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Topics: Lessons learned on public health from the Fukushima Daiichi Nuclear Power Plant accident

＜ Review ＞

Disaster epidemiology: Assessing the health impacts of environmental public health disasters

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Abstract

Introduction: Although disaster epidemiology is essentially recognized as the use of epidemiology in disaster settings, it now has unique methods and tools applicable only within public health disaster settings. Herein I will briefly describe the history and development of disaster epidemiology, its unique characteristics, and illustrate its potential to both respond to and learn from public health disasters within the current literature.

Methods: This literature review was used to motivate the potential application of disaster epidemiology more extensively in the on-going disaster-related public health recovery and research within Fukushima after the 2011 radiological disaster, and preparedness activities to mitigate any such future event. The PubMed electronic database for medical journals was used exclusively to identify literature suitable for inclusion in the literature review paper using the following search terms anywhere in the article: disaster and epidemiology; "disaster epidemiology".

Results: Disaster epidemiology can be used to understand the frequency and severity of disasters, to rapidly learn about the needs of the disaster population and intervene in those needs, and to learn how to minimize the public health impacts of future disasters: tracking, mitigating, and researching, accordingly. To date, the majority of journal articles have been focused on mitigating disasters (10 of the 19 papers).

Discussion: There was a consistent recognition of the applicability of epidemiology within disasters, as was evident in the large number of journal articles which included both the terms "epidemiology" and "disaster". However, that did not translate over to an understanding of "disaster epidemiology" as a sub-discipline because only 19 articles were focused on that concept. Within those there was variability in how the term was being used. More work is needed to better educate the scientific and public health community about the unique niche which disaster epidemiology plays within public health disaster management and preparedness.

Conclusions: Disaster epidemiology is a unique sub-discipline which can help advance the tracking, mitigation, and research of public health disasters. Further training and development of this sub-discipline within epidemiology training programs could help reduce the burden of disasters on public health and advance our understanding of unique environmental exposures within disaster settings.

keywords: disaster, epidemiology, public health, environmental

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I. Introduction

A disaster is in essence any natural or technological event which causes exposures, illnesses, injuries, and deaths while overwhelming the capacity of the existing public health infrastructure[1-3]. The prevalence of large natural disasters has been increasing over the past several decades[4]. Similarly, technology disasters, or disasters associated with a human breakdown in a technological system, such as a large industrial explosion, have been increasing in both frequency and severity over the past few decades. As our human population and population density continue to increase so does the probability that large populations will be increasingly impacted by various types of disasters. Therefore, the public health community needs to be prepared for such disasters, and have established tools in place to help manage public health disasters. But research is needed in disasters, also; often disasters can provide unique settings for human health research which cannot be done in experimentally. Dominici, et al. [5], clarify this common view in their statement "as perverse as it might sound, epidemiologists must view disasters as important opportunities to learn about the etiology of disease". In 2013 a high-profile editorial was published in the New England Journal of Medicine calling for research within public health disasters [6]. One of the tools which can both assist with the management of and research within public health disasters is disaster epidemiology.

There has always been a recognition that epidemiology has a place in modern public health disasters, yet not so for it as a sub-discipline within epidemiology. The use of epidemiological methods within disasters has evolved over the past 70 years such that it is now a distinct sub-discipline within epidemiology. Although disaster epidemiology is essentially recognized as the use of epidemiology in disaster settings [7], it now has unique methods and tools applicable only within public health disaster settings. Herein I will briefly describe the history and development of disaster epidemiology, its unique characteristics, and illustrate its potential to both respond to and learn from public health disasters within the current literature. This literature review will be used to motivate the potential application of disaster epidemiology more extensively in the on-going disaster-related public health recovery and research within Fukushima after the 2011 radiological disaster [8], and preparedness activities to mitigate any future event such as that.

II. Methods

The PubMed electronic database for medical journals [9] was used exclusively to identify literature suitable for inclusion in the literature review paper. I used the following search terms anywhere in the article: disaster and epidemiology; "disaster epidemiology". The literature was last accessed in mid-November, 2017. Only English-language journal articles were considered.

III. Results

There were 13,453 journal articles for the terms "disaster" and "epidemiology". When searching for the string of words "disaster epidemiology" there were much fewer: 3,646 anywhere, 52 in the title, and only 19 with disaster epidemiology as the focus. All 19 articles were accessed and reviewed in addition to select articles from the broader literature search.

Disaster epidemiology can really be classified into three classes: the epidemiology used to track the incidence of disasters, epidemiology used to mitigate the consequences of disasters, and epidemiology to perform etiological research within disasters (Table 1). In other words disaster epidemiology can be used to understand the frequency and severity of disasters, to rapidly learn about the needs of the disaster population and intervene in those needs, and to learn how to minimize the public health impacts of future disasters. To simplify these classes, I will call them tracking, mitigating, and researching, accordingly. To date, the majority of journal articles have been focused on mitigating disasters (10 of the 19 papers).

