

Combating Outbreaks in North Carolina: Lessons Learned

Kristina Simeonsson, Karin Hillenbrand

Outbreaks of infectious diseases occur with increasing frequency in North Carolina. A review of the public health response to outbreaks, with attention to the core public health functions of *assessment, policy development, and health assurance*, can illustrate best practices and identify areas for improvement.

Introduction

It's not a question of *if* but *when*. In recent years, the growing number of infectious disease outbreaks in North Carolina has necessitated that prevention and control of communicable diseases be a major focus for the 85 local health departments (LHDs) serving the state's 100 counties. LHDs work closely with the state health department to access assistance and resources when needed, and the state health department in turn works with federal agencies to coordinate disease reporting and outbreak investigation. Although the public may view outbreak response as reactive in nature, preparedness efforts are continuous: public health personnel engage in proactive planning aimed at preventing infectious diseases while also standing ready to respond at any time to an outbreak.

As the public health system in North Carolina responds to the current coronavirus disease 2019 (COVID-19) pandemic, an evaluation of past outbreaks can illustrate successful system responses and also identify areas where we can improve. In this commentary, we will examine selected outbreaks and describe preparedness programs using a framework based on the three core functions of public health—*assessment, policy development, and assurance*—and we will explore the related 10 Essential Public Health Services to highlight opportunities to optimize preparedness for North Carolina communities (Figure 1) [1].

Health Assessment

The core function of *assessment* includes essential services focused on monitoring population health and investigating and diagnosing health problems.

Public health surveillance is the foundation of assessment. Surveillance—the collection, analysis, and dissemination of data pertaining to disease occurrence—can take several forms: *passive, active, and syndromic*. Passive surveillance involves the legislatively mandated reporting of

infectious diseases by physicians and laboratories to LHDs; school principals, day care operators, and restaurant owners are also required to report. LHD personnel respond quickly to investigate reported cases, collecting demographic, clinical, and epidemiologic information. If confirmed as meeting case definition, reports are transmitted to the NC Division of Public Health (NCDPH) via the North Carolina Electronic Disease Surveillance System (NC EDSS). State personnel use these data to monitor trends as well as detect outbreaks that may be occurring across jurisdictions. They also report cases submitted by the LHD to the Centers for Disease Control and Prevention (CDC). Active surveillance, initiated by health departments, is often used during outbreaks to solicit additional reports of disease from providers.

In North Carolina, there are over 80 reportable diseases; recent additions over the past 5 years include zika virus, chikungunya, and novel coronaviruses, including the severe acute coronavirus type 2 responsible for the COVID-19 pandemic [2] (Table 1). It is important to note that outbreaks of infectious diseases not on the reportable list and outbreaks of unknown etiology are also reportable; outbreak investigations of diseases not on the reportable list can lead to amendment of the list. In late 2000 and early 2001, the NCDPH, in conjunction with the Forsyth County Health Department, investigated an outbreak of listeriosis in 13 adults [3]. Twelve of the cases were female, 11 of whom were pregnant. Among the pregnant women, infection resulted in five stillbirths, three preterm deliveries, and three infected newborns [3]. A case-control study demonstrated that the outbreak was caused by consumption of noncommercial, homemade Mexican-style cheese. As a result of this outbreak, listeriosis was added to the list of reportable diseases in North Carolina in June 2001 [3].

