COMMENTARY

Critical Energy Infrastructure and Health: How Loss of Power May Kill

Fredrik Granholm, MD;[1] Derrick Tin, MBBS;[2] Gregory R. Ciottone, MD[3]

1. Medical Director, Swedish Air Ambulance (SLA), Mora, Sweden
2. Senior Fellow and Faculty, BIDMC Disaster Medicine Fellowship; Department of Emergency Medicine, Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, Massachusetts USA
3. Director, BIDMC Disaster Medicine Fellowship; Department of Emergency Medicine, Beth Israel Deaconess Medical Center; Associate Professor, Harvard Medical School, Boston, Massachusetts USA

Correspondence:
Fredrik Granholm, MD
Medical Director
Swedish Air Ambulance (SLA)
Mora, Sweden
Bradgatan 9, 85460 Sundsvall Sweden
E-mail: fredrik.granholm@regiondalarna.se

Conflicts of interest/funding: Authors declare no conflicts of interest or financial interests.

Keywords: Counter Terrorism-Medicine; disaster medicine; emergency medicine; hybrid warfare

Abbreviations:
CBRNE: chemical, biological, radiological, nuclear, and explosive
EMP: electromagnetic pulse
EMS: Emergency Medical Services

Received: January 21, 2023
Accepted: February 4, 2023

doi:10.1017/S1049023X23000274

Granholm F, Tin D, Ciottone GR. Critical energy infrastructure and health: how loss of power may kill. ***Prehosp Disaster Med.*** **2023;38(2):279–280.**

The deliberate attacks on two electrical substations in North Carolina (USA) on December 3, 2022 and a later string of attacks on power facilities in Oregon (USA) and Washington (USA) has highlighted the vulnerabilities of the United States' electrical grid and the risk of subsequent effects on public health and health care facilities.[1] It has also sparked discussions on electrical grids as a target for both terrorist attack and in hybrid warfare, as we are currently witnessing in the Ukraine.

While a universally accepted definition remains elusive, "hybrid warfare" is often described as a mix of conventional warfare, irregular warfare, terrorism, and criminality utilizing different non-conventional modalities, such as drone technology, cyberattacks, electromagnetic pulse (EMP), and chemical, biological, radiological, nuclear, and explosive (CBRNE) weapons in a civilian setting.[2] These threats have been accelerated by technological advances and global competition between Russia, China, and the United States, all competing to shape international security and geopolitics.[3] The use of EMP attacks are within the scope of military doctrine and can have potentially significant cascading effects on population health from protracted power outages. Targeting critical energy infrastructure has been an escalating aspect of Russian strategy in the war in Ukraine, seriously affecting the civilian population by restricting access to heat, water, and health care.[4] However, the damage to electrical grids can also be caused by naturally occurring geomagnetic disturbances, where naturally occurring solar storms disrupt the Earth's magnetic field, which in turn, can induce electrical disruptions over a large geographic area. An example is the collapse of the Quebec, Canada electrical grid in 1989 due to a geomagnetic storm, leaving approximately six million people without electricity for nearly ten hours.

While quantitative research is sparse on the effects of power outages on public health and health care facilities, there is expert consensus that power loss can lead to both direct and indirect deaths.[5] In addition, loss of electricity contingency plans are in place for most hospitals, often in the form of on-site generators and power plants, however, these are temporary solutions and don't take into account community-based health hazards. The massive power outage of August 2003 in the Midwest and Northeast United States affected nearly 50 million people and several deaths were directly attributed to the event. This event, as well as the power loss related to Hurricane Irma in Florida (USA) in 2017, has been shown to cause immediate and severe harm to health, and to have more long-term effects.[6]

Concerningly, since 2003, health care has become increasingly more dependent on power-consuming technologies ranging from Emergency Medical Services (EMS) communications and electronic medical record-keeping, to patient monitoring, diagnostic testing, and hospital treatments. A prolonged loss of power would thus have a significant impact on health care services.

Disruption of basic municipal functions, such as providing drinkable water and handling wastewater, may also have consequences for large parts of the community and public health, increasing the risk of wide-spread infectious disease outbreaks. In addition, the inability to provide cold storage can lead to an increase in food poisoning, as well as long-term effects in society, as crucial vaccines may have to be discarded.