The first use of the term "disaster epidemiology" within the title of a journal article was in 1975 [10-12]. However, disaster epidemiology goes back much further than that, to even the structured tracking of death, disease, and injuries from wars, epidemics, and natural disasters in the 19th and early 20th centuries [13]. Some long-term assessments

Table 1 Classes and tools within Disaster Epidemiology

	Class		
	Tracking	Mitigating	Researching
Tool	Event surveillance	Rapid Needs Assessment	Cohort studies
	Descriptive studies	Cluster Analyses	Case-control studies
	Ecological studies	Outbreak Assessment	Intervention studies
	Case studies	Event registries	Quasi-experimental studies
	Public Health Practice		Human Subjects Research

of soldiers exposed to war gases during World War I were performed [14], but not using structured epidemiological methods [14]. Modern designs were first incorporated into researching epidemiology within disasters in the massive Lifespan cohort study of the survivors from Hiroshima and Nagasaki [15]. But such early adaptations of epidemiologic methods to disaster settings were not classified as disaster epidemiology, rather just epidemiology within a disaster population. Disaster epidemiology was incubated through a series of humanitarian disasters and wars in the 1950s and 1960s such that by the mid-1970s there were new epidemiological methods which were well-suited for mitigating the impacts of disasters and humanitarian crises on human health [16-19], most notably the rapid needs assessment survey [20-22]. However, these methods were very slowly adopted across the disaster management community within the 1980s [21,23-25]. On the researching side of disaster epidemiology, epidemiology began to be used as a powerful research tool in the Bhopal disaster [26,27], Mt. St. Helens eruption [28-30], and multiple natural disasters throughout the 1980s and 1990s. Larger disasters in the early 2000s helped to further develop the disaster epidemiology sub-discipline, especially the 9-1-1 and Hurricane Katrina disasters in the USA [31,32]. Yet the needs to balance researching, mitigating, and tracking public health within disasters had been identified as a significant gap in our international disaster management processes even just five years ago [6]. Since then new developments have been made to support the researching class within disaster epidemiology [4], and new funding mechanisms and associated survey tools are available for many to do expedited research following disasters, including a rapid human subjects review process [4].

Now there are multiple methods which are available to epidemiologists for tracking, mitigating, and researching public health impacts within disaster populations. The full spectrum of epidemiology designs can be used, from descriptive (e.g. cluster analysis), observational (e.g. case-control), quasi-experimental (e.g. interrupted time series), to experimental (e.g. intervention study). These can be applied within the public health practice or human subjects research context. But it is important to understand the ethics behind these activities. In public health practice the focus is on what you can give to the disaster population through rapid assessment of disease, injury, deaths, and resource needs such that the impact of the disaster is mitigated. In essence the patient is the disaster population, and disaster epidemiology is used to treat the 'patient'. In human subjects research you are trying to understand what lessons can be taken away from this event and used to better prepare for the next disaster. So it is important to remember that disaster populations have already had much taken away from them, and they should first be treated as a disaster patient and not a research subject. Delicate balance is needed to navigate the needs for both learning from a disaster and helping those within the disaster population [33]. The disaster epidemiology focus must always be on what should be done, not simply what could be done. There are always many studies which could be done in disaster populations. But which studies would best help the disaster populations while advancing improved scientific understanding? Those are the studies which should be done.

The 19 journal articles purely focused on "disaster epidemiology" within their title were regarding disasters worldwide [5,10-12,24,34-47]. The last article to really discuss disaster epidemiology as a sub-discipline within epidemiology was in 2005 [5,40]. Disaster epidemiology was not brought into prominence until the 1990 editorial in the Lancet [47]. Much of that was due to the progress that had been made in addressing the problems with disaster management highlighted in previous articles in the 1970s [39]. The problems with disaster management and the insufficient use of disaster epidemiology methods were collectively a significant impetus behind the World Health Organization selecting the 1990s as the decade during which it was hoped that we would collectively reduce the frequency and severity of disasters, especially in the developing world [47]. So it is not a surprise that the number of disaster epidemiology articles increased in the 1990s. Those were predominantly focused on international crises within resource-poor nations. But natural disasters hit more economically developed countries within the 1990s, also, both challenging and refining the newly developed disaster epidemiology mitigation methods [37,44,48-53]. But disaster epidemiology was first applied to terrorism in the 1990s, also, and later refined in the 2000s after the World Trade Center attacks [31,54-57]. With the World Trade Center disaster of 2001 came a renaissance in researching disaster populations which has continued to this day with dozens of studies having been published from research within that disaster population. Yet there has been a notable gap in the literature since then of any articles explicitly focused on disaster epidemiology within their title and content. Yes, many disaster epidemiology cases have been described and research studies performed since then. But no article systematically discussed the sub-discipline of disaster epidemiology in an engaging way. Regardless, much has been learned since that first 'call to arms' paper in 1975, and many methods developed for the tracking, mitigating, and researching applications of disaster epidemiology.

Tracking large disasters has become implicitly easier in

the modern age of the internet and electronic disease and medical record systems. Likewise, mitigating disasters through the effective use of disaster epidemiology has become easier. Several new methods have helped to assist with that process. These include improvements in cluster analyses [58-62], other spatial models [58,59,63-65], syndromic surveillance [66-69], and community needs assessments [70-75]. However, while the methods available for mitigating disasters through epidemiology have improved significantly, disaster epidemiology research methods have developed exponentially.