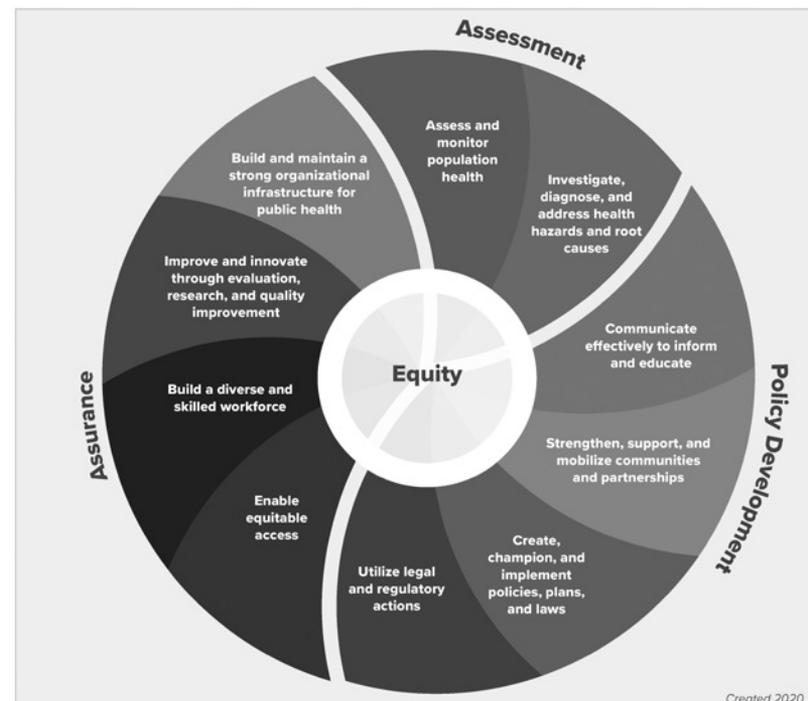
Because passive surveillance relies on individuals remembering to report, it is not always timely, nor complete. Active surveillance can be labor intensive and not sustainable during times of normal operations. Syndromic surveillance uti-

Electronically published May 3, 2021.

Address correspondence to Kristina Simeonsson, Department of Pediatrics, 600 Moye Blvd, Brody School of Medicine, Greenville, NC 27834 (simeonssonk@ecu.edu).

N C Med J. 2021;82(3):184-190. ©2021 by the North Carolina Institute of Medicine and The Duke Endowment. All rights reserved. 0029-2559/2021/82306

FIGURE 1.
The 10 Essential Public Health Services



Source. Public Health National Center for Innovations. The 10 Essential Public Health Services. <https://www.http://phnci.org/national-frameworks/10-eph>. Published September 9, 2020. Accessed March 26, 2021.

lizes automated data related to symptoms of disease early in the course of illness to identify cases, outbreaks, and clusters in near real time with more lead time than passive surveillance. North Carolina has been a leader in creating infrastructure to conduct syndromic surveillance. The North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT), created in 2004, is a state-wide syndromic surveillance system that utilizes data sources including emergency department visits from the state's 126 acute care hospitals, poison control center calls, and emergency medical services calls [4].

While syndromic surveillance provides a potential mechanism for earlier outbreak detection, there are challenges. Although the data are available in real time, LHD staff may not have the time or dedicated personnel to monitor results regularly while fulfilling their many other responsibilities. Summary syndromic surveillance reports generated for LHDs during the H1N1 influenza pandemic were useful for tracking the spread of disease on a community level. Compilation, analysis, and dissemination of syndromic data by state public health personnel during the H1N1 pandemic allowed more time and resources at the local level to be directed at outbreak response [5].

Health Policy Development

The core function of policy development incorporates essential services related to effective communication and

collaboration with community partners along with the development of policies, programs, and laws that impact health, and the use of regulatory actions to protect health.

The 2000-2001 listeriosis outbreak highlighted the importance of working with other state partners including the North Carolina Department of Agriculture and Consumer Services (NCDACS) and Environment and Natural Resources, as well as federal partners, including the Food and Drug Administration and the CDC. Public health officials used existing mechanisms at the local level to increase public awareness about the dangers of consuming unpasteurized products while pregnant. Health authorities also stopped the sale of raw milk by a local dairy farm to noncommercial processors and reminded store owners that it was illegal to sell unregulated dairy products [3].

