to the incapacity to respond effectively in case of emergencies.¹ What is more, these extremely unstable systems are further strained by rising disaster frequency and intensity, powered by climate change and urbanization, among other factors. Inadequate health infrastructure is the critical barrier to disaster response. Most low-resource settings lack adequate infrastructure and equipment to manage large-scale disasters, which frequently delays and sub optimizes care delivered to survivors.² A subsequent supply shortage of first aid material and medical-related materials means a dearth of key medications or equipment that complicates the effectual delivery of care in disasters.³ Other major issues are human factors. The lack of trained healthcare professionals and first responders can result in healthcare system overload, inadequate care toward patients, and increasing mortality rates related to disasters. Second, logistical barriers, such as transport networks and frailty of communication systems, may retard the effective delivery of aid and coordination of disaster response efforts. Sociocultural and political elements of disaster response are also highly applicable. Secondly, mistrust of health and authorities impedes emergency interventions by hindering them with unwilling community members to seek help and guideline adherence.⁴

Most importantly, political complexity of disaster response through delaying timely interventions and organized care.⁵ Economic constraints are significant challenges to disaster preparedness and response in low- resource settings. These locations are highly prone to disaster impacts, as they have limited financial resources to invest in the necessary infrastructure, training, and supplies.⁶ Furthermore, new technologies and practices are too expensive and the adoption is therefore difficult, thus not implemented so as to be useful.⁷ Despite all the challenges, there have been a few truly innovative

solutions that have recently been developed to strengthen disaster medicine in resource-poor settings. Mobile health clinics and telemedicine platforms hold great promise to deliver needed medical services to under-served settings, as well as offer remote consultations and train local healthcare providers. That is, community-based approaches, which include the capacity-building process through training programs and strengthening of local networks in emergency response and improving coordination, were found to be effective.^{8,9} Further, the invention of affordable, portable medical devices designed for low-resource settings, as well as renewable energy seekers, such as solar-powered medical equipment, has been very promising in terms of keeping medical services functional during disasters. The views are that public-private partnerships have become one of the major strategies in pooling resources and competencies from the government, NGOs, and private companies in enhancing disaster preparedness and response.^{10,11} This review aims to update more recent findings on challenges and innovative solutions for disaster medicine in low-resource settings, providing a general overview of current practices in the field while indicating further research area.

Methods

A systematic review of peer-reviewed articles, reports, and case studies from 2013 to 2024 was conducted using databases such as PubMed, Google Scholar, and Web of Science. Search terms included "disaster medicine," "low-resource settings," "emergency response," and "innovations in disaster care."

Discussion

Recent Challenges in Disaster Medicine in Low-Resources

Settings Healthcare Infrastructure and Capacity

The healthcare infrastructure in resource-poor settings is largely underdeveloped and unprepared to accommodate a large number of patients after a disaster. Brown, et al.³ highlighted a very critical shortage of medical supplies and a lack of proper facilities, which accelerate response operations for crisis mitigation at minimal levels. Moreover, diagnosis or treatment equipment is not up to date, hence substantially affecting health delivery services in terms of time and effectiveness.²

Human Resources and Training

The greatest challenge in low-resource settings is the unavailability of trained healthcare

professionals. There is a very short supply of skilled medical personnel and first responders, which contributes to the overwhelming of healthcare systems in times of disasters.² This is further worsened by inadequate training and continuous professional development that might be necessary in capacitating existing staff members to effectively manage disaster responses.⁸ The training programs for disaster preparedness and response are quite important in building local capacity to improve the general resilience of health care systems.⁹

Logistical Problems

Finally, there is the soils etiquettes that hinder disaster response, because poor transport networks and an untrustworthy communication system delay disaster responses. Logistical barriers would significantly delay the renderings of many emergency medical supplies and coordination of the response activities.¹³ Geographical remoteness in many low-resource settings presents a special challenge in reaching affected populations quickly.¹³

Socio-cultural and Political Factors

The response to disaster is societal, cultural, and political. Lopez, et. al.⁴ indicate that trust between the community and healthcare systems must be built in order to ensure that emergency interventions are effective. Many a time, disaster response becomes challenging due to the existing political instability and conflicts, hampering efforts towards rendering timely and coordinated care substantially.⁵ Engaging local communities and including their cultural perspectives in disaster planning and response can enhance the effectiveness of interventions, which might provide better ways of interventions.⁸

Economic Constraints

Economic constraints are a sinister issue in countries with fewer resources affecting each level of disaster preparedness and response. Johnson, et. al.⁶ found economic restrictions in funds limit investments that can be made in wanted infrastructure training and supplies. The high costs associated with new technologies and practices make them quite hard to adopt at all. On the other side, cost-saving innovations such as mobile health clinics and telemedicine platforms are likely solutions to help bridge these gaps.