Epidemiological research studies of environmental disasters are uniquely poised to accomplish novel etiologic research [5], especially when a longitudinal cohort design is used [76]. However, such designs usually require large sample sizes. A more innovative and powerful design is the natural experiment [77,78], which can be used even in smaller disaster populations. Such a quasi-experimental design can provide results comparable to an experiment and may be the strongest study design available when an experiment is unethical. Other quasi-experimental methods are quite robust, also [79-83]. But disaster epidemiology research has its challenges.

Disaster effects are wide-ranging and can go beyond the individual [28-30,84-92]. Environmental disasters, like Fukushima, usually involve a breakdown in man-made systems [87,93,94], which may result in community mistrust [87]. Such mistrust can result in selection biases due to poor participation [95], high attrition, volunteer bias, and loss to follow-up from emigration [76,96-101]. On the contrary, communities may be resilient [93]. Recovery efforts have proven more effective when the community is engaged [93,102-104]; then science can follow [86,105,106]. Community-based participatory research (CBPR) can do that [94,107]. Disaster communities are often socio-economically disadvantaged [108]. Therefore, it is imperative to fully engage the study community within the scientific approach, building trust, and establishing local credibility prior to initiating any studies [109]. This approach was chosen by Japanese scientists in Hiroshima and Nagasaki a priori to focus on the public health needs first and the science second before any study was ever even started with the USA, now resulting in the longest prospective cohort study in history [110]. CBPR has be used when studying a smaller disaster community, also [111-119]. Therefore, CBPR should be used when studying a disaster community [111,112,114,116,117,119-122]. Collectively, disaster epidemiology tracking, mitigating, and research methods have improved significantly since 1975. Most recently, there are now established templates and tools for performing public health service-based assessments to mitigate and track disasters [67,68,71,72,123-127], and even to study unique risk factors within them [4,128].

IV. Discussion

There was a consistent recognition of the applicability of epidemiology within disasters, as was evident in the large number of journal articles which included both the terms “epidemiology” and “disaster”. However, that did not translate over to an understanding of “disaster epidemiology” as a sub-discipline because only 19 articles were focused on that concept. Within those there was variability in how the term was being used. Some were using it clearly under the “tracking” class of definitions, others mitigating, while others were using for researching within disasters. More work is needed to better educate the scientific and public health community about the unique niche which disaster epidemiology plays within public health disaster management and preparedness.

However, this literature review has limitations. Only one electronic library database was reviewed (PubMed), and in only one language (English). This may have underestimated the number and types of journal articles which described disaster epidemiology. Further literature review is needed within other languages which use other electronic library databases to accomplish a more comprehensive assessment of the use of disaster epidemiology within public health and medicine. In the USA, disasters may or may not be officially declared major disasters by the US President [129]. If not, none of the provisions in the US federal disaster management regulations [130,131] are enacted and the affected US disaster population is to be served by other local/state resources. Hence, any support or study of the affected population must be funded through non-federal disaster appropriation mechanisms. Therefore, disasters which do not reach the threshold of a major disaster declaration within the USA may not receive sufficient support to sustain disaster epidemiology activities. Such disasters may, therefore, have an underestimation of their public health impacts and use of disaster epidemiology in the USA. Similar federal funding protocols can be found in other countries and may have similar effects on underreporting the use of and results from disaster epidemiology elsewhere. Lastly, many disaster epidemiology activities do not produce peer-reviewed publications in any language or reports which are archived within electronic library databases. Often disaster epidemiologists are so busy tracking, mitigating, and researching best practices for the disasters in which they are responsible for assisting that their work may not

be sufficiently recorded in archives which are available to the broader scientific and public health audience. Therefore, the results reported herein may vastly underestimate the application of disaster epidemiology within public health disasters worldwide.

V. Conclusion

Disaster epidemiology is a unique sub-discipline which can help advance the tracking, mitigation, and research of public health disasters. Further training and development of this sub-discipline within epidemiology training programs could help reduce the burden of disasters on public health and advance our understanding of unique environmental exposures within disaster settings. Expanding the current use of disaster epidemiology methods within the Fukushima disaster research and recovery efforts may be useful.

Conflict of Interest

The author has no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this article.

References

[1] Runkle JR, Zhang H, Karmaus W, Brock-Martin A, Svendsen ER. Long-term impact of environmental public health disaster on health system performance: experiences from the Graniteville, South Carolina chlorine spill. South Med J. 2013;106(1):74-81.

[2] Svendsen ER, Runkle JR, Dhara VR, et al. Epidemiologic methods lessons learned from environmental public health disasters: Chernobyl, the World Trade Center, Bhopal, and Graniteville, South Carolina. Int J Environ Res Public Health. 2012;9(8):2894-2909.

[3] Runkle JD, Brock-Martin A, Karmaus W, Svendsen ER. Secondary surge capacity: A framework for understanding long-term access to primary care For medically vulnerable populations in disaster recovery. Am J Public Health. 2012;102(12):e24-32.

[4] Miller A, Yeskey K, Garantziotis S, et al. Integrating health research into disaster response: The New NIH disaster research response program. Int J Environ Res Public Health. 2016;13(7):676.

[5] Dominici F, Levy JI, Louis TA. Methodological challenges and contributions in disaster epidemiology. Epidemiol Rev. 2005;27:9-12.