A 2004 outbreak of *Escherichia coli* (*E coli*) at the North Carolina State Fair resulted in 108 cases of diarrheal illness [6]. Laboratory testing matched the outbreak strain of *E coli* in 38 individuals to environmental samples from one petting zoo at the State Fair. This outbreak was another example of the importance of a coordinated response with the NCDACS. It also highlighted the gap in regulations for petting zoos; NCDAS would go on to adopt guidelines from the National Association of State Public Health Veterinarians regarding control measures to reduce spread of infection associated with animals in public settings [6]. Ultimately, the North Carolina General Assembly passed a law in 2005

Clymore SIDEBAR

requiring all animal contact exhibits at sanctioned agricultural fairs to obtain a permit from the NCDACS [7].

Vaccines are an important tool in preventing disease outbreaks, and laws requiring vaccination for all children, with review upon entry into daycare or school settings, help to maintain high vaccination coverage rates and low incidences of diseases. In 2004, an outbreak of measles in Martin County occurred when an adolescent contracted measles after traveling to England. Although an infant too young to have been vaccinated acquired the disease, no additional cases were identified despite multiple other potential exposures, highlighting the high vaccination rates in the county at the time [8]. A more recent measles outbreak in 2013 occurred after an unvaccinated person in Stokes County developed symptoms after traveling to India. This outbreak

spread to include 23 cases overall with 78% of cases occurring among unvaccinated members of a religious community in rural North Carolina [9]. Similarly, a chickenpox outbreak in 2017-2018 affected 36 children attending a private school having one of the highest rates of religious exemptions from vaccines in North Carolina [10].

Health Assurance

Assurance encompasses essential services that ensure equitable access to services, support for the public health workforce, ongoing improvement of relevant functions, and maintenance of the necessary infrastructure for public health.

Building and supporting a public health workforce is essential at the local level. Since 2002, LHDs in North

Carolina have used Epi Teams to organize their responses to communicable disease outbreaks, environmental health hazards, and other public health emergencies [11]. These Epi Teams are multidisciplinary with a wide range of expertise from epidemiology, nursing, and preparedness planning to information technology and health education. The responsibilities of these teams include surveillance and epidemiologic investigations, implementation of control measures, communication with key stakeholders, and education of the public on health risks.

In 2003, the NCDPH established the hospital-based public health epidemiologist (PHE) program in 11 of the state's largest hospitals. While the PHEs are hospital employees, they work in close partnership with local and state public health. LHD staff feel that the program has enhanced communication with hospitals, increased completeness and

timeliness of disease reporting, and improved investigations of infectious diseases in the community [12].

In 2011, an outbreak of pertussis in Alamance County underscored the need for an adequate public health workforce. This large-scale outbreak, which was centered in the public schools, necessitated case identification, contact tracing, and provision of prophylaxis to large numbers of individuals, and available public health resources were quickly overwhelmed. [13]. While the number of outbreaks, reportable disease lab reports, and cases has increased significantly in recent years, state funding for investigation of communicable diseases has not kept pace, and overall funding for LHD staffing has declined [14].

The 2011 pertussis outbreak also illustrated a public health success in ensuring equitable access to health resources. When it became apparent that those at greatest

TABLE 1.
Diseases and Conditions Reportable in North Carolina Within a Specific Timeframe

Physicians must report these diseases and conditions to the county local health department, according to the North Carolina Administrative Code: 10A NCAC 41A.0101 Reportable Diseases and Conditions. Contact information for local health departments can be accessed at www.ncalhd.org/directors. If physicians are unable to contact their local health department, they can call the 24/7 pager for NCDHHS, Communicable Disease Branch (919) 733-3419.