An analysis of the August 2003 power outage in New York (USA) revealed a sharp rise in mortality for accidental deaths (122%), as well as for non-accidental, disease-related deaths (25%).[5] Patients with trauma related to the blackout were mostly elderly with injuries related to falls. During the power outages caused by Hurricane Irma in Florida in 2017, an increase in seven-day and thirty-day mortality associated with power loss was observed among nursing home residents.[7]

Accidental deaths may also be caused by hypothermia, hyperthermia, food poisoning, and carbon monoxide poisoning. Socioeconomic factors and age have been linked to variances in responses to extreme temperatures and trauma. This indicates that there is a strong need for mitigation and preparedness planning to minimize avoidable deaths.

Historical data show an influx of patients with exacerbations of chronic cardiovascular and respiratory diseases to the emergency departments. In addition, patients may be dependent on electrically powered equipment in their homes, such as ventilators, left ventricular assist devices, and medication nebulizers.[8]

The health care system's response to accidents and illnesses in a community with a complete power outage is seriously affected by critical infrastructure dependency on electricity. Each step of the usual chain of communication related to emergency response will be defunct or severely limited, from the cellular service that most citizens take for granted, to coordination at the dispatch center, and subsequently EMS transport.

Rising costs for health care and the challenges of the coronavirus disease 2019/COVID-19 pandemic have led health managers and hospitals to implement the concepts of telehealth and remote patient monitoring technology at a rapid pace,[9] using technology to gather and exchange patient information outside the traditional setting of a hospital or health care facility. Sometimes, even creating virtual wards and monitoring vital signs from the patient's home instead of having them in the hospital.[10] This further increases the dependency on robust electrical power in the community and clearly necessitates a complete re-think of most preparedness plans. The increasingly complex home medical devices utilized in the community are also a part of the paradigm shift. Providing care in homes instead of a hospital or health care facility presents specific power-related risk.

Modern day preparedness plans must therefore consider this shift and the unique complexities of home-based health care, to then understand how a massive power outage may affect a large number of patients, both in hospitals and in the community. For instance, in the event of a large-scale power outage, the demographics of an aging population and their increasing use of anticoagulants in the home setting could lead to an influx of elderly patients with injuries requiring advanced intervention. Health care contingency planning must incorporate foundational knowledge such as this into how to respond to wide-spread electrical grid failure, and how the compounding effects of a hybrid attack would affect modern day health care. Multimodal aggression, where a massive power outage can be combined with additional stressors in the health care system such as mass-casualty incidents, criminality, and CBRNE attacks, must unfortunately also be included in a systems-wide hazard vulnerability analysis that dictates effective preparedness and response strategies.

References

1. Grether N, Pazmino G, Sarisohn H, et al. NC county announces curfew as nearly 40,000 customers remain without power after 2 substations damaged by gunfire. *CNN.com*. December 4, 2020. https://edition.cnn.com/2022/12/04/us/power-outage-moore-county-criminal-investigation/index.html. Accessed December 18, 2022.
2. Hoffman FG. *Conflict in the 21st Century: The Rise of Hybrid Wars*. Arlington, Virginia USA: Potomac Institute for Policy Studies; 2007: p51.
3. O'Rourke R. Renewed Great Power Competition: Implications for Defense—Issues for Congress. R43838. February 10, 2022. Congressional Research Service.
4. Human Rights Watch. Ukraine: Russian Attacks on Energy Grid Threaten Civilians. December 6, 2022. https://www.hrw.org/news/2022/12/06/ukraine-russian-attacks-energy-grid-threaten-civilians. Accessed December 18, 2022.
5. Casey JA, Fukurai M, Hernández D, et al. Power outages and community health: a narrative review. *Curr Envir Health Rpt.* 2020;7(4):371–383.
6. Beatty ME, Phelps S, Rohner C, Weisfuse I. Blackout of 2003: public health effects and emergency response. *Public Health Reports*. 2006;121(1):36–44.
7. Skarha J, Gordon L, Sakib N, et al. Association of power outage with mortality and hospitalizations among Florida nursing home residents after Hurricane Irma. *JAMA Health Forum.* 2021;2(11):e213900.
8. Klinger C, Landeg O, Murray V. Power outages, extreme events, and health: a systematic review of the literature from 2011-2012. *PLoS Curr*. 2014;6.
9. Dolan S. The technology, devices, and benefits of remote patient monitoring in the healthcare industry. *Insider Intelligence*. January 15, 2022. https://www.insiderintelligence.com/insights/remote-patient-monitoring-industry-explained/. Accessed December 18, 2022.
10. NHS England. Virtual wards. Case Studies. https://www.england.nhs.uk/virtual-wards/case-studies/. Accessed December 28, 2022.