[6] Lurie N, Manolio T, Patterson AP, Collins F, Frieden T. Research as a part of public health emergency response. N Engl J Med. 2013;368(13):1251-1255.

[7] Last JM, ed. A Dictionary of epidemiology, 4th ed. Oxford, England: Oxford University Press; 2001.

[8] Yasumura S. Newsmaker interview: Seiji Yasumura. Fukushima begins 30-year odyssey in radiation health. Interview by Dennis Normile. Science. 2011;333(6043):684-685.

[9] McEntyre J, Lipman D. PubMed: bridging the information gap. CMAJ. 2001;164(9):1317-1319.

[10] Rohde JE. Disaster epidemiology. Int J Epidemiol. 1975;4(4):351-352.

[11] Velimirovic B. Letter: Disaster epidemiology. Int J Epidemiol. 1975;4(3):241.

[12] Editorial: Disaster epidemiology. Int J Epidemiol. 1975;4(1):5-7.

[13] Bruesch SR. The disasters and epidemics of a river town: Memphis, Tennessee 1819-1879. Bull Med Libr Assoc. 1952;40(3):288-305.

[14] Winternitz MC, Lambert RA, Jackson L, Smith GH. The pathology of chlorine poisoning. In: Winternitz MC, ed. Collected studies on the pathology of war gas poisoning. New Haven: Yale University School of Medicine; 1920. p.1-32.

[15] Douple EB, Mabuchi K, Cullings HM, et al. Long-term radiation-related health effects in a unique human population: lessons learned from the atomic bomb survivors of Hiroshima and Nagasaki. Disaster Med Public Health Prep. 2011;5 Suppl 1:S122-133.

[16] Lechat MF. The epidemiology of disasters. Proc R Soc Med. 1976;69(6):421-426.

[17] Parrish HM, Baker AS, Bishop FM. Epidemiology in public health planning for natural disasters. Public Health Rep. 1964;79:863-867.

[18] Catastrophic accidents in the last three decades. Stat Bull Metropol Life Insur Co. 1971;52:7-9.

[19] Sommer A, Mosley WH. East Bengal cyclone of November, 1970. Epidemiological approach to disaster assessment. Lancet. 1972;1(7759):1029-1036.

[20] Lillibridge SR, Noji EK, Burkle FM, Jr. Disaster assessment: the emergency health evaluation of a population affected by a disaster. Ann Emerg Med. 1993;22(11):1715-1720.

[21] Guha-Sapir D. Rapid assessment of health needs in mass emergencies: review of current concepts and methods. World Health Stat Q. 1991;44(3):171-181.

[22] Glass RI, Cates W, Jr., Nieburg P, et al. Rapid assessment of health status and preventive-medicine needs of newly arrived Kampuchean refugees, Sa Kaeo, Thailand. Lancet. 1980;1(8173):868-872.