Immediately	Anthrax	Measles	Plague
	Botulism	Novel coronavirus infection	Smallpox
	Hemorrhagic fever virus	Novel influenza infection	Tularemia
24 hours	Acquired immunodeficiency virus (AIDS)	Hemolytic-uremic syndrome (HUS)	Salmonellosis
	Campylobacter infection	Hepatitis A	Severe acute respiratory syndrome (SARS)
	Candida auris	Hepatitis B	Shigellosis
	Carbapenem-resistant Enterobacteriaceae (CRE)	Human immunodeficiency virus (HIV) infection	Staphylococcus aureus with reduced susceptibility to vancomycin
	Chancroid	Influenza virus infection causing death	Syphilis ^b
	Chikungunya virus infection	Listeriosis	Tuberculosis
	Cholera	Meningococcal disease, invasive	Typhoid fever, acute (Salmonella typhi)
	Cryptosporidiosis	Middle East Respiratory syndrome (MERS)	Vaccinia
	Cyclosporiasis	Monkeypox	Varicella (chickenpox)
	Diphtheria	Novel coronavirus infection causing death	Vibrio infection ^c
	Escherichia coli, shiga toxin-producing infection	Ophthalmia neonatorum	Vibrio vulnificus
	Foodborne disease ^a	Paralytic poliomyelitis	Zika virus
	Gonorrhea	Pertussis (whooping cough)	
	Granuloma inguinale	Rabies, human	
Haemophilus influenzae, invasive disease	Rubella		
7 days	Acute flaccid myelitis	Interferon-gamma release assay (IGRA)	Q fever
	Anaplasmosis	Legionellosis	Rubella congenital syndrome
	Arboviral infection, invasive ^d	Leprosy	Spotted fever rickettsiosis (including RMSF)
	Babesiosis	Leptospirosis	Streptococcal infection, Group A, invasive
	Brucellosis	Lyme disease	Tetanus
	Chlamydial infection	Lymphogranuloma venereum	Toxic shock syndrome ^e
	Creutzfeldt-Jakob disease	Malaria	Trichinosis
	Dengue	Meningitis, pneumococcal	Typhoid carriage (Salmonella typhi)
	Ehrlichiosis	Mumps	Typhus, epidemic (louse-borne)
	Hantavirus infection	Nongonococcal urethritis	Yellow fever
	Hepatitis B carriage or perinatally-acquired	Pelvic inflammatory disease	
Hepatitis C, acute	Psittacosis		

Note. For diseases and conditions required to be reported within 24 hours, the initial report shall be made by telephone to the local health department, and the written disease report be made within 7 days. The reporting rules and disease report forms can be accessed at: <http://epi.publichealth.nc.gov/cd/report.html>

^aincluding Clostridium perfringens, staphylococcal, Bacillus cereus, and other and unknown causes

^bprimary, secondary, early latent, late latent, late with clinical manifestations, congenital

^cother than cholera & vulnificus

^dWNV, LAC, EEE, other, unspecified

^enon-streptococcal or streptococcal

Source. Adapted from <https://epi.dph.ncdhhs.gov/cd/lhds/manuals/cd/toc.html>

risk for morbidity from the disease were infants too young to be vaccinated, and that their source of infection was often a caregiver whose vaccination had lapsed, restrictions and cost barriers for booster doses of the pertussis vaccine (Tdap) were lifted, allowing the health department to administer the vaccine to anyone meeting CDC criteria regardless of insurance eligibility or purchase constraints. Mass vaccination clinics were organized, and local health fairs and community events served as venues for administration of the vaccine. The health department also used off-site points of distribution for Tdap vaccinations so that local providers could administer the vaccine at no cost, and the health department worked closely with staff members at local hospitals to vaccinate all new parents delivering at the

hospital, in order to create a “cocoon of protection” around vulnerable newborns [13].

The Current Pandemic

The response to the COVID-19 pandemic has been illustrative of successes. NC DETECT has adapted quickly to the pandemic by adding data elements for monitoring COVID-like illness. LHDs are able to view illness trends at the county level, and state officials generate weekly surveillance reports showing statewide trends [4]. The PHE program, heralded as having great potential for responding quickly to an emerging health crisis, has proven invaluable during the H1N1 and COVID-19 pandemics by serving as a link between public health and health care settings [15].

Information regarding disease burden, vaccine distribution, testing resources, health recommendations, and community restrictions is updated regularly and is publicly available at the state's COVID-19 Information Hub. Credible public health leaders in collaboration with policy makers demonstrate effective risk communication strategies in delivering timely, clear, simple messages to the public [16].