Innovations In Disaster Medicine in Low-Resource Settings

1. Mobile Health Clinics and Telemedicine.

Mobile health clinics have been an essential creation in times of disaster regarding dispensing health services to unreachable areas. The clinics can provide necessary healthcare, like vaccinations, primary care, and emergency response, hence easing pressure at fixed healthcare facilities. Chen et al.¹³ found this eases pressure at stationary healthcare facilities. Besides, telemedicine platforms facilitate remote consultations and specialized support arguable very helpful in a low-resource area where there may be a dearth of medical expertise.

2. Community-Based Approaches

Community-based disaster response programs have been found to build up much-needed capacity at a local level for disaster preparedness and emergency response. Training local volunteers and healthcare workers on basic emergency medicine skills and disaster response protocols has improved the time of immediate response and, at large, community resilience. Kumar, et al.⁹ found enhancing local networks and increasing community participation in the process help guarantee a unified response in times of disaster.

3. Affordable and Portable Medical Device.

Development and fielding of affordable, portable medical devices tailored for use in low-resource settings have been game-changing. Amongst others, portable ultrasound machines, ventilators running on batteries, and inexpensive diagnostic tools have created very strong capabilities in their ability to deliver critical care in a disaster area.¹⁰ All these devices have been designed to be hardy and user-friendly, working perfectly in uncondusive environments, which makes them very ideal for disaster responses.

4. Renewable Energy Solutions

Renewable energy solutions have played a very significant role, particularly in low-resource settings, in the continuity of medical services during disasters. Solar panels and solar generators can give a reliable source of energy for the operation of critical medical devices,

refrigeration of vaccines and medications, and lighting at nighttime operations, therefore diminishing the consequences of power loss.¹¹

5. Public-Private Partnerships

The role that public-private partnerships can play in bettering disaster preparedness and response is emerging as a significant strategy. This partnership brings together resources, expertise, and infrastructure of the public and private sectors in the process of formulating innovative solutions. Thompson, et. al.¹⁴ found partnerships between concerned authorities and technology companies have brought forth sophisticated data analytical tools so that disaster risk assessment and resource allocation are done more effectively.

6. Data-Driven Decision Making

Advanced data analytics and Geographic Information System have really changed the approach toward disaster medicine by providing a framework through which risk is more accurately assessed, resources allocated, and response planned. Davis, et al.¹² data-driven decision-making tools for disaster response are identification of high-risk areas, supply chain optimization, and situational awareness enhancement during disasters. To that end, these technologies bear especial advantages in low-resource settings where efficient resource use is very important.

7. Innovations in Training and Education

These innovative virtual reality and augmented reality training programs are designed to provide practice for healthcare professionals and first responders in disaster scenarios. These heightened technologies do this by simulating a true environment of disaster familiarization, allowing trainees to practice and perfect their such training is therefore paramount in the preparation of personnel towards perfecting responses in real-world disaster situations.

8. Implementation of Health Information Systems

The implementation of robust health information systems in low-resource settings has improved the coordination and management of disaster response efforts. Such systems support real-time tracking of patient data, resource inventory, and epidemiological information, hence enabling more efficient and effective response operations.⁴ Health information system also enhances communication and information sharing among healthcare providers and emergency response teams.

Case Studies and Example

1. Nepal Earthquake Response, 2015

The 2015 Nepal earthquake presented a special opportunity to practice disaster medicine in a re- source-constrained environment. Health infrastructure was badly destroyed, and as such, lack of medical supplies and facilities resulted. Mobile health clinics played a very significant role in administering timely care. These clinics were well equipped with at least the minimum requisite of medical supplies and manned by adequately trained professionals to enable them to reach many remote areas that were otherwise inaccessible.¹⁵ Community health workers were also mobilized to deliver first aid and basic health services, which proved essential in bridging the gap created by damaged infrastructure.¹⁶

2. Ebola outbreak in West Africa, 2014-2016

The 2014 West African Ebola outbreak became a glaring message about rapid response in community engagement. Other significant strategies implemented included ETUs that are designed for rapid deployment and setup affected areas. The local community health workers' application also educated the public regarding the illness and the preventive measures taken, which played a major role in containing the virus. In addition, international cooperation made it possible to avail medical supplies and personnel, thereby indicating the role of global cooperation in responding to disasters.¹⁷

3. Cyclone Idai in Mozambique, 2019

Cyclone Idai hit and caused widespread destruction in Mozambique, resulting in a critical condition in health care delivery. The cyclone destroyed a number of health facilities, hence leaving many without medical care. At the heart of this response was the setting up of temporary health centers, where provision for treatment was made through mobile clinics to affected people. These clinics did not just provide immediate medical care, but also critical services such as vaccinations and maternal services that were very essential in curtailing secondary crises.¹⁸ The use of drones in delivering medical supplies to unreachable areas was an innovation that improved the efficiency of the response.¹⁹

4. COVID-19 Pandemic Response in India

Taking the case of the COVID 19 pandemic response in India, particularly during its rampage in rural areas, one learns that adaptability and innovation in low-resource settings are most important. The acute shortage of hospital beds and medicinal supplies

led to the adoption of sundry measures, among them home isolation kits and telemedicine services. Telemedicine helped doctors reach out to patients in far-flung areas, thereby easing pressure on healthcare centers and continued care.²⁰ Furthermore, community health workers were very instrumental in the process of tracing, surveillance of the COVID-19 cases, distribution of medical supplies, and educating people for preventive measures.²¹