[23] Binder S, Sanderson LM. The role of the

epidemiologist in natural disasters. Ann Emerg Med. 1987;16(9):1081-1084.
[24] Seaman J. Disaster epidemiology: or why most international disaster relief is ineffective. Injury. 1990;21(1):5-8; discussion 15-16.
[25] Guha-Sapir D, Lechat MF. Information systems and needs assessment in natural disasters: An approach for better disaster relief management. Disasters. 1986;10(3):232-237.
[26] Dhara R. Health effects of the Bhopal gas leak: a review. Epidemiol Prev. 1992;14(52):22-31.
[27] Dhara VR, Kriebel D. The Bhopal gas disaster: it's not too late for sound epidemiology. Arch Environ Health. 1993;48(6):436-437.
[28] Baxter PJ, Ing R, Falk H, et al. Mount St Helens eruptions, May 18 to June 12, 1980. An overview of the acute health impact. JAMA. 1981;246(22):2585-2589.
[29] Merchant JA, Baxter P, Bernstein R, et al. Health implications of the Mount St. Helen's eruption: epidemiological considerations. Ann Occup Hyg. 1982;26(1-4):911-919.
[30] Merchant JA. Preparing for disaster. Am J Public Health. 1986;76(3):233-235.
[31] Centers for Disease Control and Prevention. Rapid assessment of injuries among survivors of the terrorist attack on the World Trade Center--New York City, September 2001. MMWR Morb Mortal Wkly Rep. 2002;51(1):1-5.
[32] Centers for Disease Control and Prevention. Surveillance for illness and injury after hurricane Katrina--New Orleans, Louisiana, September 8-25, 2005. MMWR Morb Mortal Wkly Rep. 2005;54(40):1018-1021.
[33] Svendsen ER, Yamaguchi I, Tsuda T, Guimaraes JR, Tondel M. Risk Communication strategies: Lessons learned from previous disasters with a focus on the Fukushima Radiation Accident. Current Environmental Health Reports. 2016;3(4):348-359.
[34] Noji EK. Disaster epidemiology: challenges for public health action. Ann Ig. 2002;14(1 Suppl 1):97-102.
[35] Noji EK. Disaster epidemiology. Emerg Med Clin North Am. 1996;14(2):289-300.
[36] Noji EK. Disaster epidemiology and disease monitoring. J Med Syst. 1995;19(2):171-174.
[37] Noji EK. Disaster epidemiology: challenges for public health action. J Public Health Policy. 1992;13(3):332-340.
[38] Lechat MF. Accident and disaster epidemiology. Public Health Rev. 1993;21(3-4):243-253.
[39] Lechat MF. Disaster epidemiology. Ann Soc Belg Med Trop. 1976;56(4-5):193-197.
[40] Fenig M, Cone DC. Advancing disaster epidemiology and response: developing a national disaster-victim database. Prehosp Emerg Care. 2005;9(4):457-467.
[41] Dhara VR, Acquilla S. Regarding distance of residence in 1984 may be used as exposure surrogate for the Bhopal disaster - further observations on post-disaster epidemiology. Indian J Med Res. 2013;138:270-272.
[42] Twum-Danso NY. Disaster epidemiology: prudent public health practice in the Pacific Islands. Pac Health Dialog. 2002;9(1):58-63.
[43] Liang NJ, Shih YT, Shih FY, et al. Disaster epidemiology and medical response in the Chi-Chi earthquake in Taiwan. Ann Emerg Med. 2001;38(5):549-555.
[44] Lillibridge SR, Noji EK. The importance of medical records in disaster epidemiology research. J AHIMA. 1992;63(10):137-138.
[45] Chakraborty AK. Disaster epidemiology and health management. Indian J Public Health. 1992;36(3):94-100.
[46] Lindtjorn B. Disaster epidemiology. Lancet. 1991;337(8733):116-117.
[47] Editorials. Disaster epidemiology. Lancet. 1990;336 (8719):845-846.
[48] Brenner SA, Noji EK. Tornado injuries related to housing in the Plainfield tornado. Int J Epidemiol. 1995;24(1):144-149.
[49] Staes C, Orengo JC, Malilay J, Rullan J, Noji E. Deaths due to flash floods in Puerto Rico, January 1992: implications for prevention. Int J Epidemiol. 1994;23(5):968-975.
[50] Hlady WG, Quenemoen LE, Armenia-Cope RR, et al. Use of a modified cluster sampling method to perform rapid needs assessment after Hurricane Andrew. Ann Emerg Med. 1994;23(4):719-725.
[51] Henderson AK, Lillibridge SR, Salinas C, Graves RW, Roth PB, Noji EK. Disaster medical assistance teams: providing health care to a community struck by Hurricane Iniki. Ann Emerg Med. 1994;23(4):726-730.
[52] Noji EK. Analysis of medical needs during disasters caused by tropical cyclones: anticipated injury patterns. J Trop Med Hyg. 1993;96(6):370-376.
[53] Armenian HK, Noji EK, Oganesian AP. A case-control study of injuries arising from the earthquake in Armenia, 1988. Bull World Health Organ. 1992;70(2):251-257.
[54] Quenemoen LE, Davis YM, Malilay J, Sinks T, Noji EK, Klitzman S. The World Trade Center bombing: injury prevention strategies for high-rise building fires. Disasters. 1996;20(2):125-132.
[55] Centers for Disease Control and Prevention. Injuries and illnesses among New York City Fire Department rescue workers after responding to the World Trade

Center attacks. MMWR Morb Mortal Wkly Rep. 2002;51 Spec No:1-5.

[56] Centers for Disease Control and Prevention. Self-reported increase in asthma severity after the September 11 attacks on the World Trade Center--Manhattaan, New York, 2001. MMWR Morb Mortal Wkly Rep. 2002;51(35):781-784.

[57] Trout D, Nimgade A, Mueller C, Hall R, Earnest GS. Health effects and occupational exposures among office workers near the World Trade Center disaster site. J Occup Environ Med. 2002;44(7):601-605.

[58] Hogg D, Kingham S, Wilson TM, Ardagh M. Spatio-temporal variation of mood and anxiety symptom treatments in Christchurch in the context of the 2010/11 Canterbury earthquake sequence. Spat Spatiotemporal Epidemiol. 2016;19:91-102.

[59] Anderson C, Lee D, Dean N. Bayesian cluster detection via adjacency modelling. Spat Spatiotemporal Epidemiol. 2016;16:11-20.

[60] Anderson C, Lee D, Dean N. Identifying clusters in Bayesian disease mapping. Biostatistics. 2014;15(3):457-469.

[61] Sturtz S, Ickstadt K. Comparison of Bayesian methods for flexible modeling of spatial risk surfaces in disease mapping. Biom J. 2014;56(1):5-22.

[62] Wakefield J, Kim A. A Bayesian model for cluster detection. Biostatistics. 2013;14(4):752-765.

[63] Delbiso TD, Rodriguez-Llanes JM, Donneau AF, Speybroeck N, Guha-Sapir D. Drought, conflict and children's undernutrition in Ethiopia 2000-2013: a meta-analysis. Bull World Health Organ. 2017;95(2):94-102.

[64] Choi J, Lawson AB. Bayesian spatially dependent variable selection for small area health modeling. Stat Methods Med Res. 2016; pii: 0962280215627184.

[65] Greene G, Paranjothy S, Palmer SR. Resilience and vulnerability to the psychological harm from flooding: The role of social cohesion. Am J Public Health. 2015;105(9):1792-1795.

[66] Todkill D, Loveridge P, Elliot AJ, et al. Utility of ambulance data for real-time syndromic surveillance: A pilot in the west midlands region, United Kingdom. Prehosp Disaster Med. 2017.p.1-6.