Despite these and other successes, there is work to be done. Disease burden disproportionately affects residents of color and those living in rural counties [17]. Lack of adequate funding for public health means that LHDs have experienced progressive loss of workforce, and struggle to keep up with case investigation and contact tracing [18]. Misinformation and pockets of distrust serve to counteract the effectiveness of public health messages about COVID-19, use of masks, need for social distancing, and vaccine safety [19].

Conclusions

It is difficult to predict how well a public health system will respond in an emergency such as a large infectious disease outbreak or pandemic; it is inherently challenging to measure preparedness in advance. The Association of State and Territorial Health Officers, in collaboration with the CDC, developed a tool—the National Health Security Preparedness Index (NHSPI)—to measure health security preparedness in each state [20]. According to the latest NHSPI report, North Carolina's overall health security level for 2019 was above the national average and the highest it has been since the NHSPI started measuring preparedness in 2013. North Carolina's strengths in the domain of health security surveillance include having a state public health veterinarian to assist with control and prevention of zoonotic diseases and having an electronic syndromic surveillance system (NC DETECT). Other measures above the national average in this domain are related to strengths of the state laboratory of public health (SLPH), with an electronic system for receiving and reporting information, legal requirements for non-government labs to send specimens associated with foodborne diseases to the SLPH, and a surge capacity plan for testing during an emergency [21].

To honor the success of the past and promote the best health outcomes for North Carolina residents in the future, we must continue to recognize the essential role of LHDs as the first line of defense in preventing, detecting, and managing outbreaks in local communities, and support LHDs with enhanced funding for maintenance of the public health workforce. We should continue to support collaboration at all levels—from LHDs and their community partners to partnerships with state and federal public health entities. We should leverage relationships with academic centers, research networks, and industry in support of the development and implementation of innovative programs like NC DETECT and the hospital-based PHEs. We must practice effective risk communication, with the delivery of timely and credible information, while combatting misinformation and

developing more effective strategies for using social media. We should enhance the state's successful immunization program by promoting a return to a universal vaccine purchase program targeted not only to all children but to all residents of the state, and by eliminating non-medical exemptions to vaccination.

While there is no question that we will continue to face challenging outbreaks—not *if* but *when*—we can learn from our achievements and take the necessary steps to address our challenges. North Carolina has led the nation in innovative programs to respond to public health threats and currently is above the national average in health security preparedness. In order to build on past successes and respond to new threats, we must assure a strong organizational infrastructure for public health. NCMJ

Kristina Simeonsson, MD, MSPH associate professor, Department of Pediatrics and Public Health, Brody School of Medicine, East Carolina University, Greenville, North Carolina.

Karin Hillenbrand, MD, MPH professor, Department of Pediatrics, Brody School of Medicine, East Carolina University, Greenville, North Carolina.

Acknowledgments

Potential conflicts of interest. K.S and K.H. report no conflicts of interest.