5. Typhoon Haiyan in Philippines, 2013

Typhoon Haiyan caused lots of devastation in areas, most of which were low resource settings in the Philippines. The initial medical response was the establishment of field hospitals by foreign aid agencies that came fitted with portable medical equipment tailor-made for emergency setups. These field hospitals provided services such as surgery, maternal health, and care for children. Community-based health campaigns were also vital to the response since local health workers were key to providing care and facilitating logistics in affected communities.²² The integration of renewable energy solutions, such as solar-powered lights and medical devices, was successful in sustaining operations in the absence of stable electricity.²³

Conclusion

Disaster medicine in low-resource settings faces significant challenges, but recent innovations provide promising solutions. By focusing on mobile health clinics, telemedicine, community-based approaches, and low-cost technologies, it is possible to enhance disaster preparedness and response. Continued investment, collaboration and improving policies are crucial to building resilient healthcare systems capable of managing disasters effectively.

References

1. Smith, J., Doe, A. Impact of inadequate healthcare facilities on disaster response. *Journal of Emergency Medicine*. 2020;45(2), 123-130.
2. Green, M., White, P. Human resource challenges in disaster response in low-income countries. *Disaster Medicine and Public Health Preparedness*. 2019;13(4), 765-772.
- Brown, K. et al. Medical supply shortages in low- *Global HealthAction*. 2021;14(1), 123-136.

3. Lopez, G., Martinez, H. (2021). Building community trust in healthcare during emergencies. *PublicHealth in Practice*. 2021;2(1):100098.
4. Ahmed, F., Rahman, S. (2020). Political instability and its impact on disaster response. *Journal of International Disaster Risk Reduction*. 2020;41,101309.
5. Johnson, E., Patel, R. Financial constraints in disaster preparedness. *Finance and Development*. 2021;58(2), 44-49.
6. Wang, H., Tan, J. Cost-effectiveness of innovations in disaster medicine. *Health Economics Review*. 2020;10(1), 23.
7. Kim, S., Park, J. Community-based training for disaster preparedness. *Community Health*. 2022;27(1), 22-29.
8. Kumar, S., Gupta, R. Strengthening local networks for disaster response. *International Journal of Disaster Risk Science*. 2019;10(3), 345-355.
9. Zhang, W., Li, X. Portable medical devices for low-resource settings. *Medical Devices: Evidence and Research*. 2021;14:165-175.
10. Ochieng, J., & Mwangi, J. Solar-powered medical equipment in disaster settings. *Energy for Sustainable Development*. 2020;55, 150-157.
11. Davis, R., & Hall, S. Logistical barriers to effective disaster response. *Journal of Humanitarian Logistics and Supply Chain Management*. 2022;12(1), 50-62.
12. Chen, Z. et al. Mobile health clinics in disaster settings: A review. *International Journal of Disaster Risk Reduction*, 2019;39:101-45.
13. Thompson, D., & Adams, B. Public-private partnerships in disaster response. *Journal of Emergency Management*. 2021;19(3), 27-35.
14. Khanal, P., Shrestha, R., & Sharma, G. Impact of mobile health clinics in post- earthquake Nepal. *Journal of Global Health*. 2019;9(2), 020302.
15. Doocy, S., Lyles, E., & Delbiso, T. Community health workers in disaster response: Lessons from Nepal. *BMC Public Health*. 2018;18(1), 1001.
16. Jones, S., Parry, E., & Evans, R. (2019). International partnerships in Ebola response: Lessons from West Africa. *Global Health*, 15(1), 8.
17. World Health Organization. Mozambique cyclone Idai response: Health cluster update. 2019. Available from <https://www.who.int/health-cluster/news-and-events/news/Mozambique-Cyclone-Idai-update/en/>
18. Rejeb, A., Keogh, J. G., & Treiblmaier, H. Leveraging the internet of things and blockchain technology in supply chain management. *Future Internet*.

2019;12(4):73.

19. Ghosh A, Gupta R, Misra A. Telemedicine for diabetes care in India during COVID19 pandemic and national lockdown period: Guidelines for physicians. *Diabetes Metab Syndr.* 2020 Jul-Aug;14(4):273-276.
20. Siddharth, S., Palaniyandi, M., Joseph, L. COVID-19 pandemic and its impact on community health in rural India: A scoping review. *Journal of Family Medicine and Primary Care.* 2020;9(8), 3854-8.
21. Nicolas, M. E., Bautista, L., San Diego, A. Field hospitals and disaster response: Typhoon Haiyan in the Philippines. *Journal of Emergency Management.* 2019;17(2), 145-150.
22. Rivera, J. P., Gaillard, J. C., & Pawar, S. The role of renewable energy in disaster response: Lessons from Typhoon Haiyan. *Renewable Energy.* 2018;123, 374-381.