[67] Thomas MJ, Yoon PW, Collins JM, Davidson AJ, MacKenzie WR. Evaluation of syndromic surveillance systems in 6 US state and local health departments. J Public Health Manag Pract. 2017. doi: 10.1097/PHH.0000000000000679.

[68] Lauper U, Chen JH, Lin S. Window of opportunity for new disease surveillance: developing keyword lists for monitoring mental health and injury through syndromic surveillance. Disaster Med Public Health Prep. 2017;11(2):173-178.

[69] Gould DW, Walker D, Yoon PW. The evolution of bioSense: lessons learned and future directions. Public Health Rep. 2017;132(1 suppl):7S-11S.

[70] Thomasson ED, Scharman E, Fechter-Leggett E, et al. Acute health effects after the Elk River chemical spill, West Virginia, January 2014. Public Health Rep. 2017;132(2):196-202.

[71] Schnall A, Nakata N, Talbert T, Bayleyegn T, Martinez D, Wolkin A. Community assessment for public health emergency response (CASPER): An innovative emergency management tool in the United States. Am J Public Health. 2017;107(S2):S186-S192.

[72] Kurkjian KM, Winz M, Yang J, et al. Assessing emergency preparedness and response capacity using community assessment for public health emergency response methodology: Portsmouth, Virginia, 2013. Disaster Med Public Health Prep. 2016;10(2):193-198.

[73] Nyaku MK, Wolkin AF, McFadden J, et al. Assessing radiation emergency preparedness planning by using community assessment for public health emergency response (CASPER) methodology. Prehosp Disaster Med. 2014;29(3):262-269.

[74] Conley AM, Vagi S, Horney JA. Use of the community assessment for public health emergency response to conduct community health assessments for public health accreditation. J Public Health Manag Pract. 2014;20(5):490-497.

[75] Buttke D, Vagi S, Schnall A, et al. Community assessment for public health emergency response (CASPER) one year following the Gulf Coast oil spill: Alabama and Mississippi, 2011. Prehosp Disaster Med. 2012;27(6):496-502.

[76] Bertazzi PA. Industrial disasters and epidemiology. A review of recent experiences. Scand J Work Environ Health. 1989;15(2):85-100.

[77] Svendsen ER, Kolpakov IE, Stepanova YI, et al. ^{137}Cesium exposure and spirometry measures in Ukrainian children affected by the Chernobyl nuclear incident. Environ Health Perspect. 2011;118(5):720-725.

[78] Cummins S, Petticrew M, Higgins C, Findlay A, Sparks L. Large scale food retailing as an intervention for diet and health: quasi-experimental evaluation of a natural experiment. J Epidemiol Community Health. 2005;59(12):1035-1040.

[79] Boyce R, Reyes R, Matte M, et al. Severe flooding and malaria transmission in the Western Ugandan Highlands: Implications for disease control in an Era of global climate change. J Infect Dis. 2016;214(9):1403-

1410.

[80] McMahon DM, Vdovenko VY, Stepanova YI, et al. Dietary supplementation with radionuclide free food improves children's health following community exposure to (137)Cesium: a prospective study. Environ Health. 2015;14:94.

[81] Zahran S, Breunig IM, Link BG, Snodgrass JG, Weiler S, Mielke HW. Maternal exposure to hurricane destruction and fetal mortality. J Epidemiol Community Health. 2014;68(8):760-766.

[82] Torche F, Kleinhaus K. Prenatal stress, gestational age and secondary sex ratio: the sex-specific effects of exposure to a natural disaster in early pregnancy. Hum Reprod. 2012;27(2):558-567.

[83] Tseng KC, Hemenway D, Kawachi I, Subramanian SV, Chen WJ. The impact of the Chi-Chi earthquake on the incidence of hospitalizations for schizophrenia and on concomitant hospital choice. Community Ment Health J. 2010;46(1):93-101.

[84] Melius SBJ. Industrial disasters. In: Gregg MB, ed. The public health consequences of disasters 1989. Atlanta: US Department of Health and Human Services; 1989. p.97-102.

[85] Baxter PJ, Bernstein RS, Buist AS. Preventive health measures in volcanic eruptions. Am J Public Health. 1986;76(3 Suppl):84-90.

[86] Lang T, Schwoebel V, Diene E, et al. Assessing post-disaster consequences for health at the population level: experience from the AZF factory explosion in Toulouse. J Epidemiol Community Health. 2007;61(2):103-107.

[87] van Kamp I, van der Velden PG, Stellato RK, et al. Physical and mental health shortly after a disaster: first results from the Enschede firework disaster study. Eur J Public Health. 2006;16(3):253-259.

[88] Mills MA, Edmondson D, Park CL. Trauma and stress response among Hurricane Katrina evacuees. Am J Public Health. 2007;97 Suppl 1:S116-123.

[89] Foxman B, Camargo CA Jr, Lilienfeld D, et al. Looking back at hurricane Katrina: lessons for 2006 and beyond. Ann Epidemiol. 2006;16(8):652-653.

[90] Kilburn KH. Effects of chlorine and its cresylate byproducts on brain and lung performance. Arch Environ Health. 2003;58(12):746-755.