References

- Centers for Disease Control and Prevention. The 10 Essential Public Health Services. CDC website. <https://www.cdc.gov/publichealthgateway/publichealthservices/essentialhealthservices.html>. Reviewed March 18, 2021. Accessed March 26, 2021.
- Reportable Diseases and Conditions. North Carolina Administrative Code. 10A NCAC41A.0101.
- MacDonald PDM, Whitwam RE, Boggs JD, et al. Outbreak of listeriosis among Mexican immigrants as a result of consumption of illicitly produced Mexican-style cheese. *Clin Infect Dis*. 2005; 40:677-682. doi: 10.1086/427803
- North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT) website. <https://www.ncdetect.org>. Accessed March 19, 2021.
- Fangman MT, Samoff E, DiBiase L, et al. Routine dissemination of summary syndromic surveillance data leads to greater usage at local health departments in North Carolina. *J Public Health Epidemiol*. 2015;7(1):1-5. doi: 10.5897/JPHE2013.0546
- Goode B, O'Reilly C, Dunn J, et al. Outbreak of *Escherichia coli* O157:H7 infections after petting zoo visits, North Carolina State Fair, October–November 2004. *Arch Pediatr Adolesc Med*. 2009;163(1):42-48. doi: 10.1001/archpediatrics.2008.525
- North Carolina Department of Agriculture & Consumer Services. Emergency Programs: Animal Contact Exhibit Information. NCAGR website. <https://www.ncagr.gov/oep/AnimalContactExhibit.htm>. Accessed March 19, 2021.
- North Carolina Public Health Officials Confirm Measles Case in Martin County [press release]. Raleigh, NC: NCDHHS; August 4, 2004. <https://www.infectioncontroltoday.com/view/north-carolina-public-health-officials-confirm-measles-case-martin-county>. Accessed February 28, 2021.
- Centers for Disease Control and Prevention. Notes from the field: Measles outbreak associated with a traveler returning from India – North Carolina, April–May 2013. *MMWR Morb Mortal Wkly Rep*. 2013;62(36):753.
- Gajanan M. Chickenpox Outbreak Hits North Carolina School with High Vaccination Exemption Rate. *Time.com*. <https://time.com/5460215/chickenbox-outbreak-north-carolina/>. Published November 20, 2018. Accessed March 29, 2021.
- North Carolina Division of Public Health. Guidance for Epi Teams in Local Health Departments. *EpiNotes Newsletter*. Raleigh, NC: NCDHHS; 2018. <https://epi.ncpublichealth.com/pdf/en2018-1.pdf>.

- Accessed February 26, 2021.
12. North Carolina Preparedness and Emergency Response Research Center. Research Brief: How the Hospital-Based Public Health Epidemiologist Program Benefits Local Health Departments. Raleigh, NC: NCPERRC; 2011. <https://sph.unc.edu/wp-content/uploads/sites/112/2015/07/nciph-perrc-ph-epid.pdf>. Published February 2011. Accessed March 19, 2021.
 13. Bass JB, Turpin-Saunders SR. Coughing up answers: a community's response to pertussis. *N C Med J.* 2013;74(5):420-424.
 14. Morrow J. Communicable Disease Funding at the Local Level. Presentation by the NC Association of Local Health Directors to the Joint Legislative Oversight Committee on Health and Human Services: February 2018; Raleigh, NC. <https://www.ncleg.gov/documents/sites/committees/JLOCHHS/Handouts%20and%20Minutes%20by%20Interim/2017-18%20Interim%20JLOC-HHS%20Handouts/February%2028,%202018/III%20Local%20Health%20Dept%20Issues.pdf>. Accessed April 26, 2021.
 15. Center for Infectious Disease Research and Policy. Hospital-based public health epidemiologist program for biosurveillance. CIDRAP website. <https://www.cidrap.umn.edu/practice/hospital-based-public-health-epidemiologist-program-biosurveillance>. Accessed March 19, 2021.
 16. North Carolina Department of Health and Human Services. COVID-19 Information Hub. State of North Carolina website. <https://www.nc.gov/covid19>. Accessed March 18, 2021.
 17. Gerald L. Invest in rural North Carolina to ensure a thriving state, pandemic or not. *N C Med J.* 2021;82(1):46-49. doi: 10.18043/ncm.82.1.46
 18. Pettigrew E. COVID-19: A mirror to our flaws. *N C Med J.* 2021;82(1):43-45.
 19. Sturgill A. Health care providers can help combat harmful misinformation about the pandemic. *N C Med J.* 2021;82(1):68-70. doi: 10.18043/ncm.82.1.43
 20. Blumenstock J, Bakker G, Jarris PE. Measuring preparedness: The National Health Security Preparedness Index. *J Public Health Manag Pract.* 2014;20(3):361-363. doi: 10.1097/PHH.000000000000073
 21. National Health Security Preparedness Index. North Carolina. NHSPI website. <https://nhspi.org/states/north-carolina/>. Accessed February 26, 2021.