[91] Kilburn KH. Brain but not lung functions impaired after a chlorine incident. Ind Health. 2003;41(4):299-305.

[92] Kilburn KH. Chlorine-induced damage documented by neurophysiological, neuropsychological, and pulmonary testing. Arch Environ Health. 2000;55(1):31-37.

[93] Day B, Waitzkin H. The medical profession and nuclear war: A social history. JAMA. 1985;254(5):644-651.

[94] Flicker S, Travers R, Guta A, McDonald S, Meagher A. Ethical dilemmas in community-based participatory research: Recommendations for institutional review boards. Journal of Urban Health-Bulletin of the New York Academy of Medicine. 2007;84(4):478-493.

[95] Yu S, Brackbill RM, Stellman SD, Ghuman S, Farfel MR. Evaluation of non-response bias in a cohort study of World Trade Center terrorist attack survivors. BMC Res Notes. 2015;8:42.

[96] Dhara R, Dhara VR. Bhopal-A case study of international disaster. Int J Occup Environ Health. 1995;1(1):58-69.

[97] Dhara VR. What ails the Bhopal disaster investigations? (And is there a cure?). Int J Occup Environ Health. 2002;8(4):371-379.

[98] van den Berg B, van der Velden P, Stellato R, Grievink L. Selective attrition and bias in a longitudinal health survey among survivors of a disaster. BMC Med Res Methodol. 2007;7:8.

[99] Grievink L, van der Velden PG, Yzermans CJ, Roorda J, Stellato RK. The importance of estimating selection bias on prevalence estimates shortly after a disaster. Ann Epidemiol. 2006;16(10):782-788.

[100] Huizink AC, Smidt N, Twisk JWR, Slottje P, Smid T. Epidemiological disaster research: the necessity to include representative samples of the involved disaster workers. Experience from the epidemiological study air disaster Amsterdam-ESADA. Journal of Epidemiology and Community Health. 2006;60(10):887-889.

[101] Dhara VR, Dhara R. The Union Carbide disaster in Bhopal: a review of health effects. Arch Environ Health. 2002;57(5):391-404.

[102] Okubo MSRE. Radiation Effects Research Foundation: A Cooperative Japan-US Research Organization-Greetings and Welcome. 2007.

[103] Srinivasa Murthy R. Has the world forgotten Bhopal? Lancet. 2001;357(9258):810.

[104] Koplan JP, Falk H, Green G. Public health lessons from the Bhopal chemical disaster. JAMA. 1990;264(21):2795-2796.

[105] Roorda J, van Stiphout WA, Huijsman-Rubingh RR. Post-disaster health effects: strategies for investigation and data collection. Experiences from the Enschede firework disaster. J Epidemiol Community Health. 2004;58(12):982-987.

[106] Dayal HH, Brodwick M, Morris R, et al. A community-based epidemiologic study of health sequelae of exposure to hydrofluoric acid. Ann Epidemiol. 1992;2(3):213-230.

[107] Svendsen ER, Whittle NC, Sanders L, et al. GRACE: public health recovery methods following an

environmental disaster. Archives of environmental & occupational health. 2010;65(2):77-85.

[108] Elliott MR, Wang Y, Lowe RA, Kleindorfer PR. Environmental justice: frequency and severity of US chemical industry accidents and the socioeconomic status of surrounding communities. J Epidemiol Community Health. 2004;58(1):24-30.

[109] Israel BA, Schulz AJ, Parker EA, Becker AB. Community-based participatory research: policy recommendations for promoting a partnership approach in health research. Education for health (Abingdon, England). 2001;14(2):182-197.

[110] Little MP. Cancer and non-cancer effects in Japanese atomic bomb survivors. J Radiol Prot. 2009;29(2A):A43-59.

[111] Heath SE, Kenyon SJ, Zepeda Sein CA. Emergency management of disasters involving livestock in developing countries. Rev Sci Tech. 1999;18(1):256-271.

[112] Krajeski RL, Peterson KJ. "But she is a woman and this is a man's job": lessons for participatory research and participatory recovery. Int J Mass Emerg Disasters. 1999;17(1):123-130.

[113] Jones RN, Hughes JM, Glindmeyer H, Weill H. Lung function after acute chlorine exposure. Am Rev Respir Dis. 1986;134(6):1190-1195.

[114] Bailey C, Convery I, Mort M, Baxter J. Different public health geographies of the 2001 foot and mouth disease epidemic: 'citizen' versus 'professional' epidemiology. Health Place. 2006;12(2):157-166.

[115] Hoyle GW, Chang W, Chen J, Schlueter CF, Rando RJ. Deviations from Haber's Law for multiple measures of acute lung injury in chlorine-exposed mice. Toxicol Sci. 2010;118(2):696-703.

[116] Moore S, Daniel M, Linnan L, Campbell M, Benedict S, Meier A. After Hurricane Floyd passed: investigating the social determinants of disaster preparedness and recovery. Fam Community Health. 2004;27(3):204-217.

[117] Group TW. 'Gold standard' for remediation of wtc contamination. New Solut. 2004;14(3):199-217.

[118] Moore BB, Sherman M. Chronic reactive airway disease following acute chlorine gas exposure in an asymptomatic atopic patient. Chest. 1991;100(3):855-856.

[119] Chemtob CM, Nakashima JP, Hamada RS. Psychosocial intervention for postdisaster trauma symptoms in elementary school children: a controlled community field study. Arch Pediatr Adolesc Med. 2002;156(3):211-216.

[120] Bolin R, Stanford L. The Northridge earthquake: community-based approaches to unmet recovery needs. Disasters. 1998;22(1):21-38.

[121] Yehuda R, Bryant R, Marmar C, Zohar J. Pathological responses to terrorism. Neuropsychopharmacology. 2005;30(10):1793-1805.

[122] Farquhar S DN. Community and University Participation in Disaster-Relief Recovery: An Example from Eastern North Carolina Journal of Community Practice. 2004;12(3/4):203-217.

[123] Carroll YI, Rashid FA, Falk H, Howley MM. Examples of applied public health through the work of the Epidemic Intelligence Service officers at CDC's National Center for Environmental Health: 2006-2015. Public Health Rev. 2017;38:1.

[124] Platt JM, Lowe SR, Galea S, Norris FH, Koenen KC. A longitudinal study of the bidirectional relationship between social support and posttraumatic stress following a natural disaster. J Trauma Stress. 2016;29(3):205-213.

[125] Li J, Cone JE, Alt AK, et al. Performance of self-report to establish cancer diagnoses in disaster responders and survivors, World Trade Center Health Registry, New York, 2001-2007. Public Health Rep. 2016;131(3):420-429.

[126] Hunter MD, Hunter JC, Yang JE, Crawley AW, Aragon TJ. Public health system response to extreme weather events. J Public Health Manag Pract. 2016;22(1):E1-10.

[127] Carr Z, Clarke M, Akl EA, et al. Using the Grade Approach to Support the Development of recommendations for public health interventions in radiation emergencies. Radiat Prot Dosimetry. 2016;171(1):144-155.

[128] Kwok RK, Engel LS, Miller AK, et al. The GuLF STUDY: A prospective study of persons involved in the deepwater horizon oil spill response and clean-up. Environ Health Perspect. 2017;125(4):570-578.

[129] Salkowe RS, Chakraborty J. Federal Disaster Relief in the US: The role of political partisanship and preference in presidential disaster declarations and turndowns. Journal of Homeland Security and Emergency Management. 2009;6(1):1547-7355.

[130] Moss M, Schellhamer C, Berman DA. The Stafford Act and priorities for reform. Journal of Homeland Security and Emergency Management. 2009;6(1) :1547-7355.

[131] Agency FEM. Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended, and related authorities. In: FEMA, ed. 592. Vol PL 100-707. Washington, D.C.: FEMA; June 2007. p.125.

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災害疫学

―環境に影響を与える災害における公衆衛生の視点での健康影響の評価法―

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抄録

導入：「災害疫学」は，災害時に利用される疫学だと基本的には認識されている．しかし，公衆衛生上の問題をもたらす災害時に適用することから，他の疫学的な手法とは異なる特性を持つようになった．そこで,「災害疫学」の歴史を振りかえりその発展の経緯や災害疫学が持つ特性を概説する．また,関連する文献をレビューすることで,「災害疫学」が情報の集約によりいざという時の対応の効率化に役立つだけでなく，災害がもたらす影響をより深く学ぶことで次の事態によりよく備えられるようになる二つの側面の特徴を示す.

方法：2011年の東京電力福島第一原子力発電所災害に対する現在進行中の公衆衛生面での復興活動やそれを支える研究に対して,「災害疫学」をより広範に適用させることや将来新たな災害が発生した場合の対応措置の準備に役立たせることを意図して文献をレビューした.

結果：「災害疫学」は，追跡調査，影響緩和措置，調査といった手法等を介して，災害を定量的な面からその重大性を理解し，災害に見舞われた人々のニーズを迅速に把握し，そのニーズに対応するだけでなく，将来の災害による公衆衛生上の影響を最小限に抑える方法を学ぶために用いることができる．これまで，学術雑誌に掲載されたこの分野の論文の大部分は災害がもたらす影響の緩和に焦点を当てていた（19本中10本で）.

考察：「疫学」と「災害」の両方のキーワードを含む数多くの論文では，災害の中での疫学の適用性についての一貫した認識があった．しかし,19の論文のみがその概念に焦点を当てていたことは,「災害疫学」が疫学のサブカテゴリーとして認識されていないことを示している．しかも，これらの文献では，用語の使い方にばらつきがあった．災害対応での公衆衛生上の課題やそれへの備えの観点から,本来，対応が求められるものの見過ごされがちな分野について,「災害疫学」の意義に関して科学や公衆衛生コミュニティの理解を深めるためには，さらにその学問体系について概念整理を深める必要がある.

結論：「災害疫学」は，疫学の中で特徴のあるサブカテゴリーで，災害時の公衆衛生対応として，追跡的な調査,被害軽減,研究を進める上で役立つ概念である．疫学の重要なサブカテゴリーである「災害疫学」についても教育や手法開発を進めることは災害時における公衆衛生上の課題を軽減し，災害での対応で課題にもなる環境中の有害物質への災害時の曝露の理解を促進するのにも役立つ.

キーワード：災害，疫学，公衆衛生，環境